# THE INFLUENCE OF BODY POSITIONS UPON PULMONARY FUNCTION TESTS IN POSTOPERATIVE PATIENTS

By
Carolyn Bawden, B.S.N.

A Thesis

Presented to
The Oregon Health Sciences University
School of Nursing
in partial fulfillment
of the requirement for the degree of
Master of Nursing

June, 1988

APPROVED:

[redacted]

Naomi Ballard, R.N., M.A., M.S., C.N.R.N.,
Associate Professor, Thesis Advisor

[redacted]

Mary McFarland, R.N., M.S.N., Associate Professor,
Associate Dean for Undergraduate Studies, First Reader

[redacted]

Carol Duncan, R.N., M.N., Pulmonary Clinical Specialist,
Second Reader

[redacted]

Carol A. Lindeman, R.N., Ph.D., F.A.A.N.,
Dean, School of Nursing

# TABLE OF CONTENTS

LIST_OF_TABLES

LIST_OF_FIGURES

CHAPTER | | Page
---|---|---
I | INTRODUCTION | 1
| Factors Associated with Pulmonary Complications | 2
| Preoperative Factors | 3
| Age and Gender | 3
| Obesity | 5
| Smoking History | 5
| Concurrent Disease Entities | 6
| Perioperative Factors | 7
| Incisional Type | 7
| Anesthetic and Premedication Agents | 9
| Stress Response | 9
| Operative Complications and Extended Operative Times | 10
| Postoperative Factors | 10
| Pharmacological Agents and Fluids | 10
| Respiratory Therapy Interventions | 12
| Positioning of the Patient | 13

CHAPTER | Page

I (Continued)

Statement of the Problem .................... 14

Purpose of the Study .................... 19

Hypotheses .................... 19

Overview of the Study .................... 20

II REVIEW OF LITERATURE .................... 23

Preoperative Factors .................... 24

Age .................... 24

Obesity .................... 26

Smoking History .................... 29

Concurrent Disease Entities .................... 30

Perioperative Factors .................... 35

Incisional Type .................... 35

Anesthetic and Premedication Agents .................... 40

Stress Response .................... 43

Postoperative Factors .................... 45

Narcotics .................... 45

Respiratory Interventions .................... 46

Positioning .................... 51

Normal Mechanisms and Positioning .................... 51

Physiological Disturbances and Positioning .................... 58

Surgery and Positioning .................... 60

Summary .................... 62

CHAPTER | Page


III METHODS .................................... 64

Sample and Setting ........................... 64

Design ....................................... 66

Independent Variables ........................ 67

Dependent Variables .......................... 69

Tidal Volume ................................. 69

Respiratory Rate ............................. 70

Minute Ventilation ........................... 71

Forced Vital Capacity ........................ 73

Forced Expired Volume in 1 Second (FEV1) ..... 74

Control Variables ............................ 75

Data Collection .............................. 76

Data Analysis ................................ 78

IV ANALYSIS OF DATA ............................ 83

Characteristics of the Sample ................ 84

Preoperative ................................. 85

Age and Gender ............................... 85

Weight-Height Ratios ......................... 87

Smoking History .............................. 89

Concurrent Disease Entities .................. 93

Perioperative ................................ 94

Incisional Type .............................. 95

| CHAPTER | | Page |
|---|---|---|
| IV | Perioperative (Continued) | |
| | Operative Complications and Length of Surgical Procedure ............ | 97 |
| | Type of Anesthesia ...................... | 98 |
| | Estimated Blood Loss in Surgery ......... | 98 |
| | Postoperative ........................... | 99 |
| | Narcotics and Sedatives ................. | 99 |
| | Respiratory Interventions ............... | 100 |
| | Positioning ............................. | 100 |
| | Tidal Volume ................................ | 103 |
| | Effect of Positioning Upon Tidal Volume ... | 103 |
| | Effect of Positioning Upon Tidal Volume for the Three Incisional Types ............ | 107 |
| | Effect of Positioning Upon Tidal Volume for Two Sequences ........................ | 109 |
| | Effect of Control Variables Upon Positioning and Tidal Volume .............. | 110 |
| | Preoperative Factors .................... | 112 |
| | Age ................................... | 112 |
| | Weight/Height Ratios .................. | 115 |
| | Concurrent Disease Entities ........... | 117 |
| | Perioperative Factors ................... | 119 |
| | Operative Complications ............... | 119 |
| | Surgical Length ....................... | 119 |

CHAPTER | Page

IV Perioperatiave (Continued)

Estimated Blood Loss .................. 124

Postoperative Factors ................... 125

Use of Incentive Spirometer ........... 125

Ambulation and Repositioning .......... 125

Respiratory Rate ............................ 128

Effect of Positioning Upon Respiratory Rate .......................... 128

Effect of Positioning Upon Respiratory Rate for Three Incisional Types ........... 129

Effect of Positioning Upon Respiratory Rate for Two Sequences .................... 132

Effect of Control Variables Upon Positioning and Respiratory Rate ......... 134

Minute Ventilation .......................... 134

Effect of Positioning Upon Minute Ventilation ........................ 135

Effect of Positioning Upon Minute Ventilation for Three Incisional Types .... 135

Effect of Positioning Upon Minute Ventilation for Two Sequences ............ 141

Effect of Control Variables, Positioning and Minute Ventilation ........ 143

Preoperative Factors ..................... 143

Concurrent Disease Entities ........... 143

Perioperative Factors ................... 146

CHAPTER | Page

Perioperative (Continued)

Surgical Length ........................ 146

Estimated Blood Loss .................. 147

Postoperative Factors .................... 147

Use of Incentive Spirometer ........... 147

Ambulation and Repositioning .......... 150

Forced Vital Capacity ...................... 156

Effect of Positioning Upon Forced Vital Capacity ........................... 157

Effect of Positioning Upon FVC for the Three Incisional Types .................. 157

Effect of Positioning Upon FVC for Two Sequences ................................ 163

Effect of Control Varibles Upon Positioning and FVC ...................... 165

Preoperative Factors ................... 165

Age ..................................... 165

Weight-Height Ratios .................. 165

Smoking ............................... 166

Concurrent Disease Entities ........... 166

Perioperative Factors .................. 166

Surgical Length ...................... 166

Estimated Blood Loss .................. 167

Postoperative Factors .................. 167

CHAPTER | Page


Postoperatve (Continued)

Use of Incentive Spirometer ........... 167

Ambulation and Repositioning .......... 168

Forced Expired Volume in 1 Second ........... 168

Effects of Positioning Upon FEV1 .......... 169

Effect of Positioning Upon FEV1 for Three Incisional Types ................ 169

Effect of Positioning Upon FEV1 for Two Sequences ......................... 175

Effect of Control Variables Upon Positioning and FEV1 ...................... 177

Preoperative Factors .................... 177

Weight/Height Ratios .................. 177

Smoking History ...................... 177

Concurrent Disease Entities .......... 177

Perioperative Factors .................. 178

Surgical Length ...................... 178

Estimated Blood Loss .................. 178

Postoperative Factors .................. 178

Use of Incentive Spirometer ........... 178

Ambulation and Repositioning .......... 179

V Summary and Conclusions ...................... 180

Summary ................................... 180

CHAPTER | Page

V (Continued)

Conclusions .................................. 182
Hypotheses ................................. 182
Position ................................. 182
Incisions ................................ 185
Upper Abdominal Incision............... 186
Lower Abdominal Incision .............. 188
Combination Incision .................. 191
Sequencing ............................... 194
Limitations .................................. 196
Strengths of the Study ....................... 198
Clinical Implications ........................ 198
Recommendations .............................. 202

REFERENCES

## APPENDICES


A Subject Data Sheet

B Informed Consent Oregon Health Sciences University

C General Consent Form
Veterans Administration Hospital

D Nursing Consent Form
Veterans Administrative Hospital

E Tidal Volume Tables for Control Variables

Table E-1
Seven Subjects with Pulmonary Disease Separated by Incisional Type According to Mean Tidal Volume in Three Positions

Table E-2
Three Subjects with Neuromuscular Disease Separated by Incisional Type According to Mean Tidal Volume in Three Positions

Table E-3
Subjects with Concurrent Cardiac, Pulmonary, and Neuromuscular Disease Separated According to Mean Tidal Volume in Three Positions for Sequence 2

Table E-4
Twenty-one Subjects Using the Incentive Spirometer Separated by Sequence According to Mean Tidal Volume in Three Positions

Table E-5
Thirteen Subjects Ambulated Prior to Testing Separated by Sequence According to Mean Tidal Volume in Three Positions

Table E-6
Ten Subjects Repositioned Prior to Testing Separated by Sequence According to Mean Tidal Volume in Three Positions

APPENCICES

F Analysis of Variance Summary and Planned Comparisons Data for Respiratory Rate

Table F-1
Analysis of Variance Summaries for the Respiratory Rate

Table F-2
Comparison of the Respiratory Rate Means for the Positions of Flat, 45 Degrees, and 90 Degrees Using a Planned T-test and Tukey Test

G Minute Ventilation Tables for Control Variables

Table G-1
Twenty-four Subjects Over Age 50 for Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions

Table G-2
Twenty-four Subjects Over Age 50 Separated by Incisional Type According to Minute Ventilation in Three Positions

Table G-3
Fifteen Overweight Subjects for Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions

Table G-4
Fifteen Overweight Subjects Separated by Incisional Type According to Minute Ventilation in Three Positions

Table G-5
Twenty-four Smoking Subjects for Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions

Table G-6
Twnety-four Smoking Subjects Separated by Incisional Type According to Minute Ventilation in Three Positions

APPENDICES


Table G-7
Sixteen Subjects with Cardiac Disease for Total Sample and Separated According to Minute Ventilation in Three Positions

Table G-8
Sixteen Subjects with Cardiac Disease Separated by Incisional Type According to Minute Ventilation in Three Positions

Table G-9
Five Subjects with Operative Blood Loss Greater than 500 cc for Total Sample and Sequence According to Minute Ventilation in Three Positions

Table G-10
Five Subjects with Operative Blood Loss Greater than 500 cc Separated by Incisional Type According to Minute Ventilation in Three Positions

Table G-11
Ten Subjects Repositioned After Surgery Separated by Incisional Type According to Minute Ventilation in Three Positions

H Nomograms for Normal Men and Women for FVC and FEV1 Predictions and FVC Tables for Control Variables

H-1 Prediction Nomogram for Normal Men

H-2 Prediction Nomogram for Normal Women

Table H-3
Fifteen Overweight Subjects Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

Table H-4
Fifteen Overweight Subjects Classified According to Ventilatory Ability as Measured by FVC for Three Incisional Types

APPENDICES

Table H-5
Six Underweight Subjects Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

Table H-6
Six Underweight Subjects Classified According to Ventilatory Ability as Measured by FVC for Three Incisional Types

Table H-7
Twenty-four Smoking Subjects Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

Table H-8
Twenty-four Smoking Subjects Classified According to Venitlatory Ability as Measured by FVC for Three Incisional Types

Table H-9
Sixteen Subjects with Cardiac Disease Classified According to VEntilatory Ability as Measured by FVC for the Sample Population and Two Sequences

Table H-10
Sixteen Subjects with Cardiac Disease Classified According to Ventilatory Ability as Measured by FVC for Three Incisional Types

Table H-11
Seven Subjects with Pulmonary Disease Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

Table H-12
Seven Subjects with Pulmonary Disease Classified According to Venitlatory Ability as Measured by FVC for Three Incisional Types

Table H-13
Three Subjects with Neuromuscular Disease Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

APPENDICES

Table H-14
Three Subjects with Neuromuscular Disease Classified According to Ventilatory Ability as Measured by FVC for Three Incisional Types

Table H-15
Nineteen Subjects with Operative Time Greater than Two Hours for Total Sample and Separated by Sequence According to FVC in Three Positions

Table H-16
Nineteen Subjects with Operative Time Greater than Two Hours Separated by Incisional Type According to FVC in Three Positions

Table H-17
Five Subjects with Operative Blood Loss Greater than 500 cc for Total Sample and Sequence According to FVC in Three Positions

Table H-18
Five Subjects with Operative Blood Loss Greater than 500 cc Separated by Incisional Type According to FVC in Three Positions

Table H-19
Twenty-one Subjects Using the Incentive Spirometer for Sample and Separated by Sequence According to FVC in Three Positions

Table H-20
Twenty-one Subjects Using the Incentive Spirometer Separated by Incisional Type According to FVC in Three Positions

Table H-21
Twelve Subjects Ambulated After Surgery for Sample and Separated by Sequence According to FVC in Three Positions

Table H-22
Twelve Subjects Ambulated After Surgery Separated by Incisional Type According to FVC in Three Positions

APPENDICES

Table H-23
Ten Subjects Repositioned After Surgery for Sample and Separated by Sequence According to FVC in Three Positions

Table H-24
Ten Subjects Repositioned After Surgery Separated by Incisional Type According to FVC in Three Positions

I FEV1 Tables for Control Variables

Table I-1
Fifteen Overweight Subjects Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

Table I-2
Fifteen Overweight Subjects Classified According to Ventilatory Ability as Measured by FEV1 for Three Incisional Types

Table I-3
Six Underweight Subjects Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

Table I-4
Six Underweight Subjects Classified According to Ventilatory Ability as Measured by FEV1 for Three Incisional Types

Table I-5
Twenty-four Smoking Subjects Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

Table I-6
Twenty-four Smoking Subjects Classified According to Venitlatory Ability as Measured by FEV1 for Three Incisional Types

APPENDICES

Table I-7
Sixteen Subjects with Cardiac Disease Classified According to VEntilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

Table I-8
Sixteen Subjects with Cardiac Disease Classified According to Ventilatory Ability as Measured by FEV1 for Three Incisional Types

Table I-9
Seven Subjects with Pulmonary Disease Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

Table I-10
Seven Subjects with Pulmonary Disease Classified According to Venitlatory Ability as Measured by FEV1 for Three Incisional Types

Table I-11
Three Subjects with Neuromuscular Disease Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

Table I-12
Three Subjects with Neuromuscular Disease Classified According to Ventilatory Ability as Measured by FEV1 for Three Incisional Types

Table I-13
Nineteen Subjects with Operative Time Greater than Two Hours for Total Sample and Separated by Sequence According to FEV1 in Three Positions

Table I-14
Nineteen Subjects with Operative Time Greater than Two Hours Separated by Incisional Type According to FEV1 in Three Positions

Table I-15
Five Subjects with Operative Blood Loss Greater than 500 cc for Total Sample and Sequence According to FEV1 in Three Positions

APPENDICES

Table I-16
Five Subjects with Operative Blood Loss Greater than 500 cc Separated by Incisional Type According to FEV1 in Three Positions

Table I-17
Twenty-one Subjects Using the Incentive Spirometer for Sample and Separated by Sequence According to FEV1 in Three Positions

Table I-18
Twenty-one Subjects Using the Incentive Spirometer Separated by Incisional Type According to FEV1 in Three Positions

Table I-19
Twelve Subjects Ambulated After Surgery for Sample and Separated by Sequence According to FEV1 in Three Positions

Table I-20
Twelve Subjects Ambulated After Surgery Separated by Incisional Type According to FEV1 in Three Positions

Table I-21
Ten Subjects Repositioned After Surgery for Sample and Separated by Sequence According to FEV1 in Three Positions

Table I-22
Ten Subjects Repositioned After Surgery Separated by Incisional Type According to FEV1 in Three Positions

J Thesis Abstract

## LIST OF TABLES


| TABLE | | Page |
|---|---|---|
| 1 | Preoperative Factors Influencing Postoperative Ventilatory Ability .......... | 4 |
| 2 | Perioperative Factors Influencing Postoperative Ventilatory Ability .......... | 8 |
| 3 | Postoperative Factors Influencing Postoperative Ventilatory Ability .......... | 11 |
| 4 | Age Characteristics for Thirty-four Subjects ...................... | 85 |
| 5 | Means, Range Values, and Standard Deviations for Subjects According to Age Separated by Incisional Type and Positioning Sequence ...................... | 86 |
| 6 | Number of Subjects According to Gender for Three Incisional Types and Two Positioning Sequences ...................... | 88 |
| 7 | Number and Percentage of Thirty-four Subjects Having Specific Weight-Height Ratios ...................... | 88 |
| 8 | Number and Percentage of Subjects According to Weight-Height Ratio Separated by Incisional Type and Positioning Sequence ...................... | 90 |
| 9 | Number and Percentage of Thirty-four Subjects According to Smoking Characteristics ........................... | 91 |
| 10 | Number and Percentage of Subjects According to Smoking History Separated by Incisional Type and Positioning Sequence ...................... | 92 |

| TABLE | | Page |
|---|---|---|
| 11 | Number and Percentage of Thirty-four Subjects with Concurrent Disease Entities | 94 |
| 12 | Number and Percentage of Subjects According to Specific Disease Entities Separated by Incisional Type and Positioning Sequence | 95 |
| 13 | Perioperative Characteristics of Thirty-four Subjects Separated by Incisional Type and Sequence | 96 |
| 14 | Mean, Range, and Standard Deviation for the Length of Surgery for the Thirty-four Sample Subjects | 98 |
| 15 | Number and Percentage of Subjects Who Used the Incentive Spirometer and Were Repositioned in the Postoperative Period Separated by Incisional Type and Positioning Sequence | 101 |
| 16 | Analysis of Variance Summaries for the Tidal Volume | 105 |
| 17 | Comparison of the Tidal Volume Means for the Three Positions of Flat, 45 Degrees, and 90 Degrees Using a Planned T-test and Tukey Test | 106 |
| 18 | Twenty-four Subjects over Age 50 Grouped According to Mean Tidal Volume in Three Positions | 112 |
| 19 | Twenty-four Subjects over Age 50 Separated by Incisional Type According to Mean Tidal Volume in Three Positions | 113 |
| 20 | Twenty-four Subjects over Age 50 Separated by Sequence According to Mean Tidal Volume in Three Positions | 114 |

| TABLE | | Page |
|---|---|---|
| 21 | Fifteen Overweight Subjects and Six Underweight Subjects Grouped According to Mean Tidal Volume in Three Positions .... | 115 |
| 22 | Fifteen Overweight Subjects Separated by Incisional Type According to Mean Tidal Volume in Three Positions .................. | 116 |
| 23 | Fifteen Overweight Subjects Separated by Sequence According to Mean Tidal Volume in Three Positions ........................ | 117 |
| 24 | Sixteen Subjects with Cardiac Disease and Seven Subjects with Pulmonary Disease Grouped According to Mean Tidal Volume in Three Positions ........................ | 118 |
| 25 | Sixteen Subjects with Cardiac Disease Separated by Incisional Type According to Mean Tidal Volume in Three Positions ....... | 120 |
| 26 | Subjects with Concurrent Cardiac, Pulmonary, and Neuromuscular Disease Separated According to Mean Tidal Volume in Three Positions for Sequence 1 .................. | 121 |
| 27 | Subjects with Surgical Traits Grouped According to Mean Tidal Volume in Three Positions ........................ | 122 |
| 28 | Nineteen Subjects with Operative Times Greater than Two Hours Separated by Incisional Type According to Mean Tidal Volume in Three Positions ............ | 123 |
| 29 | Nineteen Subjects with Operative Times Greater than Two Hours Separated by Sequence According to Mean Tidal Volume in Three Positions ........................ | 124 |
| 30 | Twenty-one Subjects Who Used the Incentive Spirometer Separated by Incisional Type According to Mean Tidal Volume in Three Positions ................................ | 126 |

| TABLE | | Page |
|---|---|---|
| 31 | Thirteen Ambulated and Ten Repositioned Subjects in the Postoperative Period Grouped According to Mean Tidal Volume in Three Positions | 127 |
| 32 | Analysis of Variance Summaries for the Minute Ventilation | 137 |
| 33 | Comparison of the Minute Ventilation Means for the Three Positions of Flat, 45 Degrees, and 90 Degrees Using a Planned T-test and Tukey Test | 138 |
| 34 | Seven Subjects with Pulmonary Disease for Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions | 144 |
| 35 | Seven Subjects with Pulmonary Disease Separated by Incisional Type According to Minute Ventilation in Three Positions | 145 |
| 36 | Nineteen Subjects with Operative Times Greater than Two Hours of Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions | 148 |
| 37 | Nineteen Subjects with Operative Times Greater than Two Hours Separated by Incisional Type According to Minute Ventilation in Three Positions | 149 |
| 38 | Twenty-one Subjects Using the Incentive Spirometer for Sample and Separated by Sequence According to Minute Ventilation in Three Positions | 151 |
| 39 | Twenty-one Subjects Using the Incentive Spirometer Separated by Incisional Type According to Minute Ventilation in Three Positions | 152 |

| TABLE | | Page |
|---|---|---|
| 40 | Thirteen Subjects Ambulated After Surgery Separated by Incisional Type According to Minute Ventilation in Three Positions ........................... | 153 |
| 41 | Thirteen Subjects Ambulated After Surgery for Sample and Separated by Sequence Acording to Minute Ventilation in Three Positions ........................... | 154 |
| 42 | Ten Subjects Repositioned After Surgery for Sample and Separated by Sequence According to Minute Ventilation in Three Positions ........................... | 155 |
| 43 | Percentage of Predicted Values of Forced Vital Capacity and Degree of Airway Obstruction ................................. | 156 |
| 44 | Analysis of Variance Summaries for the Forced Vital Capacity ...................... | 159 |
| 45 | Comparison of the Forced Vital Capacity Means for the Three Positions of Flat, 45 Degrees, and 90 Degrees Using a Planned T-test and Tukey Test ...................... | 160 |
| 46 | Analysis of Variance Summaries for the Forced Expired Volume in One Second ........ | 171 |
| 47 | Comparison of the Forced Expired Volume in One Second Means for the Three Positions of Flat, 45 Degrees, and 90 Degrees Using a Planned T-test and Tukey Test ............. | 172 |

## LIST OF FIGURES


| FIGURE | | Page |
|---|---|---|
| 1 | Model for Study on Postoperative Pulmonary Function .......................... | 18 |
| 2 | Comparison of the Mean Tidal Volume of Thirty-four Subjects for Three Positions ............................ | 104 |
| 3 | Comparison of the Mean Tidal Volume of Thirty-four Subjects by Incisional Type for Three Positions ................... | 108 |
| 4 | Comparison of the Mean Tidal Volume of Thirty-four Subjects by Sequence for Three Positions ........................ | 111 |
| 5 | Comparison of the Mean Respiratory Rate of Thirty-four Subjects for Three Positions ........................ | 130 |
| 6 | Comparison of the Mean Respiratory Rate of Thirty-four Subjects by Incisional Type for Three Positions ................... | 131 |
| 7 | Comparison of the Mean Respiratory Rate of Thirty-four Subjects by Sequence for Three Positions ........................ | 133 |
| 8 | Comparison of the Mean Minute Ventilation of Thirty-four Subjects for Three Positions ........................... | 136 |

| FIGURE | | Page |
|---|---|---|


9 Comparison of the Mean Minute Ventilation of Thirty-four Subjects by Incisional Type for Three Positions .................. 140

10 Comparison of the Mean Minute Ventilation of Thirty-four Subjects by Sequence for Three Positions ............................ 142

11 Comparison of the Mean Forced Vital Capacity of Thirty-four Subjects for Three Positions ........................ 158

12 Comparison of the Mean Forced Vital Capacity of Thirty-four Subjects by Incisional Type for Three Positions ........ 162

13 Comparison of the Mean Forced Vital Capacity of Thirty-four Subjects by Sequence for Three Positions ............... 163

14 Comparison of the Mean Forced Expired Volume in One Second of Thirty-four Subjects for Three Positions ............... 170

15 Comparison of the Mean Forced Expired Volume in One Second of Thirty-four Subjects by Incision for Three Positions ............................ 174

16 Comparison of the Mean Forced Expired Volume in One Second of Thirty-four Subjects by Sequence for Three Positions .................................. 177

# CHAPTER I

## INTRODUCTION

Many advances have been made in the respiratory care of the surgical patient in the last fifty years. For example, scientists have discovered new anesthetic agents that suppress pulmonary mechanics to a minimum degree during the operative procedure and antibiotics that control postoperative pulmonary infections. Monitoring of arterial blood gases before, during, and after the surgical procedure assists the health team in making therapeutic decisions about the delivery of oxygen and respiratory treatments to the postoperative patient. These advances in medical knowledge aid the health team in increasing the understanding of the respiratory system and its reaction to surgery.

The increased technology and knowledge base, however, has had little effect upon the occurrences of postoperative pulmonary complications. The percentages of postoperative complications range from 2% for simple procedures to 70% for upper abdominal and thoracic procedures (Ali, Weisel, Layup, Kripke, & Hechtman, 1974: Breslin, 1981: Latimer, Dickman, Day, Gunn, &

Schmidt, 1971: and Wightman, 1968). Drain (1984) identified pulmonary complications as the largest single cause of morbidity and mortality in the postoperative period. Schwartz (1983) described respiratory failure as the major cause in 25% of postoperative deaths and a contributory factor in another 25%. The statistics do not reflect the discomfort experienced by the patient who must endure prolonged hospital stays and increased nursing and respiratory treatments (Johnson, 1975). Warren and Grimwood (1980) found that once postoperative complications developed, the average hospital stay increased by five days with a corresponding increase in cost. The impact of these postoperative complications upon the patient and the health care system attests to the need to define nursing interventions that promote postoperative pulmonary function.

## Factors Associated with Pulmonary Complications

In order to pursue the development of nursing interventions for postoperative pulmonary complications, a clear understanding of pulmonary complications is necessary. Factors that contribute to the development of pulmonary complications can be divided into three categories: (1) preoperative factors that are present in the subject who comes for surgery, (2) perioperative factors that occur as a consequence of the surgery and of the body's reaction to surgery, and (3) postoperative factors including medications and treatments that are given to the patient after a surgical procdure that influence or change pulmonary function.

## Preoperative Factors

Preoperative factors are identified as those elements inherent in the patient who comes to the clinical setting (see Table 1). Factors included in this category are age, gender, the relationship of weight to height, smoking history, and the presence of pulmonary, cardiac, and neuromuscular disease. Age, gender, and weight to height relationship have been used in nomograms to predict volumes for pulmonary function tests. The nomograms are based on testing of hundreds of subjects of both genders with varying age and weight distributions.

### Age and Gender

Two lung volumes are known to decrease with age--forced vital capacity (FVC) and forced expired volume in one second (FEV1). The volumes peak between the ages of 31 and 40 years. Anyone over 50 years of age

Table 1

*Preoperative Factors Influencing Postoperative Ventilatory Ability*

| | Minute Ventilation | Tidal Volume | Forced air capacity | Forced Expired Volume in 1 sec. |
|---|---|---|---|---|
| Age > 50 | 0 | - | - | - |
| Weight > 10 % above ideal | 0 | - | - | - |
| Smoking | 0 | 0 | - | - |
| Pulmonary disease | + or - | + or - | - | - |
| Cardiac disease | 0 | 0 | 0 | 0 |
| Neuromuscular disease | 0 | - | - | - |

*Note.* + = increase in measurement
- = decrease in measurement
0 = no change in measurement

has decreased volumes and is at risk for developing pulmonary complications in the postoperative period (Breslin, 1981; Luce, 1984; and Wightman, 1968). Females have lower lung volumes than males, but this is not related to the development of pulmonary complications.

Obesity

Obesity also decreases lung volumes. Obesity is defined as weight exceeding the Metropolitan Life Insurance weight/height table by 10% (Luce, 1980). Wightman (1968) documented the development of postoperative atelectasis in obese patients. Atelectasis developed from the limited anteroposterior excursion of the thorax and decreased descent of the diaphragm during respiration. The obese patient has an increased oxygen consumption with an increased carbon dioxide production and an increase in stress to the gas transport system (Luce, 1984; Szczepanski, Skaarup, & Staehr-Johansen, 1973; and Wightman, 1968). Functional residual capacity (FRC) was low due to the mechanical limitation to breathing imposed by excess weight (Wightman, 1968).

Smoking History

A smoking history is another risk factor. Fourteen percent of smokers in one study developed postoperative complications as compared with 6% of nonsmokers (Luce, 1981). Morton (1944) calculated that patients undergoing abdominal surgery who smoked more than ten cigarettes per day were six times more likely to develop postoperative pulmonary complications. Breslin (1981) described smoking as a risk factor in developing complications due to the high incidence of chronic bronchitis in smokers.

Concurrent Disease Entities

Concurrent disease entities have only begun to be studied in relationship to the development of postoperative pulmonary complications. Wightman (1968) found that 26% of patients with pulmonary disease developed postoperative pulmonary complications. Other researchers have documented changes in pulmonary function due to pulmonary disease that increase the risk of developing postoperative complications (Douglas, Rehder, Beynen, Sessler, & Marsh, 1977; Neagley & Zwillich, 1985; and Sharp, Drutz, Moisan, Foster, & Machnach, 1980). Patients with neuromuscular and cardiac disease develop pulmonary complications in relationship to the extent and type of interference with pulmonary mechanics and ventilation-perfusion ratios (Black & Hyatt, 1971; Dawson, Kaneko, & McGregor, 1965; and Hales & Kazemi, 1977). Exact changes in pulmonary function vary from disease to disease.

## Perioperative Factors

Perioperative factors affecting pulmonary function include premedications, anesthesia, and the surgical procedure (see Table 2). Perioperative factors are those factors that are related to the surgical procedure. Perioperative factors have been identified by retrospective examination of hospital records of surgical patients to correlate characteristics of patients who developed postoperative pulmonary complications with those who did not. Direct measurement of pulmonary function tests before and after a surgical procedure has also been carried out to compare the results. (Ali & Khan, 1979; Elman et al. 1981; and Szczepanski, Skaarap, & Staehr-Johansen, 1973).

### Incisional Type

The extent, site, and direction of the surgical incision influences ventilatory ability. Patients with upper and lower abdominal incisions have a marked dysfunction of the thoracoabdominal musculature which interferes with pulmonary functioning (Ali et al. 1974). Patients with upper abdominal incisions demonstrate a higher degree of dysfunction due to the close proximity of the incision to the diaphragm. The breathing pattern

Table 2

Perioperative Factors Influencing

Postoperative Ventilatory Ability

| | Minute Ventilation | Tidal Volume | Forced air capacity | Forced Expired Volume in 1 sec. |
|---|---|---|---|---|
| Type of premedications | +, -, or 0 | +, -, or 0 | +, -, or 0 | +, -, or 0 |
| Type of anesthesia | +, -, or 0 | +, -, or 0 | +, -, or 0 | +, -, or 0 |
| Length of surgical procedure > 2 hours | - | - | - | - |
| Complications: | | | | |
| - Estimated blood loss > 500 cc | - | - | - | - |
| - Hypotension | - | - | - | - |
| Type of surgery: | | | | |
| - Thoracic and upper abdominal | - | - | - | - |
| - Lower abdominal | 0 | 0 | 0 | 0 |
| Stress response | +, -, or 0 | +, -, or 0 | +, -, or 0 | +, -, or 0 |

Note. + = increase in measurement
- = decrease in measurement
0 = no change in measurement

changes from an abdominal to a rib cage pattern. Rib cage breathing leads to declines in vital capacity, tidal volume, and FRC. The decreases in lung volumes in the operative period lead to hypoventilation and the development of atelectasis (Ford, Whitelaw, Rosenal, Cruse, & Guenter, 1983; and Luce, 1984). Patients with incisions that disrupt the linea alba muscle also demonstrate a dysfunction in ventilatory ability (Ali & Khan, 1979).

Anesthetic and Premedication Agents

One cause of ventilatory function disturbance in the perioperative period is the pharmacological interference with the neural and muscular mechanism of respiration. Different premedications and anesthetic agents have varying effects upon these mechanisms from hypoventilation or hyperventilation to normal ventilation. Inhalational agents given during the operative procedure cause alterations in alveoli and capillary gaseous exchange. The abnormalities are gradually reduced with postoperative oxygen but persist for three to five days after the surgical procedure (Lawrence, 1971).

Stress Response

Another perioperative factor that influences ventilatory ability is the stress response of the body to the surgical procedure. The stress response is a series of neuroendocrine and metabolic changes that occur as a reaction to bodily injury. Anesthetic agents and other drugs depress or stimulate various endocrine responses which include muscle wasting and weakness, and a decreased immunological response (Schwartz, 1984).

### Operative Complications and Extended Operative Times

Complications of the operative procedure and operative times greater than two hours also lead to decreased postoperative pulmonary function. Some of the complications that have been identified are blood loss greater than 500 cc and hypotension during the operative procedure. (Ali et al. 1974; Breslin, 1981; and Latimer et al. 1971).

## Postoperative Factors

Three categories of factors are seen in this time period (see Table 3). These factors are pharmacological agents and fluids, respiratory therapy interventions, and positioning of the patient.

### Pharmacological Agents and Fluids

Pharmacological agents that impact upon ventilatory ability in the postoperative period are narcotics, sedatives, and bronchodilators. Narcotics and sedatives which are given to control discomfort and pain in the

Table 3

*Postoperative Factors Influencing Postoperative Ventilatory Ability*

| | Minute Ventilation | Tidal Volume | Forced air capacity | Forced Expired Volume in 1 sec. |
|---|---|---|---|---|
| Intervention | | | | |
| Ambulation | ++ | + | + | + |
| Incentive spirometry | ++ | ++ | ++ | ++ |
| Turn-cough-deep breath | + | + | + | + |
| Positioning | | | | |
| Head of bed 90 degrees | +++ | +++ | +++ | +++ |
| Head of bed 45 degrees | ++ | ++ | ++ | ++ |
| Head of bed flat | - | - | - | - |
| Medications | | | | |
| Narcotics | - | - | - | - |
| Sedative | - | - | - | - |
| Bronchodilators | 0 | + | + | + |

*Note*. + = increase in measurement
++ = greater increase in measurement
+++ = greatest increase in measurement
- = decrease in measurement
0 = no change in measurement

postoperative period cause suppression of pulmonary effort and decreased lung volumes (Gilman, Goodman, Rall, & Murad, 1985; Latimer et al. 1971; and Schwartz, 1983). The medications suppress the cough reflex and interfere with the clearing of secretions from the airways. Bronchodilators dilate the airways and improve ventilation in patients with vasoconstrictive abnormalities (Gilman et al. 1985). The use of bronchodilators with postoperative patients is limited. Normally only subjects taking the medication in the preoperative period would continue to do so in the postoperative period. Postoperative fluids influence ventilatory ability by altering the viscosity of bronchial secretions and by maintaining an equilibrium in body fluid balance (Schwartz, 1983).

Respiratory Therapy Interventions

The second grouping of postoperative factors is respiratory interventions that are given to the patient. These interventions have been tested by directly measuring pulmonary function tests before and after an intervention is given to the patient or by comparing subjects given one intervention with subjects given another intervention. Some of the interventions that have been identified are (a) incentive spirometry with sustained inspiratory maneuvers, deep breathing exercises, and intermittent positive pressure breathing (Celli, Rodriguez, & Snider, 1984); (b) chest physiotherapy (Warren & Grimwood, 1980); and (c) blow bottles (Heisterberg, Johansen, Larsen, Holm, & Andersen, 1979). All of the interventions showed changes in ventilatory ability with the postoperative patient but none was statistically significant in reducing pulmonary complications (Celli et al. 1984).

Positioning of the Patient

The third grouping of postoperative factors is the positions of patients. Physiological principles describe ventilation and perfusion changes in the upright lung (Anthonisen & Milic-Emili, 1966; Kaneko, Milic-Emili, Dolovich, Dawson, & Bates, 1966; Moreno & Lyons, 1961; and West, 1978). Ventilation is better in the base of the lung than in the apex in the upright position due to gravity pulling down on the lungs and exerting more force upon the base. Perfusion is also better in the base than the apex in the upright position due to a hydrostatic pressure gradient determined by arterial, venous, and alveolar pressures (West, 1978). The pressure is greatest in the base of the lungs creating more perfusion (West, 1978). Position changes thus determine perfusion ratios in the lung in normal subjects. Ng and McCormick (1982) attribute the distribution of ventilation in the lungs to the distensibility of the lung and chest wall (compliance), body position, and airway resistance. The distribution of perfusion to the lungs is dependent upon the volume of cardiac output, body position, and pulmonary vascular resistance (PVR). The changing of ventilation and perfusion distributions in the lungs by body positioning can affect respiratory rate, the lung volumes of tidal volume, residual volume, functional reserve capacity, and total lung capacity. and the amount of physiological dead space.

## STATEMENT OF THE PROBLEM

The identification of preoperative, perioperative, and postoperative factors that contribute to the development of postoperative pulmonary complications has helped to understand the problem but has not altered the rate of occurrences. Patients with increased risk continue to require surgery. Individual patient responses to preoperative and perioperative factors are difficult to predict. Manipulation is impossible as the factors are already present when the patient comes to the hospital for surgery or are determined by the physician in the operating room. The postoperative period holds the most promise for the nurse to develop strategies and interventions that could impact upon the reduction of pulmonary complications.

The question remains, what type of inteventions might be used to improve ventilatory ability. The review of literature describes positioning as such an intervention. Positioning has long been ordered in routine postoperative orders of early ambulation, dangling, and turning of the surgical patinet. The intervention, however, has not been standardized so that it is carried out in a prescribed way, nor has it been evaluated for effectiveness in improving ventilatory ability.

From prior studies the two positions noted to significantly change ventilatory ability are the head of bed flat and the head of the bed at 90 degrees (Kauppinen-Walin, Sovij:arvi, Muittari, & Uusitralo, 1980; Schaanning & Refsum, 1976; and Hsu & Hickey, 1976). The head of the bed flat had been identified as the worse position for ventilatory ability as measured by pulmonary function tests and the 90 degree position as the best. Both of these positions need further study to determine what effect the position has upon ventilation. Additional positions such as the head of bed at 45 degrees also need to be evaluated for ventilatory effects.

Research has also demonstrated a difference in pulmonary functioning between different incisional types (Ali et al. 1974; and Szcepanski et al. 1973). Subjects with upper abdominal incisions are expected to exhibit greater changes in ventilatory ability in the postoperative period than those with lower abdominal incisions. Patients with lower abdominal incisions are expected to develop fewer postoperative pulmonary complications. For this reason, patients with lower abdominal incisions are excluded from many routine postoperative interventions such as incentive spirometry, and are considered less in need of normal postoperative turning, coughing, deep breathing. This happens despite the fact that these subjects have all of the same preoperative, perioperative, and postoperative risk factors as the patients with upper abdominal incisions. Additional study of the effect of incisions is needed.

The following questions will be addressed in the present study:

1. What is the effect of positioning upon ventilatory ability as measured by pulmonary function tests in postoperative patients on day one?

2. What is the effect of the relationship between positioning and the type of incision for postoperative patients on day one after surgery?

The identification of optimal positions for pulmonary function will help to guide the deliverance of postoperative care to surgical patients. Repositioning may take on greater significance as as intervention to be used at regular intervals in the postoperative period. Figure 1 represents the model for the present study. From the figure, two groups of surgical patients have been identified for the study. The groups are subjects with upper abdominal incisions and subjects with lower abdominal incisions. Each group of subjects will be placed into the three positions of head of bed at 90 degrees, head of bed at 45 degrees, and head of bed flat. In each position, pulmonary function test will be taken. The expected results of the pulmonary fuction test for both groups is that the pulmonary function tests will be highest or demonstrate better ventilatory ability with the head of the bed at 90 degrees and will be lowest or demonstrate the worse ventilatory ability with the head of the bed flat. The 45 degree position will have medium values.

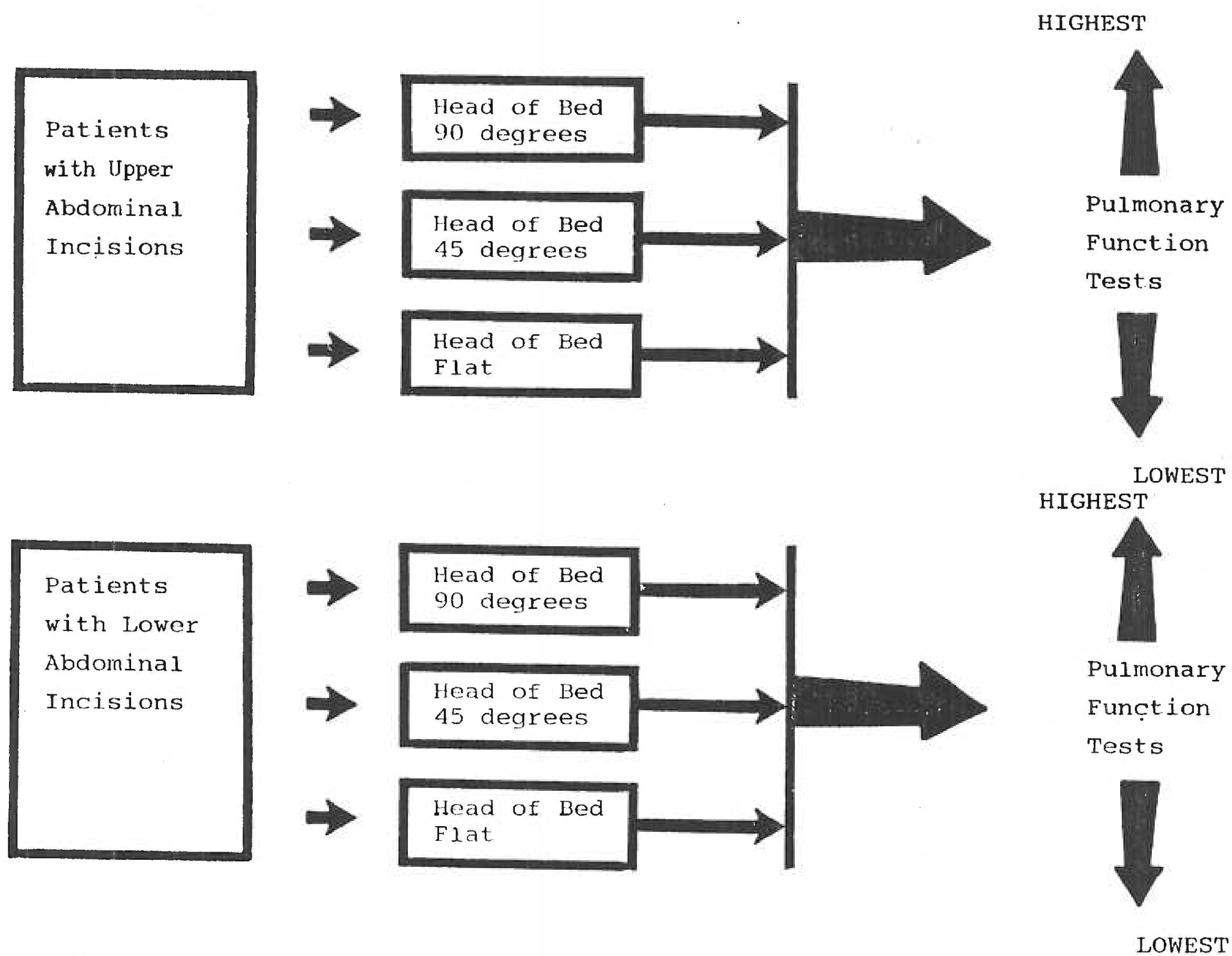



Figure 1. Model for Study on Postoperative Pulmonary Function.

## PURPOSE OF THE STUDY

The purpose of the study was to determine which of the three positions is most effective in improving pulmonary function measures: (a) head of bed flat, (b) head of bed 45 degrees, or (c) head of bed 90 degrees. Another purpose was to determine if different incisional types (upper or lower abdominal incisions) would alter pulmonary function measures when the patients are placed in the three positions.

## HYPOTHESES

1. In the first twenty-four hours after a surgical procedure under general anesthesia, postoperative patients will have the highest pulmonary function test results of tidal volume, respiratory rate, minute ventilation, forced vital capacity, and forced expired volume in 1 second with the head of the bed at 90 degrees and the lowest values with the head of the bed flat.

2. In the first twenty-four hours after a surgical procedure under general anesthesia, positioning of postoperative patients with upper and lower abdominal incisions will cause the highest pulmonary function test results of tidal volume, respiratory rate, minute ventilation, forced vital capacity, and forced expired volume in 1 second to be in the head of the bed at 90 degree position and the lowest values to be in the head of bed flat position.

## OVERVIEW OF THE STUDY

The occurrence of postoperative pulmonary complications has remained a problem of the same magnitude for the last fifty years. The identification of preoperative and perioperative factors that determine the development of pulmonary complications has not helped to alleviate the problem. The renewed interest in nursing interventions and standards of care of the surgical patient has led to the identification of postoperative interventions that could improve ventilatory ability and thus decrease the occurrences of pulmonary complications. The present study was based on the identification of the nursing intervention of positioning as a way to improve ventilatory ability in the surgical patient and to decrease postoperative pulmonary complications.

The design of the study was a 3 by 2 factorial design with repeated measures. The factors were the three positions (head of bed flat, head of bed elevated 45 degrees, and head of bed elevated 90 degrees) and the two incisional types (upper abdominal and lower abdominal). Subjects with upper abdominal and lower abdominal incisions were placed into the three positions in the first postoperative day with pulmonary function measures of tidal volume (VT), minute ventilation (VE), respiratory rate (f), forced vital capacity (FVC), and forced expired volume in 1 second (FEV1) taken in each position. A data questionnaire was filled out on each subject to identify preoperative, perioperative, and postoperative factors about each subject.

After obtaining permission from patients scheduled for surgery that involved an upper or lower abdominal incision, preoperative measurements of the pulmonary function tests were done to familiarize subjects with the testing equipment. The morning after the surgical procedure, pulmonary function tests were given to each subject in the three positions. Three readings of each measurement were taken in each position with the best or highest measurement recorded. Thirty-four postoperative patients participated in the study. The purpose of the study was to identify the optimum position for the best pulmonary function measures for the three groups of postoperative patients.

The data were analyzed using a one-way analysis of variance with repeated measures to determine if positioning did have an effect upon pulmonary function measures. Secondly, the data were analysed with an analysis of variance with repeated measures to determine if the effect of positioning upon the pulmonary function measures varied from one incisional type to another. Planned comparisons and Tukey tests were done to determine which positional changes made the greatest change in pulmonary function tests for the two analyses of variances. The level of significance of the data was 0.05.

# CHAPTER II

## REVIEW OF LITERATURE

Wightman (1968) made a survey of postoperative complications in the patient undergoing general anesthesia. The survey showed that (a) the incidence of pulmonary complications has changed little in 30 years; (b) the highest incidence of complications was seen in patients with upper abdominal incisions, and a low incidence was seen in patients with lower abdominal incisions; (c) patients having urgent operations for gastroduodenal bleeding had an exceptionally high incidence of pulmonary complications; (d) cigarette smoking and preexisting chronic pulmonary disease were shown to be important factors for increasing the incidence of postoperative pulmonary complications; (e) the duration of the operation, wound infection, and obesity were shown to be unrelated to the development of pulmonary complications; (f) the most common complication--bronchitis--was frequently an exacerbation of preexisting disease; and (g) atelectasis was not usually associated with preexisting chronic respiratory disease. Many other factors have been discovered and documented since the paper was presented.

The factors are separated into three groups for the purposes of the following discussions. The first group is that of preoperative factors--factors which are already affecting the patient at the time of surgery. Risk factors identified from this period are age, sex, weight/height proportion, smoking history, and concurrent disease entities especially pulmonary, cardiovascular, and neuromuscular.

The second group of risk factors is perioperative elements, those elements which impact the patient at the time of surgery. Topics that will be covered under this heading are the type of surgical incision, the type of premedications and anesthesia, and the stress response of the body to surgery.

The third group of risk factors is postoperative elements. The topics that have been identified here are types of narcotics and sedatives given to the patient, respiratory therapies, and the nursing intervention of positioning.

## Preoperative Factors

### Age

Age is a factor that determines the development of postoperative pulmonary complications. As age increases, small bronchi and bronchides collapse earlier in the expiratory cycle, and recoil ability of the lung diminishes. In a study by Breslin (1981), patients over the age of 50 with upper abdominal surgeries all demonstrated moderate to severe postoperative pulmonary alterations. Pneumonia and atelectasis were more frequently demonstrated in this group.

Luce (1984) documented pulmonary changes with aging. Atelectasis was three times more common in patients 60 years of age or older than in younger individuals. Normal pulmonary changes associated with aging were increases in closing volumes and decreases in lumg volumes, flow rates, and arterial oxygen tension. Respiratory muscle strength and endurance also declined with age.

Latimer et al. (1971) noted impairment in pulmonary function in 10% of patients younger than 50 years of age as compared to 42% of patient older than 50 years. The patient at age 50 or older was at increased risk to develop postoperative pulmonary complications. Age, however, remained most helpful in predicting the occurrences of pulmomary complications when other factors, such as general health and more specific physiological indices of pulmonary function, were unknown.

## Obesity

Obesity is defined as weight in excess of 10% of ideal body weight as determined by the standard Metropolitan Life Insurance Company weight/height tables (Luce, 1980). Luce (1980) reviewed some of the respiratory complications of obesity. Luce described obesity as a generalized increase in body mass with an excessive accumulation of fat in the abdominal and thoracic regions. The excessive fat creates an elastic resistance of the chest wall to normal inspiratory movement. The work required by the respiratory muscles to overcome the chest wall resistance is greater than normal and makes a high metabolic demand upon the body. The increased metabolic production leads to an increased oxygen need and consumption, particularly during exercise. Pulmonary function abnormalities associated with obesity included a pattern of shallow, rapid breathing. The pattern of breathing is an attempt by the body to conserve energy. Rapid, shallow breaths are less work than deep, slow breaths. The obese patient also demonstrated a mismatch of ventilation and perfusion that was more unequal in the supine position.

Rochester and Enson (1974) outlined the major respiratory complications of obesity in 42 patients with and without hypoventilation. The complications included heightened demand for ventilation with an increased work of breathing; respiratory muscle inefficiency, diminished functional reserve capacity, expiratory reserve volume, and vital capacity; and, closure of peripheral lung units. All of the lung changes were related to a reduction in lung compliance by 25% in obese patients and 40% in obese patients with hypoventilation. A respiratory resistance to inspiration of 30% to 50% existed in these patients. In addition, an increase in end-expiratory abdominal pressure was noted. The inspiration resistance caused an increase in the work of breathing by 40% to 50% in obese subjects without hypoventilation. The oxygen consumption associated with the increased work of breathing was increased by 2% to 16%. Both groups of obese patients had increased total and pulmonary blood volumes with normal ratios between the two. The increased blood volumes led to perfusion throughout the lung but a marked underventilation of the dependent regions of the lungs.

Eriksen, Andersen, and Rasmussen (1977) studied 6 massively obese patients (mean weight 130 kilograms) after jejuno-ileal bypass operations. The measurements were made in the semirecumbent position. Arterial blood gas analysis, forced vital capacity, forced expired volume in 1 second, and peak expiratory flow rates were measured in the first 5 days after surgery. Arterial oxygen tension decreased by 74%, and forced vital capacity decreased by 45% in the first 24 hours after surgery but were restored by Day 5. The peak expiratory flow rates decreased by 77%. The forced expired volume in 1 second remained the same in the postoperative period but was only 70% of the predicted preoperative normal volumes.

Vaughan and Wise (1975) evaluated 22 markedly obese females (mean of 140% in excess of ideal weight) after a surgical procedure. Arterial blood gases were taken the first 3 days after surgery. There was a statistically significant increase in arterial oxygen tension, carbon dioxide tension, and base excess with the assumption of the semirecumbent position on postoperative Days 1 and 2 when compared to the supine position. No difference was demonstrable in postoperative Day 3. From the study, the semirecumbent position in Days 1 and 2 in the postoperative period for obese patients is a valuable maneuver.

To summarize, lung volumes and compliance are decreased in the obese. The work and energy cost of breathing is greatly increased with high metabolic demands and oxygen consumption. The changes in the lungs of the obese patient tend to be related to postural changes. Breathing is more compromised in the supine position in these patients. Limitations of the studies presented on the obese patient are the small number of subjects per study and the lack of replication of findings from study to study.

## Smoking History

A history of smoking is a risk factor in the development of postoperative pulmonary complications. Wightman (1968) showed a statistically significant higher occurrence of postoperative pulmonary complications among cigarette smokers.

Wanner (1985) and Vastag, Matthys, Kohler, Gronbeck, and Daikeler (1985) studied the changes of cigarette smoking on airway mucosal function. Long-term exposure to cigarette smoke led to impairment of mucociliary clearance associated with epithelial lesions, mucus hypersecretion, and ciliary dysfunction. Structural and functional changes in the mucosa were evident in smokers and in those subjects with bronchitis. Bronchitis was identified as an important factor in the development of postoperative pulmonary complictions (Breslin, 1981; Wightman, 1968). Latimer et al. (1971) found that macroatelectasis developed in 35% of smokers in the postoperative period. Macroatelectasis was described as the evidence of atelectasis, consolidation, or incomplete lung expansion in postoperative chest x-rays or documented postoperative temperature elevation with basilar rales, absent breath sounds, or tubular breathing. Morton (1944) studied 1,257 patients scheduled for abdominal surgery. He noted that patients who smoked more than 10 cigarettes daily developed pulmonary complications six times more frequently than nonsmokers.

## Concurrent Disease Entities

Patients coming into the hospital for surgery may have concurrent diseases or dysfunctions in body systems that predispose them to the development of postoperative pulmonary complications. The most notable dysfunctions occur in the pulmonary, cardiac, and neuromuscular systems. Researchers have attempted to identify specific pulmonary dysfunctions that are associated with various disease entities.

Hales and Kazemi (1977) studied the changes in pulmonary function tests after uncomplicated myocardial infarction in 78 patients without congestive heart failure as determined by radiographic and clinical examination. The findings showed a reduction in vital capacity that returned to normal after several weeks. Forced expired volume in 1 second (FEV1) and maximum flow rate reductions and dysfunction of the small airways were also seen. The total lung capacity was normal or reduced. Residual volumes increased slightly. The distribution of perfusion was shifted away from dependent parts of the lung towards the apices. The basis mechanism for the pulmonary function abnormalities is thought to be pulmonary water. The pulmonary water may be very minimal with uncomplicated myocardial infarction so as not to appear on chest x-ray or be audible with the stethoscope. The minimal water may cause measurements of pulmonary extravascular fluid to be high. Minimal water stays primarily in the pulmonary interstitial space. On the other side of the spectrum is the severe pulmonary water or pulmonary edema that causes evential alveolar filling and collapse. Hales and Kazemi did not describe how the measurements of pulmonary water were made nor did they give any data on the subjects.

Dawson et al. (1965) reviewed pulmonary changes associated with the most common valvular heart disease, mitral stenosis. In this disorder, the stenotic mitral valve impedes the blood flow from the left atrium to the left vetricle. The increase in left atrial pressure and elevation of the pulmonary arterial pressure causes a chronic hypertension with a fixed cardiac output. Ventilation/perfusion ratios are altered in two ways: (a) pulmonary hypertension causes a reversal of the perfusion distribution, and (b) the left lung may be less ventilated than the right lung.

Douglas et al. (1977) studied 6 subjects with acute respiratory failure. During acute respiratory failure, an arterial hypoxemia existed despite the administration of high fractional concentrations of inspired oxygen. The therapy with high concentrations of oxygen predisposed the lungs to pulmonary edema with interstitial pneumonia and atelectasis. The degree of pulmonary edema varied with the severity of the respiratory failure. Postoperative patients developing acute respiratory failure required extensive pulmonary intervention to improve.

Sharp et al. (1980) studied 17 patients with severe disabling chronic obstructive pulmonary disease. Measurements were made of respiratory muscle electromyograms; transdiaphragmatic, gastric, and esophageal pressures; and thoracoabdominal diameters. One pattern of breathing described in these patients was characterized by inspiratory expansion of the rib cage accompanied by inspiratory decrease in both diameters of the abdomen. The low flattened diaphragm in chronic obstructive pulmonary disease did not contract but rather was pulled up by the elevation of the rib cage during inspiration, sucking the abdomen inward. Airway obstruction was noted in these pateints as measured by the forced expired volume in one second (FEV1) and the ratio of forced expired volume to forced vital capacity. The lungs of patients with chronic obstructive pulmonary disease tended to more hyperinflated than normal. Patients often complained of chronic dyspnea. Numerous articles have been written about other identified changes that occur with chronic obstructive pulmonary disease. The characteristic obstructive pattern as well as limited respiratory muscular activity places these patients at increased risk for postoperativae complications.

Neagley and Zwillich (1985) attempted to document decreased oxygen saturation with positioning in patients with another pulmonary disorder, pleural effusion. Pleural effusions were determined by chest x-ray and physical examination. Statistically significant decreases in oxygen saturation were found when the larger pleural effusion side was dependent or down as compared to both the sitting position and the pleural effusion side being independent or up. Ten stable patients spontaneously breathing room air who has asymmetric pleural effusions were subjects in the study.

Black and Hyatt (1971) studied 15 patients with neuromuscular disease and 5 patients with both chronic obstructive pulmonary disease and neuromuscular disease. Measurements were made of vital capacity, maximal midexpiratory flow, and maximal breathing capacity. Residual volume and total lung capacity were also determined. The results of Black and Hyatt's study indicated that muscle weakness was evident in the patients with neuromuscular disease on inspiration and expiration but was not always present in patients with chronic obstructive pulmonary disease. Muscle weakness was an important indicator of an ineffective cough mechanism. Inability to produce sufficient expiratory pressure to compress airways with high flow rates as in a cough, makes the patient more susceptible to complications of respiratory infections. One of the limitations of the study was the sampled age group; all subjects were in their fifth decade of life. Another limitation was the sample size.

Some of the preoperative factors that have been documented in the literature as influencing the development of postoperative pulmonary complications have been presented. The factors include age, sex, weight-height relationship, smoking history, and concurrent cardiac, pulmonary, and neuromuscular disease. These plus perioperative factors define the potential risk that a surgical patient has in developing postoperative pulmonary complications.

## Perioperative Factors

### Incisional Type

One specific factor that puts patients at risk to develop postoperative pulmonary complications is the type of surgical incision. Ali et al. (1974) compared patients undergoing elective surgeries with a variety of surgical types. Meyers, Lembeck, O'Kane, & Baue (1975) limited their study to right paramedian and right intercostal incisions. Ford et al. (1983) related the incisional site to the diaphragm and diaphragmatic function. Elman et al. (1981) compared transverse and median vertical supraumbilical incisions for cholecystectomy patients. Ali and Khan (1979) studied upper midline and subcostal incisions on cholecystectomy patients. Palmer and Gardiner (1964) described the effect of incisional type used for partial gastrectomy upon pulmonary physiology. Detailed summaries of these studies follow.

Ali et al. (1974) studied 58 patients undergoing elective surgery. Subjects were assigned to five different groups: Group I included those undergoing upper abdominal incisions; Group II included those undergoing lower abdominal incisions; Group IIIa included those having superficial incisions under general anesthesia; Group IIIb included those having superficial incisions under spinal anesthesia; Group IV included those having thorocotomy incisions; and, Group V included those having posterior incisions. The pulmonary function measures used in the study were vital capacity, tidal volume, and functional reserve capacity (FRC). All of the groups demonstrated decreases in the measurements with the upper abdominal incision group having the most significant reduction. The decrease in vital capacity correlated with the development of clinical pulmonary complications.

Meyers et al. (1975) using a sample of 28 patients, limited the type of incision to right paramedian and right subcostal incisions. Twenty-five of the subjects had a cholecystectomy, one a ventral herniorrhaphy, one a subtotal gastric resection, and one a splenectomy. Meyers and associates measured vital capacity (VC), residual volume (RV), FEV1, and FRC. All of the postoperative measurements decreased with the maximum decrease in Days 1 and 2. By Day 5 the values returned to preoperative values. Patients with a 40% or less decrease in FRC did not develop pulmonary complications. The FRC increased with a change in position from bed to chair. The preoperative FRC increase with position change was 14% and the postoperative increase was 17%.

Ford et al. (1983) looked at diaphragmatic function in 15 patients who had undergone a cholecystectomy. Postoperatively, FEV1 and VC decreased in all subjects. Minute ventilation did not change. Tidal volume decreased after surgery. Diaphragmatic function, which was assessed by changes in transdiaphragmatic pressure swings during quiet tidal breathing, decreased in the postoperative period. The decrease in swings reflected reduced diaphragmatic activity. The reduction in acitvity may be responsible for the atelectasis, reduced vital capacity, and hypoxemia in postoperative patients. Postoperative subjects shifted from abdominal to rib cage breathing. The reduction in diaphragm activity and changes in breathing patterns returned to normal after 24 hours.

Elman et al. (1981) compared the direction of the incision in elective cholecystectomy patient with changes in postoperative pulmonary function. Fifteen women with transverse incisions and 15 women with median vertical incisions were studied in the first 4 days after elective surgery. Ventilatory function was measured by VC, FEV1, blood gas tensions, and alveolo-arterial oxygen tension on the day before the operation and in the first, second, and fourth postoperative days. Blood gas tensions decreased significantly, but did not vary between the transverse incision and the median vertical incision groups. The ventilatory function measurements were decreased in all subjects. The greater decrease in ventilatory function measurement that lasted for the longer period of time was seen in the group with the median vertical incision. This reduction in ventilatory function is thought to be related to the disruption of the linea alba muscle that aids the rectus abdominis muscles in breathing. The median vertical incision is also thought to be more painful for the patients causing splinting or decreased abdominal motion with respiration. Finally, the abdominal muscles are more likely to go into spasm with the median vertical incision.

Ali and Khan (1979) studied the effects of upper midline and subcostal abdominal incisions on postoperative pulmonary function in 49 patients undergoing elective cholecystectomy. Nineteen patients had a midline incision and nine patients a right subcostal incision. The mean vital capacity was depressed 30% of the preoperative value in the midline group and 46% in the subcostal group on the day of the operation. Postoperative arterial oxygen pressure dropped from 76% to 88% of the preoperative value in the midline incision group and from 84% to 95% in the subcostal incision group over a 7-day period. More pulmonary complications were seen in the midline group. The midline incision group was thought to have more pulmonary problems due to the disruption of the linea alba which helps maintain vital capacity. Additionally, the midline incision requires a greater degree of retraction for adequate exposure during the operative procedure. The increased retraction damages the linea alba.

Palmer and Gardiner (1964) found decreased postoperative pulmonary mechanical function in 32 patient with surgery for chronic peptic ulcer disease. The researchers measured tidal volume, VC, FEV1, and expired reserve volume in the semirecumbent position. Breathing was observed to be shallow, rapid, and predominantly in the expiratory position. Arterial blood gases were also measured in the subjects. An arterial hypoxemia was found that lasted from the immediate postoperative period to 5 days after the surgery. The hypoxemia did not parallel the reduction in pulmonary mechanical function.

Szczepanski et al. (1973) studied 634 patients with several incisional types. The subjects fell into three groups: Group I included 484 subjects with intraperitoneal surgeries; Group II included 96 subjects with osteosynthesis of the neck of the femur; and Group III included 54 patients with transvesical prostatectomy. Pulmonary complications occurred more frequently in the abdominal surgery group based on chest x-ray interpretation. No statistical difference was found in the incidence of pulmonary complications between the patients in Groups I and III. The variables that most influenced the occurrence of pulmonary complications were age, obesity, and perioperative blood loss of greater than 500 cc. The older patient who was obese and had a large perioperative blood loss was at the greatest risk to develop pulmonary complications.

## Anesthetic and Premedication Agents

Researchers have examined the exact mechanisms of anesthetic agents in causing postoperative complications. Lawrence (1971) and Palmer and Gardiner

(1962) looked at the effects of anesthesia upon pulmonary complications in the postoperative patient. A hypoxia occurs in the postoperative period that is related to the inability to match lung ventilation to capillary perfusion during the perioperative period. Reasons for the mismatch are the reduced elasticity of the lungs to inflate and the lack of alveolar lining material to keep the sacs open. These two mechanisms have been found in the anesthesized lungs. Additionally, anesthesized patients tend to be underventilated during the operative procedure due to the depressive nature of the anesthesia and the lack of spontaneous breathing modes. With the decreased ventilation of the lungs and the development of atelectic regions, the blood flow to the lungs will continue around the less well ventilated alveoli. In this way, a variable portion of cardic output is returned to the left side of the heart in desaturated form. The degree of desaturation of the blood determines the level of postoperative hypoxia. The hypoxia identified by the studies is most pronounced in patients over the age of 50 and in those with deep and long anesthetic times.

Premedications are given before a surgical procedure to decrease anxiety, to relieve pain, and to provide an amnesiac affect before surgery. Medications commonly administered are sedative-hypnotics, antianxiety agents, opioids, antiemetics, and anticholinergic medications (Gilman et al. 1985). The opioids are known to cause respiratory depression. The anticholinergics tend to dry respiratory tract secretions. The other groupings have minimal affect upon the pulmonary system. However, all of these medications act with and influence the body's reaction to anesthetic agents.

Anesthetic agents are divided into three groupings: inert gases, simple inorganic and organic compounds, and complex organic molecules. All of these agents tend to decrease minute ventilation and to change the breathing pattern to rapid, shallow breaths (Gilman et al. 1985). Muscle relaxants are routinely given with anesthetic agents to allow muscular relaxation without deep levels of anesthesia. The action of the muscle relaxants extends into the postoperative period producing apnea and hypoventilation. Muscle relaxants also increase pulmonary secretions due to histamine release. The response of the surgical patient to premedications and anesthetic agents varies with individual patients much as response to all medications.

## Stress Response

The stress response refers to the endocrine, metabolic, and humoral changes that occur with surgical or mechanical trauma to the body. The stress response begins with an adrenergic response. During this phase the blood flow to the heart and brain are increased. The cardiac output is increased with a rise in the blood pressure and cardiac work. The adrenergic phase is precipitated by direct stimulation of the sympathetic system and by an increase in circulating catecholamines from the adrenal medulla. The first response to the injury releases epinephrine which leads to sweating, tachycardia, elevated blood pressure, dry mouth, and pulmonary secretions, pallor, and hypotension. The epinephrine also increases the amount of available energy and results in hyperglycemia. Fat metabolism increases with a release in free fatty acids. Protein catabolism occurs.

A second delayed response of the pituitary/hormonal system then occurs. Almost all of the hormones produced by both lobes of the pituitary are released in increased amounts. The first and immediate response is concerned with maintaining blood flow and energy supplies to the vital organs. The response is supported by ancillary responses mediated by the catecholamines, ADH, renin, and aldosterone which are concerned with the maintenance or restitution of circulating blood volume. The second response is that of an enormous metabolic stimulation. This phase leads to muscle wasting and an increase in the body's caloric needs. The muscles of the body including the respiratory system are weakened.

The respiratory response to the stress of the surgical procedure is controlled during the surgery by mechanical and pharmacological means. In the postoperative period, the endocrine levels remain elevated for up to 4 days. The increased endocrine levels are accompanied by further muscular wasting. To compensate for these increased levels, the respiratory system maintains a respiratory pattern of rapid, shallow breathing. This type of breathing pattern may lead to the development of postoperative pulmonary complications.

Perioperative factors affecting pulmonary function include premedications, anesthesia, and the surgical procedure including the incision type. Perioperative factors are based upon the decisions and preferences of the anesthesiologist and the surgeon. Events that occur in the perioperative period will determine postoperative ventilatory ability. Postoperative factors that add to the preoperative and perioperative risk factors for developing pulmonary complications will now be discussed.

## Postoperative Factors

### Narcotics

Postoperative pain medications fall into the narcotic category. Narcotics given in the postoperative period potentiate the premedications and the anesthetic agents, which may remain in the system from 1 to 5 days after the surgical procedure. Therapeutic doses of opioids and other pain relievers depress all phases of respiratory activity including rate, minute ventilation, and tidal volume. The decreased respiratory volume is due to the reduction in the rate of breathing. The medications additionally depress the cough reflex and dry respiratory secretions. The depressive nature of these medications upon the pulmonary system tends to lead to the development of atelectasis and other postoperative pulmonary complications.

## Respiratory Interventions

Specific methods to improve lung volumes in the postoperative patient have been documented. Some of the methods will be discussed here. Morran et al. (1983) and Warren and Grimwood (1980) looked at two forms of physiotherapy in postoperative patients undergoing a cholecystectomy. The physiotherapy in the study by Morran et al. was described as 15 minutes of breathing exercises (6 minutes of diaphragmatic breathing, 6 minutes of lateral costal breathing, and 3 minutes of apical breathing) with assisted coughing and vibration of the chest. The frequency of such treatment was not discussed in the study presentation. Warren and Grimwood described physiotherapy as instruction in deep breathing and effective coughting two to four times daily. Morran et al. found no decrease in atelectasis with the first physiotherapy regimen but a decrease in chest infections. Warren and Grimwood, however, found a statistically significant reduction in postoperative pulmonary complications with the second method. The patients in their study who developed complications tended to be older, to have spent more time in the hospital prior to surgery, and to have had longer anesthesia times.

Celli et al. (1984) and Jung, Wight, Nisser, and Rosoff (1980) compared intermittent positive pressure breathing, incentive spirometer, and deep breathing exercises on patients after abdominal surgery. Celli et al. (1984) found the frequency of pulmonary complications to be 48% in the control group, 22% in the intermittent positive pressure breathing group, 21% in the incentive spirometer group, and 22% in the deep breathing group. The researchers concluded that intermittent positive pressure breathing, deep breathing exercises, and incentive spirometry all prevented the occurrence of postoperative pulmonary complications. The intermittent positive pressure breathing treatments, however, caused abdominal distention in the postoperative patients. Therefore, incentive spirometry and deep breathing exercises were described as the treatments of choice. Jung et al. (1980) did not find any statistical significance in the incidence of atelectasis between the three treatments. The single factor most likely to determine the development of postoperative atelectasis in the study was age greater than 50 years.

Stock, Downs, Gauer, Alster, and Imrey (1985) and Ricksten, Bengtsson, Soderberg, Thorden, and Kvist (1986) compared subjects given continuous positive airway pressure and positive expiratory pressure administered by mask to subjects given incentive spirometry to a control group given a regimen of coughing and deep breathing. Stock et al. (1985) found that the mean functional residual capacity (FRC) increased more rapidly in the postoperative period in patients having the continuous positive airway pressure treatments than those receiving incentive spirometry or deep breathing. The incidence of pneumonia decreased compared to the normal postoperative population with all treatments. The researchers concluded that the frequency and supervision of respiratory therapy was more important than the type of therapy delivered after an abdominal operation. Ricksten et al. (1986) found that the continuous positive airway pressure and positive expiratory pressure delivered by mask for 30 breaths per waking hour in the postoperative period was superior to the incentive spirometry treatments with respect to gas exchange, preservation of lung volumes, and the development of atelectasis.

Drain (1984) studied lung volumes in patients who performed sustained maximum inspiration after verbal encouragement by the nurse and patients performing deep breathing maneuvers after verbal encouragement by the nurse. The decrease in FRC in the first 2 hours after surgery was less in patients using sustained maximal inspiration. No other significant findings were noted.

Schwieger et al. (1986) compared incentive spirometry treatment with no specialized postoperative respiratory care. Incentive spirometry was given for 5 minutes every hour at least 12 times per day through postoperative Day 3. No statistically significant difference between the two groups in radiological evidence of postoperative pulmonary complications, arterial oxygen pressure, spirometric measurement, and clinical evaluation was noted.

Heisterberg et al. (1979) studied 48 patients undergoing gastric and biliary tract surgery. The patients were divided into two groups: one group receiving blow-bottle treatment for 10 minutes every 4 hours in the postoperative period and one group receiving instructions in breathing exercises and postural drainage which was carried out two times every hour. There was no difference in the frequency of radiological changes indicating postoperative pulmonary complications between the two groups.

Bartlett (1984) reviewed much of the research performed up to 1984 which compared and determined the most effective respiratory therapy in preventing postoperative pulmonary complications. Bartlett identified the basis for atelectasis and the development of pulmonary complications as a mechanism of lack of lung inflation. The lack of lung inflation is complicated by small airway or parenchymal lung damage due to bacteria or endotoxins, humoral or particulate materials in the blood stream, aspiration, and fluid overload. The effective respiratory therapy, therefore, is one which emphasizes large volume inflation with the inflating pressure applied for a considerable period of time. The maneuver must be done several times each hour in the postoperative period. Bartlett found no consistent studies that demonstrated any success with the reduction of postoperative pulmonary complications with: (a) postoperative coughing; (b) forced expiration; (c) blowing into gloves, bottles, or other devices; (d) airway humidification; (e) nebulized mist treatments; (f) rebreathing carbon dioxide; (g) transtracheal irrigation and stimulation; (h) prophylactic endotracheal suctioning without specific indications; and (i) the use of breathing exercises that do not assure sustained maximal inflation volume. The researcher suggested that incentive spirometry be combined with continuous positive airway pressure and intermittent positive pressure breathing to assist with the sustained maximal inflation.

While respiratory therapies have been studied in the postoperative period and have had some success in the prevention of postoperative pulmonary complications, the intervention of physical positioning of patients seems to hold answers to ways to improve ventilatory ability in the surgical patient.

## Positioning

### Normal Mechanisms with Positioning

Regional differences of structure and function occur within the lung. These regional differences include such things as blood flow, ventilation, gas exchange, pleural pressure, alveolar size, and mechanical stress (West, 1978). In addition, each of the regional differences change with positional changes.

In the normal erect lung, the blood flow per unit volume is very high near the bottom of the lung (1.29 liters/minute) and very low at the apex of the lung (0.07 liters/minute) (West, 1978). This distribution of pulmonary blood flow is explained by the relationships between pulmonary arterial, alveolar, and venous pressures. The pressures create a hydrostatic pressure gradient up the lung. Flow begins in the lungs at the level where arterial pressure exceeds alveolar pressure. This relationship difference determines blood flow until the level where the venous pressure is greater than alveolar pressure. Then the pressure gradient is dependent on the differences of arterial and venous pressures (Anthonisen & Milic-Emili, 1966; Hughes, Glazier, Maloney, & West, 1976).

Upon changing to the supine position, the apical blood flow increases, and the basal blood flow changes very little. The differences in blood flow between the areas are abolished. The perfusion differences now exist between the anterior part of the lung which is uppermost and the posterior part of the lung which is dependent. Perfusion to the lungs also increases due to an increased cardiac output in the supine position. The increased output is related to the increased venous return to the heart (Lewis & Christianson, 1978). Exercise in the upright position increases both apical and basal blood flow (West, 1978).

The distribution of ventilation in the normal erect lung is similar to that of perfusion. The base of the lung is better ventilated (0.82 liters/minute) than the apex of the lung (0.24 liters/minute), but the magnitude of the difference is not as great (West, 1978).

The nonuniform distribution of ventilation is related to four factors (Slonim & Hamilton, 1981). The first factor is the shape and structure of the thoracic cage. During inspiration, the upper part of the chest is only able to expand two-thirds as much as the lower chest. The curvature of the ribs and the rigid thoracic structure prevent greater ventilation in the upper chest.

The second factor is the ability of the hemidiaphragms to expand the lungs. The descent of the hemidiaphragms expand the lower lobes of the lungs more than the upper lobes. The expansion of the upper lobes is accompanied by a stretching of the supporting structures attached to them. More pressure is necessary to expand the same volume of upper lung area as lower lung area.

The third factor is the difference between peripheral lung tissue and deep lung tissue. Peripheral lung tissue at a given level in the upright lung expands more than deep lung tissue. The expansion of deep lung tissue is limited by larger, stiffer supporting airways that require a greater pressure per unit volume to expand.

The fourth factor that contributes to uneven ventilation within the lung is the regional differences in pleural pressure related to the weight of the lungs. The lung weight creates a more positive intrapleural pressure at the bottom of the thorax. The base of the lung has an expanding pressure of 2.5 cm water. At this pressure, the resting lung volume is relatively small.

For a small decrease in intrapleural pressure, the change in volume of the lung is relatively large. At the apex, the lung has a much larger pressure expanding it. The apex is a larger resting volume. A change in pressure here creates a much smaller change in lung volume. The base of the lung has a smaller expanding pressure on it but actually ventilates better than the apex of the lung (West, 1978).

Gas exchange within the lung depends upon the ratio of the ventilation to the blood flow or perfusion. The ratio of ventilation to perfusion is relatively low at the bottom of the lung and as high as three at the apex (normal value is between 0.8 and 1.0). Due to the change in ratio of ventilation to perfusion in different lung regions, a mismatch of ventilation and perfusion occurs. This leads to a regional difference in gas exchange. Calculations based on physiological studies show that 15 times more oxygen is taken up by the lower lung than the upper lung. Five times more carbon dioxide is excreted by the lower lung than the upper lung. At rest, the apex of the upright lung takes little part in gas exchange. In the supine position, the regional differences disappear.

Other regional differences within the lung are as follows. Pleural pressure differences in the lungs vary up and down the lung, contributing to the pressure gradients that control ventilation and perfusion. The apex of the lung is overexpanded while the base is relatively compressed. The distortion is probably caused by the weight of the lung and is associated with a more negative intrapleural pressure at the apex of the lung. The size of alveoli vary within the lungs. The apical alveoli of the upright lung are larger than the basal alveoli due to the compression of basal alveoli from lung weight. Finally, the mechanical stress upon the lung is highest at the apex due to gravity and makes this lung area vulnerable to mechanical failure. Regional differences in perfusion, ventilation, and gaseous exchange are present in the lungs. The differences vary with positional changes of the lungs.

Measurements of ventilatory function of the lungs have been documented to change with positional changes. Kauppinen-Walin et al. (1980) examined several methods of measurement of FRC. Forty healthy subjects, both smokers and nonsmokers, male and female, were selected for the study. Twenty subjects were aged 19 to 21, and 20 subjects were aged 65 to 70. Radiospirometric and helium-dilution in closed-circuit measurement methods were performed in supine and sitting positions. The results indicated that the FRC determined by radiospirometry is significantly larger than the FRC determined by the helium-dilution method. Both methods indicated that the FRC was larger in the sitting than in the supine position. The study supports the increase of lung volumes with the change from supine to the sitting position. Variations between different methods of measurement of FRC need to be considered in the result of similar studies.

Craig, Wahba, and Don (1971) investigated the closure of small airways in dependent lung zones in healthy subjects in different positions. The functional consequence of airway closure was thought to be impairment of ventilation to the affected lung regions leading to adverse effect on pulmonary gas exchange. The subjects were placed in the predetermined positions of seated, supine, supine with head down 15 degrees, and the lithotomy position with head down 15 degrees. Five minutes rest was allowed between positional changes. FRC was measured by a closed-circuit helium technique. The lung volumes of functional reserve volume, total lung capacity, and expiratory reserve volume (ERV) decreased significantly with the change of the position from sitting to supine. The vital capacity did not change significantly. The volume changes were similar in direction and magnitude to those reported in previous studies.

Craig, Wahba, Don, Couture, and Becklake (1971) further investigated gaseous exchange with postural change in 22 normal subjects aged 21 to 78. The subjects were studied sitting in a straight-backed chair or supine on an operating room table. FRC, ERV, and inspiratory capacity (IC) were measured with 10 minutes between postural changes. Closing volume, the lung volume at which small airways start to close, was measured. In some subjects, the gas exchange was better in the seated position. In other subjects, the gas exchange was better in the supine position. In another group of subjects, the gas exchange was the same in both positions. When FRC exceeded the closing volume in both positions, gas exchange was improved.

In a study of 6 subjects, Burki (1982) used a minimum of 10 determinants of total respiratory compliance in an investigation of the effect of four different body positions: seated, supine, right lateral decubitus, and left lateral decubitus. No significant change in the total lung compliance with change in posture occurred with any individual. No data on the subjects was given with which to analyze the results.

The small sample size renders the study results inconclusive. Further study is needed due to the inconsistency of study results and that of other researchers.

The final positional study (Helms, Hulse, & Hatch, 1982) presented here was instigated to measure differences in lung volumes and mechanics in the supine and right lateral positions. The sample included 23 infants and young children aged 3 weeks to 30 months. Lung volumes, dynamic compliance, and total pulmonary resistance were measured. Fourteen subjects were studied under light sedation and the remaining nine under general anesthesia before elective surgery. In the sedated group, no significant differences were found between the two positions for lung mechanics. In the anesthesized group, the dynamic lung complicance was lower in the supine position.

## Physiological Disturbances and Positioning

Dawson et al. (1965) studied mitral stenosis patients with Xenon-133 gas in the sitting position. With mitral stenosis, the apex was better perfused than the base in the sitting position. The left lung was slightly less ventilated per unit volume than the right in the sitting position. The ventilation-perfusion ratio was significantly less than normal. No significant ratio of left-to-right lung ventilation in the apex and base was found in the supine position.

Schaanning and Refsum (1976) studied 16 subjects with chronic obstructive lung disease in supine and sitting positions. The subjects--nine men and seven women with a mean age of 55 years--had moderate degrees of lung disease by clinical, radiological, and physiological parameters. Tidal volume was higher in the sitting position in the study. The partial pressure of arterial oxygen was the same in all positions but the partial pressure of carbon dioxide was slightly lower in the sitting position. The results supported earlier studies.

The significance of positioning of patients with various physiological disturbances is documented in research. Due to the regional differences in ventilation and perfusion within the lungs, pulmonary mechanics change as position changes. Therefore, each positional change brings a variety of pulmonary changes to a particular patient.

Surgery and Positioning

Russell (1981) studied repositioning of postoperative patients to improve ventilatory ability. Nineteen subjects were placed in sitting and supine positions 30 to 60 minutes after a surgical procedure. The sample included 11 men and 8 women from 18 to 87 years of age. Ten patients underwent lower abdominal incisions and nine patients underwent upper abominal incisions. A statistically significant deterioration in oxygenation occurred in the sitting-up position. Critics of the study stated that 30 to 60 minutes after a surgical procedure, the anesthetic effects would always produce such results.

Hsu and Hickey (1976) studied 28 patients undergoing various operative procedures. Measurements of functional reserve capacity (FRC) were made by closed-circuit constant-volume helium-dilution technique in both sitting and supine positions. The measurements were made preoperatively and for 1, 3, and 5 days postoperatively or until the FRC returned to control. Patients with upper abdominal operations had decreased FRC in both positions on Day 1 and Day 3. FRC returned to control value on Day 5. Changing body position from supine to sitting increased the FRC. However, the increase in FRC was less than the preoperative increase in FRC with position change. The difference in the preoperative and postoperative values is related to the body's response to the surgical procedure. The changes in FRC with positioning was related to the regional differences in ventilation and perfusion caused by positioning.

Dawson et al. (1965) explained the various changes with mitral stenosis. Douglas et al. (1977) and Piehl and Brown (1976) looked at acute respiratory failure and adult respiratory distress syndrome. Sharp et al. (1980), Schaanning and Refsum (1976), and Neagley and Zwillich (1985) explained pulmonary changes that occur with positioning of patients with chronic obstructive pulmonary disease and pleural effusions.

The study of positioning and the changes in ventilatory ability in the postoperative period is documented by two studies. Russell (1981) studied positioning of postoperative patients 30 to 60 minutes after surgery using supine and sitting positions. Hsu and Hickey (1976) studied 28 patient in the two positions 1 to 7 days after surgery. The studies show the changes in pulmonary function after surgery. Numerous factors could be added to each of these studies to explain the reason for such changes.

Postoperative factors that influence the development of pulmonary complications consist of pain medications, respiratory therapy interventions, and nursing interventions. While much is known about the pysiological changes with pain medications, the timing and dosage of such medications to achieve optimum pulmonary function has had limited study. Much study has, however, been directed towards identifying which respiratory therapy treatment would be more beneficial to postoperative patients. Nursing interventions have been replications of respiratory therapy treatments. Positioning of the postoperative patient as a nursing intervention to improve ventilatory abiltiy and thus to decrease the development of pulmonary complications has become an intervention worthy of further study.

## Summary

Despite all the research directed towards the identification of risk factors in the development of postoperative pulmonary complications, the percentage of such complications has not changed in 50 years. The improvements in the preparation of patients for surgery, including teaching, weight loss, and cessation of smoking; the improvements in perioperative management of patients such as new drugs and anesthetic agents, monitoring modes and knowledge of fluid management; and the improvements in postoperative respiratory treatments have not significantly decreased postoperative pulmonary complications. Research into the problem continues to be of importance towards improving the standards of patient care for the surgical patient.

# CHAPTER III

# METHODS

This study was designed to determine if a change in position from supine to 45 degrees to 90 degrees would improve the pulmonary function tests of tidal volume, respiratory rate, minute ventilation, forced vital capacity, and forced expired volume in 1 second for postoperative patients with upper and lower abdominal incisions.

## Sample and Setting

A convenience sample of 34 adult inpatients, male and female, in a university-affiliated teaching hospital and a hospital run by the Veterans Administration was tested. The two hospitals are located in a metropolitan area of 380,000 people.

Subjects were approached for inclusion in the study if their names appeared on the operative schedule posted each evening for surgical procedures to be performed the following day in either hospital. Subjects had to be present in the hospital the evening before the procedure. The subjects also had to be scheduled for a surgical procedure that normally would require an upper abdominal or lower abdominal incision. Subjects were all scheduled for general anesthesia.

The researcher approached subjects that met the following criteria:

1. At least 18 years of age.
2. Able to read and understand English.
3. Able to tolerate the three positions of head of bed flat, head of bed 45 degrees, and head of bed 90 degrees.
4. Alert to follow simple directions and take deep breaths.
5. Free of infectious disease.

The exclusion of patients with infectious diseases was done to protect subjects from cross-contamination by equipment and personal contact.

Although only those subjects expected to have an upper or a lower abdominal incision under general anesthesia were approached for inclusion in the study, some differences in actual subjects were seen. The first difference was that a third type of incision was being used in the subject population--a combination of the upper and lower abdominal incisions. The ability to predict the incisional type in the preoperative period was not reliable for patients being considered for upper and lower abdominal incisions. As a result, a third category of a combination incision was added to the study design.

The second difference in actual subjects from proposed subjects was the type of anesthesia. While only subjects scheduled for a general anesthesia were to be included in the study, two subjects received spinal anesthesia. The subjects were included in the study due to their ability to meet all other criteria and due to the preparatory steps already carried out with each of the subjects.

## Design

The design of the study is a 3 x 3 factorial design with repeated measures. The factors are the three positions (90 degrees, 45 degrees, flat) and the three incision types (upper, lower, combination). A third incisional type was added to the design after several weeks of data collection to allow for those subjects who had incisional areas that extended beyond the limits imposed by either an upper or lower abdominal incision. The design uses repeated measures in order to separate individual variability from treatment and experimental variability. Without this type of measurement, individual characteristics of subjects, such as age, history, height and weight, would distort the experimental results. Repeated measurements design allowed subjects to serve as their own controls.

## Independent Variables

One independent variable for the study is the body position with three levels: supine, head of bed elevated 45 degrees (15 inches), and head of bed elevated 90 degrees (30 inches). The three postiions were chosen for three reasons. First, each position is currently used by medical and nursing personnel to assess and treat surgical patients. Second, the three positions are dissimilar enough to register measurable physiological changes in the pulmonary system. Third, the positions of head of bed at 90 degrees and head of bed flat have been used in previous studies. The addition of the head of bed at 45 degrees was done to define exactly when pulmonary function measures change as the head of the bed is raised. The addition of the head of bed at 45 degrees was done to define exactly when pulmonary function measures change as the head of the bed is raised.

Since it was impossible to place subjects into all of the various combinations of the three positions to allow for possible effects, two sequences of the positions--flat to 45 degrees to 90 degrees and 90 degrees to 45 degrees to flat--were incorporated into the study to act as control variables. Pulmonary function measures are not thought to be influenced by either sequence. The pulmonary function measures of the two sequences would be similar and would indicate that starting at either flat or 90 degrees would not produce an unknown effect.

A second independent variable is the type of abdominal incision. Two types of incisions are upper abdominal incisions, and lower abdominal incisions. An upper abdominal incision is defined as an incision extending no higher than the nipple line and no lower than the umbilicus. This type of incision is normally used for operations on the stomach, duodenum, gallbladder, liver, spleen, and transverse colon. A lower abdominal incision is defined as an incision below the umbilicus but above the pelvic symphysis. The lower abdominal incision is used for surgeries on the pelvic organs, bladder, and prostate. A third type of incision appeared in the sample population. The inability to predict who would require the third type of incision made patient selection impossssible in the preoperative period. Therefore, the combination incision was added to the design of the study. The third category of incisions--combination--refers to those incisions not within the above boundaries for upper or lower abdominal incisions but within the space from the nipple line to the pelvic symphysis. This type of incision is used for more extensive abdominal surgery where it is necessary to have a wider viewing area during the surgical procedure.

## Dependent Variables

The dependent variables are the measurements of tidal volume, respiratory rate, minute ventilation, forced vital capacity, and forced expired volume in one second. The measurements were chosen for two reasons. First, the measurements are easily done at the bedside with minimal equipment. Second, the measurements are commonly used to evaluate ventilatory function in patients to determine specific needs for oxygen therapy and respiratory treatments.

### Tidal Volume

Tidal volume refers to that volume of air inhaled or exhaled during normal breathing. Tidal volume can be measured directly by simple spirometry. The subject breathes into a bellows or spirometer, and the volume change is recorded. The instrument that was used to measure the tidal volume was the Wright respirometer. The respirometer consists of a vane connected to a series of gears such that gas flowing through the body of the instrument rotates the vane and registers a volume. The measurement gives some indication of the ability of the patient to move air in and out of the lungs. Tidal volume has a low reliability related to the variability of the measure from minute to minute and from breath to breath. The steps that were taken to increase the reliability of the measurement were: (a) the subjects practiced with the Wright respirometer the night before surgery to ensure the ease of use, (b) the subjects established a breathing rhythm with the instrument in place before the actual measuring, and (c) an average tidal volume was taken by dividing the minute ventilation by the respiratory rate. Refer to the section on minute ventilation for the description of that measurement.

## Respiratory Rate

The respiratory rate is the number of respirations per a one minute time period. A respiration consists of two phases. The first phase is inspiration or the enlarging of the chest cavity as a result of contraction of the diaphragm and intercostal muscles. Intrathoracic pressure in the chest falls below atmospheric pressure and air is sucked into the lungs. The second phase is the passive act of expiration when the muscles of the thoracic cage relax back to resting size. The normal range for the respiratory rate is 12 to 20 respirations per minute. The respiratory rate may increase due to a lack of oxygen or a rise in carbon dioxide. Rates greater than 35 per minute in adults indicate respiratory failure. The respiratory rate is counted by observing the rise and fall of a subjects' chest and recording the two phases as one respiration for a timed period.

## Minute Ventilation

Minute ventilation is the total volume of gas either inspired or expired in 1 minute. Conventionally, the expired volume is measured as minute ventilation. As VE includes both alveolar and dead space ventilation, the absolute values of the measurement are not indicative of hypoventilation or hyperventilation. Therefore, the best index of ventilation is when VE is used in conjunction with arterial blood gas values. VE increases in response to hypoxia, hypercapnia, acidosis, low compliance states, and exercise. VE decreases in opposite conditions. VE becomes a significant consideration during the weaning process.

VE may be determined by allowing subjects to breathe either into or out of a bellows, spirometer, or similar metering device for a least one minute. The reliability of the measurement is variable depending on the minute to minute and breath to breath changes in breathing patterns. The steps that were taken to increase the reliability of the measurement were: (a) the subjects practiced with the Wright respirometer the night before surgery to ensure the ease of use, and (b) the subjects were instructed to take neither shallow breaths nor deep breaths but to breathe as normally as possible through the mouthpiece. The validity of the minute ventilation is poor when taken alone but the measurement of the minute ventilation was used with the respiratory rate to evaluate tidal volume in the present study. The tidal volume is more reflective of how deep individual breaths are in the postoperative patient. Subjects in the present study expired into a metering device for 1 minute. The expired volumes were recorded in liters per minute. The normal value is five to seven liters per minute. VE was measured for 1 minute for three consecutive times in each position with the largest exhaled volume recorded.

## Forced Vital Capacity

Forced vital capacity is that volume of gas that can be expired as forcefully and rapidly as possible after maximal inspiration. FVC is a useful measurement in respiratory care as a representation of the maximum volume available to the patient for ventilation under conditions of stress. FVC consists of two steps: a full inspiration to total lung capacity followed by a rapid, forceful maximal expiratory effort into a spirometer. FVC was measured with a Respiradyne pulmonary function monitor produced by the Chesebrough-Ponds Corporation. The subjects took a full inspiration and exhaled as rapidly as possible into the mouthpiece of the instrument. The Respiradyne registered the volume and computed a time interval curve. FVC appeared in numerical form on the monitor. The instrument was small and compact enabling the researcher to take the hand held instrument to the bedside. FVC is a measurement recommended by the American Thoracic Society (ATS) in 1977 as one to be carried out with pulmonary function studies because of the high reliability of the measurement. Standards were also set to determine the reliability of the instrument used. The Respiradyne meets ATS standards. The reliability of the measurement--FVC--is related to the effort and cooperation of the patient. Therefore, the subjects were allowed to practice with the instrument the night before the actual testing, and three readings were taken of the FVC in the postoperative period with the largest one recorded.

## Forced Expired Volume in 1 Second

Forced expired volume on one second is the volume of air forcefully expelled in the first second of a forced vital capacity maneuver. FEV1 is used to ascertain the severity of airway obstruction. A patient with an abnormal FEV1 will require significant energy expenditure to increase ventilation in response to stress. FEV1 was measured with the Respiradyne along with the FVC. FEV1 appeared as a numerical value on the monitor screen. The measurement requires the same two steps of inspiration and expiration. The volume of air in 1 second is measured from the time interval curve developed from the measurement of FVC. The reliability of the tool is the same as for FVC. FEV1 was the second measurement to be recommended by ATS to be carried out to evaluate pulmonary functioning.

## Control Variables

A data sheet was filled out on each subject with demographic information, and past and present medical information (see Appendix A). The information included several variables that could influence the results of the study. Variables identified in research that needed to be included were those that impact upon the patient in the preoperative, perioperative, and postoperative periods. Preoperative factors include age, sex, weight and height proportion, smoking history, and pulmonary and cardiovascular disease. Perioperative factors include anesthetic medications, anesthesia time, surgical complications, and the extent of the surgical procedure. Postoperative factors include medications given after the surgical procedure and respiratory therapies ordered after surgical procedures. All of the factors lead to a variance in postoperative pulmonary function. These data were used in interpreting the results of the study.

## Data Collection

The study was reviewed and accepted by the Human Subjects Committee prior to the beginning of data collection for both institutions. Potential subjects were approached by the researcher for inclusion in the study the night before surgery. Subjects were approached if they were on the surgery schedule for the following day for surgeries with the desired incisional type and if they were in the hospital the evening before surgery. All subjects meeting the criteria and available for testing the morning after surgery were eligible. The subjects were told about the testing and signed a permit form for the testing procedure (see Appendices B, C, and D). Subjects were assigned a code number for all future identification.

After permission was obtained, the subjects were given the pulmonary function measuring equipment to view and to practice using. The mouthpieces of both instruments were demonstrated to the subjects. Subjects kept and used their own mouthpieces. The subjects were told that the test would require exhaling for one minute into the mouthpiece of the Wright respirometer, breathing as normally as possible. Additionally, subjects would inhale as deeply as possible and exhale rapidly and totally into the mouthpiece of the Respiradyne. The researcher observed the subject practicing with the instruments to ensure proper technique. The researcher collected one set of readings with the subject in the upright position.

The data collection for the positional sequence of the four measures took place between 6 a.m. and 8 a.m. the morning after surgery. The time frame was imposed to limit the number of interventions which may have occurred after the surgical procedure that could change the ventilatory measurements.

The researcher approached the selected subjects the morning after surgery. Patients found with the head of the bed 0 degrees to 45 degrees elevation were repositioned to head of bed flat. The positional sequence of this group of patients was flat to head of bed elevated 45 degrees to head of the bed elevated 90 degrees. Patients found with the head of the bed elevated above 45 degrees were repositioned to head of bed at 90 degrees. The positional sequence of this group of patients was head of bed elevated 90 degrees to head of 45 degrees to head of bed flat. Blood pressure, pulse rate, temperature, and respiratory rate were recorded on all of the subjects.

In position number one, the subject was asked to exhale into the Wright respirometer mouthpiece for one minute. Respiratory rate was counted simultaneously. Subjects then repeated the exhalation for one minute into the Wright respirometer two additional times with the respiratory rate counted for each minute in position one. Tidal volumes were calculated from the minute ventilation volumes and the respiratory rates recorded here. FVC and FEV1 were measured with the Respiradyne. The subject was instructed to inhale as deeply as possible and to exhale into the mouthpiece as rapidly as possible. The subject repeated the FVC and FEV1 two additional times in position one. Five minute rest periods were allowed between positional changes. Subjects were then placed into the other two positions, and measurements of pulmonary function were made in the same manner for positions two and three.

## Data Analysis

The data were recorded on the Subject Data Sheet (see Appendix A). It was coded and placed into subject files. The subject files were summarized with descriptive statistics. Frequency distributions were computed with mean, range, and standard deviations calculated for the dependent measures and some of the control variables. Frequency distributions and percentages were calculated for nominal scale data.

To determine the effect of positioning, incisional type, and the sequence of positioning upon the dependent variables, an analysis of variance (ANOVA) was used. ANOVA is an extension of the difference-of-means test (Blalock, 1979). ANOVA is used to simultaneously compare more than two sample means. An example from the present study would be a comparison of the mean tidal volume values of patients placed into three positions. Although, ANOVA is a test of the differences in central tendencies, it is based upon a comparison of variances. It has a known sampling distribution called the F-distribution. The F distribution is based upon the following assumptions: (1) an interval level of measurement, (2) independent observations, (3) a normally distributed population, (4) independent random samples, and (5) homogeneity of sample variances (Loether & McTavish, 1974). In the present study, the observations were not independent and the sample was not randomly selected. However, because of the strength of the F-ratio, the ANOVA was selected as a better test than nonparametric measures. The lack of independence in the observations was overcome by the use of repeated measures

ANOVA. In this technique, subjects serve as their own controls (Winer, 1962). By comparing subjects with themselves, individual variability can be separated from the treatment effects and the experimental error. In repeated measures ANOVA, the F-statistic is the ratio of the mean sum of squares of the treatment effects to the mean sum of squares of the residual uncontrolled sources of variation. The level of significance for the study was 0.05.

The ANOVA determines whether or not the effects of three or more treatments is significantlly different. It does not distinguish between the significant and nonsignificant treatments. Therefore, two statistical tests were used to determine the relative weight of the effects found with the ANOVA. The t-test and the Tukey were used to compare the means of the treatment groups. The planned comparison or t-test is an _a priori_ contrast which is used to verify predicted directions of change between two treatment groups (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975). The Tukey or q-statistic is a post hoc comparison that analyzes each possible pair of means to determine if the two means are significantlly different from one another. The Tukey is a more conservative test than the t-test because it will indicate that two means are significantly different only when the means are far apart.

In analyzing the relationship between the variables, four steps were taken. First, in answer to the question what is the effect of positioning upon ventilatory ability as measured by pulmonary function tests in postoperative patients, a one-way analysis of variance with repeated measures to determine the relationship between positioning and pulmonary function measures was carried out. Second, to answer the question what is the effect of the relationship between positioning and the type of incision upon pulmonary function measures, an ANOVA with repeated measures to determine the relationships between incisional type and pulmonary function tests was carried out. Third, the relationship between the sequence of the positions and pulmonary function vales was studied using an ANOVA with repeated measures. This step was done to establish that no unknown treatment effect occurred related to the sequencing of position. Fourth, a 3 x 2 ANOVA was used to determine that no relationship was occurring between sequencing and incisional type. After each step, the planned comparisons and Tukey tests were done to determine the treatment having the most effect. Finally, crosstabulations were used to determine the relationship between the independent variables and the control variables. Percentages of subjects were described when looking at the sample. Numbers were used when looking at specific groupings within the sample. This was because of the small numbers of subjects for specific groupings within the sample. The use of percentages would have shown significant increases or decreases in percentages of subjects when only one or two subjects may have changed.

# CHAPTER IV

## ANALYSIS OF DATA

In the first part of this chapter, the characteristics of the sample population are presented with descriptions of the preoperative, perioperative, and postoperative factors that are similar between the subjects. In the second part of the chapter, the dependent variables of tidal volume, respiratory rate, minute ventilation, forced vital capacity, and forced expired volume in one second are presented. Three analyses of data were calculated for each of the dependent variables. The first analysis described the effect of the positions of supine, 45 degrees, and 90 degrees upon the pulmonary function mean values. The second analysis described the relationship between the positions and the incisional types upon the pulmonary function mean values. The last analysis described the relationship between two sequences of positions and the dependent variables. The two sequences of positions were head of bed flat to 45 degrees to 90 degrees and head of bed at 90 degrees to 45 degrees to flat.

## Characteristics of the Sample

The sample population was comprised of thirty-four surgical patients who underwent a surgical procedure between December, 1985 and January, 1987. Subjects were tested between 0600 and 0800 in the morning the day after the surgical procedure. Six of the subjects were from a university affiliated hospital and twenty-eight subjects were from a hospital run by the Veterans Administration.

The subjects were divided into three incisional types--upper abdominal with ten subjects, lower abdominal with thirteen subjects, and combination with eleven subjects. Subjects were placed into two sequences of positions in the postoperative period. Sequence 1 subjects were found the morning after surgery with the head of the bed no higher than 45 degrees. Subjects in sequence 1 were placed with the head of bed flat, repositioned to head of bed 45 degrees and then repositioned to head of bed 90 degrees. Twenty-two subjects were positioned according to sequence 1. Sequence 2 was carried out in subjects who were found the morning after surgery with the head of the bed higher than 45 degrees. Subjects in sequence 2 were place with the head of bed 90 degrees, repositioned to head of bed 45 degrees and then repositioned to head of bed flat. Twelve subjects were positioned according to sequence 2.

## Preoperative

### Age and Gender

The age distributions for the sample population are presented in Table 4. The ages of subjects ranged from 29 to 72 years with a mean of 53.9. Twenty-four of the subjects were over the age of 50.

Table 4

Age Characteristics for Thirty-four Subjects

| | |
|---|---|
| Mean | 53.9 years |
| Range | 29 to 72 years |
| Standard Deviation | 12.69 years |
| Number of Subjects over 50 years | 24 (72%) |

The age distributions for the different groups of the sample population are tabulated in Table 5.

Table 5

*Means, Range Values, and Standard Deviations for Subjects According to Age Separated by Incisional Type and Positioning Sequence*

| | Mean | Range | Standard Deviation | Subjects > 50 years of age |
|---|---|---|---|---|
| *Incision Type* | | | | |
| Upper Abdominal[a] | 58 | 37-71 | 9.08 | 9 |
| Lower Abdominal[b] | 47 | 31-72 | 13.57 | 5 |
| Combination[c] | 57 | 29-67 | 9.63 | 10 |
| | | | | 24 |
| *Position Sequence* | | | | |
| Sequence 1[d] | 55 | 31-71 | 11.94 | 16 |
| Sequence 2[e] | 50 | 29-72 | 14.36 | 8 |
| | | | | 24 |

[a]*n* = 10. [b]*n* = 13. [c]*n* = 11. [d]*n* = 22. [e]*n* = 12.

The mean ages of patients with upper and combination incisions was ten years greater than that of the lower abdominal incision group. Nine subjects with upper abdominal incisions and ten subjects with combination incisions were older than 50. Only five subjects with lower abdominal incisions were older than 50. The mean age of sequence 1 subjects was five years older than sequence 2 subjects. Although more subjects in sequence 1 were older than those in sequence 2, the percentages of those over 50 were 66% and 72% respectively.

The sample population was composed of twenty-six males (76.5%) and 8 females (23.5%). The distribution of gender was similar for the three incision types (see Table 6). No females were assigned to sequence 2.

Weight-Height Ratios

Table 7 represents the distribution of weight-height ratios for the sample population. The ideal body weight of subjects' was calculated from the formula proposed by Purcell (1986). Ten per cent above the ideal body weight was defined as overweight and ten per cent under the ideal body weight was defined as underweight according to Luce (1980).

Table 6

*Number of Subjects According to Gender for Three Incisional Types and Two Positioning Sequences*

| | Male | Female |
|---|---|---|
| *Incision Type* | | |
| Upper Abdominal[a] | 9 | 1 |
| Lower Abdominal[b] | 10 | 3 |
| Combination[c] | 7 | 4 |
| *Position Sequence* | | |
| Sequence 1[d] | 14 | 8 |
| Sequence 2[e] | 12 | 0 |

[a] *n* = 10. [b] *n* = 13. [c] *n* = 11. [d] *n* = 22. [e] *n* = 12.

Table 7

*Number and Percentage of Thirty-four Subjects Having Specific Weight-Height Ratios*

| | |
|---|---|
| Ideal for Height | 12 (35%) |
| >10% Overweight | 15 (44%) |
| >10% Underweight | 6 (18%) |
| Missing Data | 1 ( 3%) |

Six subjects were 10% overweight in the upper abdominal group with five subjects in the combination group and four in the lower abdominal group. The upper abdominal group also had three subjects at least 10% underweight with one subject in the lower abdominal group and two subjects in the combination group. In the two position sequences, eleven subjects in sequence 1 and four subjects in sequence 2 were 10% or more overweight. Four subjects were 10% or more underweight in sequence 1 as were two subjects in sequence 2 (see Table 8).

Smoking History

Subjects with a smoking history were separated into three categories. The categories were those who currently smoked, those who had smoked at one time but had stopped for an unknown period of time, and those who had never smoked. Data was also collected on the packs per year smoking history which is a calculation of the number of packs per day multiplied by the number of years one smokes. The data for the sample population is presented in Table 9.

Smoking history was also compared between the three incision groups and the two sequence groups. Eight subjects with upper abdominal incisions (80%), nine subjects with lower abdominal incisions (64%), and seven subjects with combination incisions (64%) currently

Table 8

*Number and Percentage of Subjects According to Weight-Height Ratio Separated by Incisional Type and Positioning Sequence*

| | Ideal Weight | >10% Over-weight | >10% Under-weight | Missing |
|---|---|---|---|---|
| *Incision Type* | | | | |
| Upper Abdominal[a] | 1 (10%) | 6 (60%) | 3 (30%) | |
| Lower Abdominal[b] | 6 (46%) | 5 (38%) | 1 ( 8%) | 1 (8%) |
| Combination[c] | 5 (45%) | 4 (36%) | 2 (18%) | |
| *Position Sequence* | | | | |
| Sequence 1[d] | 6 (27%) | 11 (50%) | 4 (18%) | 1 (5%) |
| Sequence 2[e] | 6 (50%) | 4 (33%) | 2 (17%) | |

[a]*n* = 10. [b]*n* = 13. [c]*n* = 11. [d]*n* = 22. [e]*n* = 12.

Table 9

Number and Percentage of Thirty-four Subjects According to Smoking Characteristics

| | |
|---|---|
| **Subjects** | |
| Currently Smokes | 18 (53%) |
| Ex-Smokers | 6 (18%) |
| Never Smoked | 10 (29%) |
| **Number of Packs Per Year of Smoking** | |
| Mean | 27 Packs |
| Range | 10 to 112 Packs |
| Standard Deviation | 27.5 Packs |

smoked or had smoked in the past. The highest mean for packs per year smoked occurred with the combination group (33.8 packs per year). The mean packs per year for subjects with upper abdominal incisions was 26.4 and 20.2 for subjects with lower abdominal incisions. The lower abdominal incision subjects smoked less than the other two incision groups. Fifteen subjects in sequence 1 were currently smokers or had smoked in the past (68%) while nine subjects in sequence 2 fit that criteria (83%). The packs per year means were 27.9 for sequence 1 subjects and 23.7 for sequence 2 subjects (see Table 10).

Table 10

Number and Percentage of Subjects According to Smoking History Separated by Incisional Type and Positioning Sequence

| | Currently Smokes | Stopped Smoking | Never Smoked | Mean Packs Per Year[a] |
|---|---|---|---|---|
| **Incision Type** | | | | |
| Upper Abdominal[b] | 7 (70%) | 1 (10%) | 2 (20%) | 26.4 |
| Lower Abdominal[c] | 7 (54%) | 2 (15%) | 4 (31%) | 20.4 |
| Combination[d] | 4 (36%) | 3 (27%) | 4 (36%) | 33.8 |
| **Position Sequence** | | | | |
| Sequence 1[e] | 11 (50%) | 4 (18%) | 7 (32%) | 27.9 |
| Sequence 2[f] | 7 (58%) | 2 (16%) | 3 (25%) | 23.7 |

[a]Packs per year = packs per day times number of years smoked.

[b]*n* = 10. [c]*n* = 13. [d]*n* = 11. [e]*n* = 22.

[f]*n* = 12.

Concurrent Disease Entities

The presence of concurrent disease entities of the cardiac, pulmonary, and neuromuscular systems influences ventilatory ability. Table 11 shows the numbers and percentages of subjects in the sample population that had concurrent diseases. Sixteen of the subjects (40%) had cardiac disease, seven (21%) had pulmonary disease, and three (9%) had neuromuscular disease that would interfere with pulmonary function.

Four subjects with upper abdominal incisions (40%), five subjects with lower abdominal incisions (38%), and seven subjects with combination incisions (63%) had cardiac disease. Twelve subjects in sequence 1 (54%) and four subjects in sequence 2 (33%) had cardiac disease. Four subjects with lower abdominal incisions (31%), two subjects with upper abdominal incisions (20%), and one subject with a combination incision (9%) had pulmonary disease. Five subjects in sequence 1 (23%) and two subjects in sequence 2 (17%) had pulmonary disease.

Components of neuromuscular disease were present in many subjects although only three subjects had diseases that might interfere with respiratory function. Two subjects had cerebral vascular disease wtih residual weakness and one subject had spondylitis. The two subjects with cerebral vascular accidents had upper

Table 11

Number and Percentage of Thirty-four Subjects with Concurrent Disease Entities

| | |
|---|---|
| Cardiac | 16 (47%) |
| Pulmonary | 7 (21%) |
| Neuromuscular | 3 ( 9%) |

abdominal incisions in sequence 1. The patient with spondylitis had a combination incision with a sequence 2 placement (see Table 12).

The exact effect of each disease entity on ventilatory ability varies from subject to subject and from disease to disease. Therefore, subjects were used as their own controls in this study so that the variability would be kept to a minimum. Subjects were compared to themselves concerning their specific disease entity.

## Perioperative

The perioperative factors that impact upon ventilatory ability in postoperative patients include surgical time greater than two hours, complications in

Table 12

Number and Percentage of Subjects According to Specific Disease Entities Separated by Incisional Type and Positioning Sequence

| | Cardiac | Pulmonary | Neuromuscular |
|---|---|---|---|
| Incision Type | | | |
| Upper Abdominal[a] | 4 (40%) | 2 (20%) | 2 (20%) |
| Lower Abdominal[b] | 5 (38%) | 4 (31%) | 0 |
| Combination[c] | 7 (63%) | 1 ( 9%) | 1 ( 9%) |
| Position Sequence | | | |
| Sequence 1[d] | 12 (55%) | 5 (23%) | 2 ( 9%) |
| Sequence 2[e] | 4 (33%) | 2 (17%) | 1 ( 8%) |

[a]*n* = 10. [b]*n* = 13. [c]*n* = 11. [d]*n* = 22. [e]*n* = 12.

surgery including a blood loss greater than five hundred cubic centimeters, general anesthesia, and incisional type. Table 13 shows the perioperative characteristics of the sample population.

Incisional Type

Both upper abdominal and combination incisions tend to disrupt ventilatory ability in the postoperative period to a greater degree than lower abdominal incisions (Ali et al., 1974). Of the total sample, ten subjects

Table 13

*Perioperative Characteristics of Thirty-Four Subjects Separated by Incisional Type and Sequence*

| | Incision Type | | | Sequence | |
|---|---|---|---|---|---|
| | Upper[a] | Lower[b] | Comb.[c] | I[d] | II[e] |
| *Surgical Time* (minutes) | | | | | |
| Mean | 157.0 | 104.6 | 189.5 | 163.4 | 118.3 |
| Range | 80-285 | 45-315 | 60-330 | 45-330 | 55-220 |
| Std. Deviation | 59.9 | 69.8 | 82.9 | 87.3 | 45.8 |
| > 120 minutes | 7 | 3 | 9 | 13 | 6 |
| *Anesthesia* | | | | | |
| General | 10 | 11 | 11 | 20 | 12 |
| Spinal | 0 | 2 | 0 | 2 | 0 |
| *Est. Blood Loss* (cc) | | | | | |
| Mean | 154.5 | 72.3 | 441.8 | 258.8 | 112.9 |
| Range | 20-700 | 0-750 | 10-1300 | 0-1300 | 0-500 |
| Std. Deviation | 197.0 | 200.8 | 427.8 | 376.9 | 168.3 |
| > 500 cc | 1 | 1 | 3 | 5 | 0 |

*Note.* Comb. = combination incision.

[a]$n$ = 10. [b]$n$ = 13. [c]$n$ = 11. [d]$n$ = 22. [e]$n$ = 12.

(29%) had upper abdominal incisions, thirteen subjects (38%) had lower abdominal incisions, and eleven subjects (32%) had combination incisions. Sequence 1 had six subjects (27%) with upper abdominal incisions and eight subjects (36%) with combination incisions. Sequence 2 had four subjects (34%) with upper abdominal incisions and three subjects (25%) with combination incisions.

### Operative Complications and Length of Surgical Procedure

Two subjects had operative complications. One subject with a combination incision in sequence 2 was slow to awaken and one subject with a lower abdominal incision in sequence 1 had a complication of the nicking of the spermatic artery during the operative procedure.

The risk of developing pulmonary complications in the postoperative period increases as the surgical times become greater than two hours regardless of the amount of time over two hours. Table 14 shows the characteristics of the length of surgery for the sample population.

The highest mean for the amount of surgical time was in the subjects with combination incisions (see Table 13). Seven subjects with upper abdominal incisions (70%) had surgical times greater than two hours and nine subjects with combination incisions (81%) had surgical times greater than two hours. Three subjects with lower

Table 14

Mean, Range, and Standard Deviation for the Length of Surgery for the Thirty-four Sample Subjects

| | |
|---|---|
| Mean | 147.5 Minutes |
| Range | 45 to 330 Miinutes |
| Standard Deviation | 78.6 Minutes |
| Number of Subjects with Operative Time >120 Minutes | 19 (56%) |

abdominal incisions (23%) had surgical times greater than two hours. Thirteen subjects in sequence 1 (59%) had increased times as compared with six subjects in sequence 2 (50%).

Type of Anesthesia

Thirty-two subjects had general anesthesia and two subjects had spinal anesthesia. The two subjects with spinal anesthesia had lower abdominal incisions and were in sequence 1.

Estimated Blood Loss in Surgery

The greatest mean for estimated blood loss greater than 500 cc occurred in the combination group. Only five subjects experienced this type of blood loss. Three subjects were in the combination incision group, one was in the upper abdominal incision group, and one was in the lower abdominal incision group. All of the five with estimated blood loss greater than 500 cc were in sequence 1 (see Table 13).

## Postoperative

The postoperative factors that influence ventilatory ability in the postoperative period include sedative and narcotic use, respiratory therapy interventions, and positioning interventions.

### Narcotics and Sedatives

The use of narcotics and sedatives in the postoperative patient has a depressive effect upon ventilatory ability (Gilman et al., 1985). However, in the present study, no attempt was made to standardize the types of medications given nor the time period between the administration of the medications and the pulmonary function testing. Wide variances exist in the study between individual subjects' use of these medications in the postoperative period. Therefore, no trends in the administration of medications and the measurement of pulmonary function tests can be extrapolated.

Respiratory Interventions

The use of respiratory therapy interventions is noted in Table 15. The respiratory therapy that is most often ordered by the physician for the postoperative patient is incentive spirometry. Incentive spirometry was ordered much less frequently for subjects with lower abdominal incisions in the present study. Nine subjects with upper abdominal incisions (90%) had the intervention ordered, as compared with eight subjects with combination incisions (72%), and four subjects with lower abdominal incisions (30%). Thirteen subjects in sequence 1 (59%) had the intervention ordered and eight subjects in sequence 2 (67%). The documentation of the actual use of the intervention was not recorded.

Positioning

The last area of influence of ventilatory ability in the postoperative period was the nursing intervention of positioning. Table 15 records the positioning documented for the sample population. The numbers in the chart show that ten patients with lower abdominal incisions had been out of bed walking prior to the pulmonary function testing the morning after surgery. One patients with upper abdominal incisions and two subjects with combination incisions had walked prior to pulmonary function testing. Many subjects in the upper abdominal

Table 15

Number and Percentage of Subjects Who Used the Incentive Spirometer and Were Repositioned in the Postoperative Period Separated by Incisional Type and Positioning Sequence

| | Incentive Spirometer | Ambulated | Chair | Dangled |
|---|---|---|---|---|
| Incision Type | | | | |
| Upper Abdominal[a] | 9 (90%) | 1 (10%) | 2 (20%) | 2 (20%) |
| Lower Abdominal[b] | 4 (30%) | 10 (77%) | 2 (15%) | 0 |
| Combination[c] | 8 (72%) | 2 (18%) | 3 (27%) | 1 ( 9%) |
| Total Subjects | 21 | 13 | 7 | 3 |
| Position Sequence | | | | |
| Sequence 1[d] | 13 (59%) | 8 (44%) | 3 (13%) | 3 (13%) |
| Sequence 2[e] | 8 (67%) | 5 (45%) | 4 (33%) | 0 |
| Total Subjects | 21 | 13 | 7 | 3 |

[a]$n$ = 10. [b]$n$ = 13. [c]$n$ = 11. [d]$n$ = 22. [e]$n$ = 12.

and combination groups had not been out of bed since surgery. Physicians orders may have read "ambulate in morning" to restrict some of this activity. Eight subjects in sequence 1 (36%) ambulated as compared wtih eight subjects in sequence 2 (67%).

As Table 15 indicates the subjects with different repositioning interventions. This particular intervention was much less likely to be carried out for the sample population than ambulation.

The characteristics for the sample population have been presented. Factors that have been implicated in the developement of postoperative pulmonary complications have been reviewed. These factors may alter the relationships between the independent and dependent variables in the study. Further analysis of the data gathered for the study will help to clarify some of the relationships between the dependent, independent, and control variables.

## Tidal Volume

The tidal volume was calculated by dividing the minute ventilation by the respiratory rate. Normal tidal volume is 6 to 7 milliliters per kilogram of body weight. To calculate the normal tidal volume for a subject, the body weight was divided by 6 and by 7 to give a range of normal. These numbers were then used to determine if the subjects' tidal volume measurement value was decreased, increased, or within the predicted range of normal.

### Effect of Positioning Upon Tidal Volume

The means for the tidal volume were (a) 492 ml with the head of the bed flat, (b) 530 ml with the head of the bed elevated 45 degrees, and (c) 572 ml with the head of the bed elevated 90 degrees (see Figure 2). The tidal volume increased as the subjects went from head of the bed flat to head of the bed 45 degrees to head of the bed 90 degrees. Table 16 shows that the F statistic was significant for a relationship between positioning and tidal volume ($F = 4.03$, $p = .022$). The t-statistic for the difference in group means between the head of the bed flat and elevated 90 degrees (see Table 17) was significant ($t = 2.83$, $p \leq .01$). Significance was seen with the entire move from flat to 90 degrees and not with incremental moves

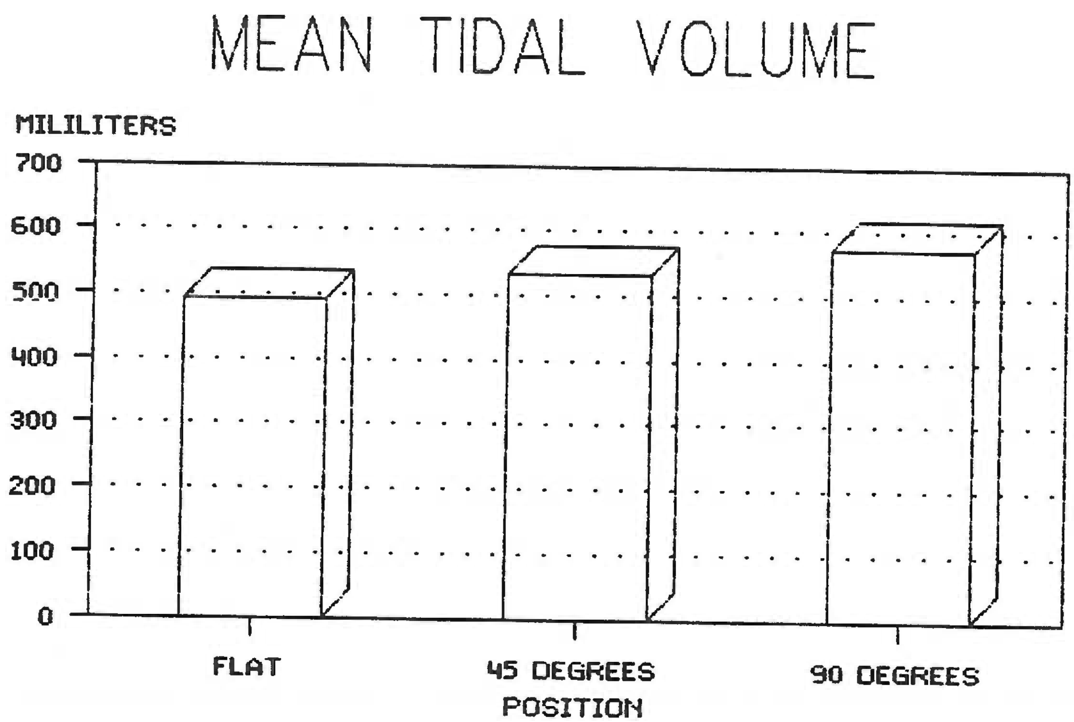



Figure 2. Comparison of the mean tidal volume of 34 subjects for three positions.

Table 16

Analysis of Variance Summaries for the Tidal Volume

| | Sum of Squares | df | Mean Square | Grand Mean | F | Probability |
|---|---|---|---|---|---|---|
| **Total** | | | | | | |
| Sample | | | | | | |
| Between | 6,326,682 | 33 | 191,717 | | | |
| Within | 999,412 | 68 | 14,697 | | | |
| Between Measures | 108,757 | 2 | 54,379 | 531.5 | 4.03 | .022 |
| Residual | 890,655 | 66 | 13,495 | | | |
| Total | 7,326,097 | 101 | 72,536 | | | |
| **Incision** | | | | | | |
| Upper Abdominal | | | | | | |
| Between | 1,539,099 | 9 | 171,011 | | | |
| Within | 205,360 | 20 | 10,268 | | | |
| Between Measures | 42,690 | 2 | 21,354 | 542.9 | 2.36 | .123 |
| Residual | 162,670 | 18 | 9,037 | | | |
| Total | 1,744,459 | 29 | 60,154 | | | |
| Lower Abdominal | | | | | | |
| Between | 3,631,233 | 12 | 302,603 | | | |
| Within | 279,195 | 26 | 10,738 | | | |
| Between Measures | 11,327 | 2 | 5,663 | 545.2 | 0.51 | .608 |
| Residual | 267,869 | 24 | 11,161 | | | |
| Total | 3,910,428 | 38 | 102,906 | | | |
| Combination | | | | | | |
| Between | 1,122,008 | 10 | 112,201 | | | |
| Within | 514,857 | 22 | 23,403 | | | |
| Between Measures | 123,146 | 2 | 61,573 | 505.0 | 3.14 | .065 |
| Residual | 391,710 | 20 | 19,586 | | | |
| Total | 1,636,865 | 32 | 51,152 | | | |
| **Sequence** | | | | | | |
| Sequence 1 | | | | | | |
| Between | 4,662,578 | 21 | 222,028 | | | |
| Within | 787,039 | 44 | 17,887 | | | |
| Between Measures | 187,711 | 2 | 93,855 | 514.4 | 6.58 | .003 |
| Residual | 599,329 | 42 | 14,270 | | | |
| Total | 5,449,617 | 65 | 83,840 | | | |
| Sequence 2 | | | | | | |
| Between | 1,609,005 | 11 | 146,273 | | | |
| Within | 212,373 | 24 | 8,849 | | | |
| Between Measures | 2,888 | 5 | 1,444 | 563.0 | 0.15 | .860 |
| Residual | 209,485 | 22 | 9,522 | | | |
| Total | 1,821,378 | 35 | 52,039 | | | |

Table 17

Comparison of the Tidal Volume Means for the Three

Positions of Flat, 45 Degrees, and 90 Degrees

Using a Planned T-test and Tukey Test

| | $\bar{x}_1 - \bar{x}_2$ | | | | $\bar{x}_2 - \bar{x}_3$ | | | | $\bar{x}_1 - \bar{x}_3$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}_1$ | $\bar{x}_2$ | t | q | $\bar{x}_2$ | $\bar{x}_3$ | t | q | $\bar{x}_1$ | $\bar{x}_3$ | t | q |
| Sample Population | 492 | 531 | 1.37 | 1.94 | 531 | 572 | 1.46 | 2.07 | 492 | 572 | 2.83* | 4.01** |
| Upper Abdominal Incisions | 512 | 521 | 0.21 | 0.30 | 521 | 596 | 1.77** | 2.50 | 512 | 596 | 1.98** | 2.80 |
| Lower Abdominal Incisions | 539 | 529 | 0.73 | -0.34 | 529 | 569 | 0.97 | 1.37 | 539 | 569 | -0.24 | 1.03 |
| Combination Incisions | 419 | 542 | 2.26** | 2.92 | 542 | 554 | 0.20 | 0.28 | 419 | 554 | 2.07** | 3.20 |
| Sequence 1 | 453 | 507 | 1.51 | 2.13 | 507 | 583 | 2.10** | 2.97 | 453 | 583 | 3.61* | 5.09 |
| Sequence 2 | 564 | 574 | -0.25 | 0.35 | 574 | 552 | -0.55 | -0.78 | 564 | 552 | -0.30 | -0.42 |

$\bar{x}_1$ = Head of Bed Flat

$\bar{x}_2$ = Head of Bed 45 Degrees

$\bar{x}_3$ = Head of Bed 90 Degrees

* $p \leq .01$

** $p \leq .05$

from flat to 90 degrees. This finding was supported by the Tukey test ($q = 4.01$, $p \leq .05$).

## Effect of Positioning Upon Tidal Volume for the Three Incisional Types

The means for the tidal volume were (a) 512 ml with the head of the bed flat, (b) 521 ml with the head of the bed at 45 degrees, and (c) 596 ml with the head of the bed at 90 degrees for the upper abdominal incisiion group. The means for the lower abdominal incision group were (a) 539 ml with the head of the bed flat, (b) 529 ml with the head of the bed 45 degrees, and (c) 569 ml with the head of the bed 90 degrees. The combination incision group had tidal volume means of (a) 419 ml with the head of the bed flat, (b) 542 ml with the head of the bed 45 degrees, and (c) 554 ml with the head of the bed 90 degrees (see Figure 3). The tidal volume improved for subjects with the move from flat to 90 degrees. The F statistic to describe the relationship between tidal volume and the three positions for the incisional types was 2.36 ($p = .123$) for the upper abdominal group, 0.51 ($p = .608$) for the lower abdominal group, and 3.14 ($p = .065$) for the combination group (see Table 16). The analysis of the three incisional types with the changes in tidal volume with the three positions did not produce a significant value. This is contrary to the

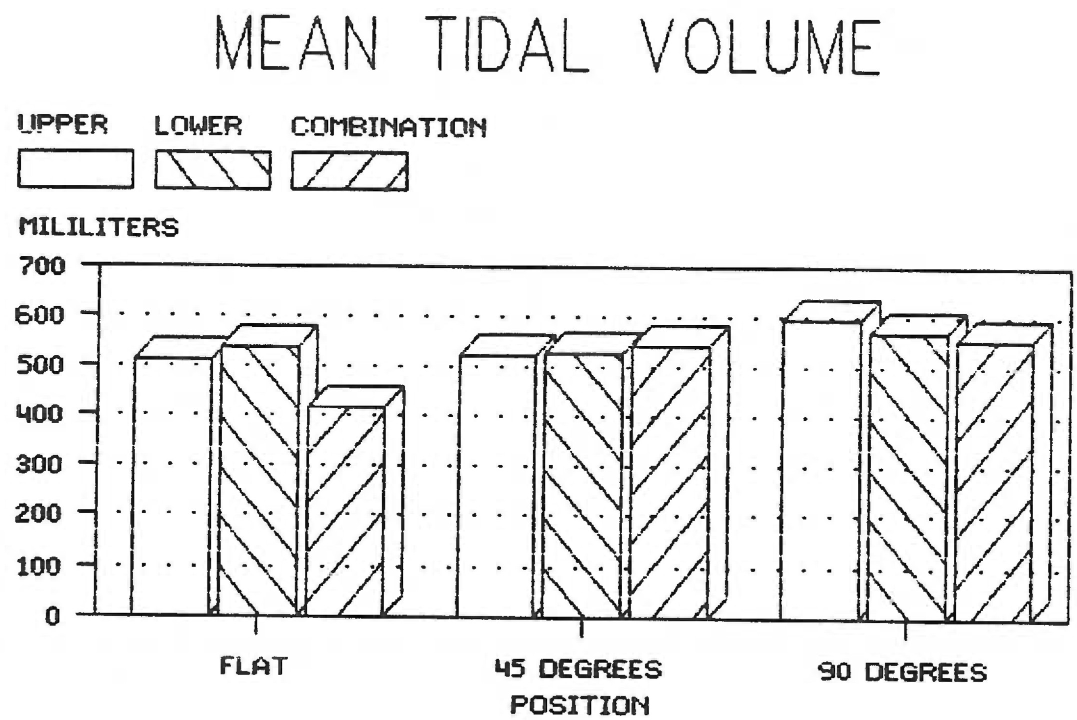



Figure 3. Comparison of the mean tidal volume of 34 subjects by incisional type for three positions.

to the research information that describes a significant relationship between incisional type and pulmonmary function measures. Further investigation of the results is necessary.

The t-test was significant for the difference in means between the head of bed flat and the head of the bed elevated 45 degrees for the combination incision group ($t = 2.26$, $p \leq .05$). Signifcance was also seen in the difference between means for the head at 45 degrees and the head of the bed elevated 90 degrees for the upper abdominal incision group ($t = 1.77$, $p \leq .05$). Finally, significance was seen in the difference between means for the head of the bed flat and the head of the bed elevated 90 degrees for the upper abdominal incision group ($t = 1.98$, $p \leq .05$) and the combination incision group ($t = 2.07$, $p \leq .05$) (see Table 17).

## Effect of Positioning Upon Tidal Volume for Two Sequences

The two sequences of positioning compared by tidal volume were sequence 1, head of bed flat to 45 degrees to 90 degrees, and sequence 2, head of bed 90 degrees to 45 degrees to flat. The means for the tidal volume for sequence 1 were (a) 453 ml with the head of the bed flat, (b) 507 ml with the head of the bed at 45 degrees, and (c) 552 ml with the head of the bed at 90 degrees. The means for the tidal volume for sequence 2 were (a) 564 ml with the head of the bed flat, (b) 574 ml with the head of the bed at 45 degrees, and (c) 552 ml with the head of the bed at 90 degrees (see Figure 4). The F statistic for the relationship between tidal volume and positioning for the two sequences was 6.57 ($p = .003$) for sequence 1 and 0.15 ($p = .860$) for sequence 2 (see Table 16). Positioning did have a significant impact upon tidal volume measurements for sequence 1 subjects.

For sequence 1 subjects, the t-statistic was 2.10 ($p \leq .05$) for the difference between the means for 45 to 90 degrees and 3.61 ($p \leq .01$) for the difference between the means for flat to 90 degrees (see Table 17). Sequence 1 subjects had higher tidal volume measurements when the head of the bed was elevated from the flat position. Sequence 2 subjects had no significant t-test values. Tukey values were not significant for any of the differences between means.

## Effect of Control Variables Upon Positioning and Tidal Volume

The factors that influence tidal volume have been identified for the preoperative, perioperative, and postoperative periods (see Tables 1, 2, and 3).

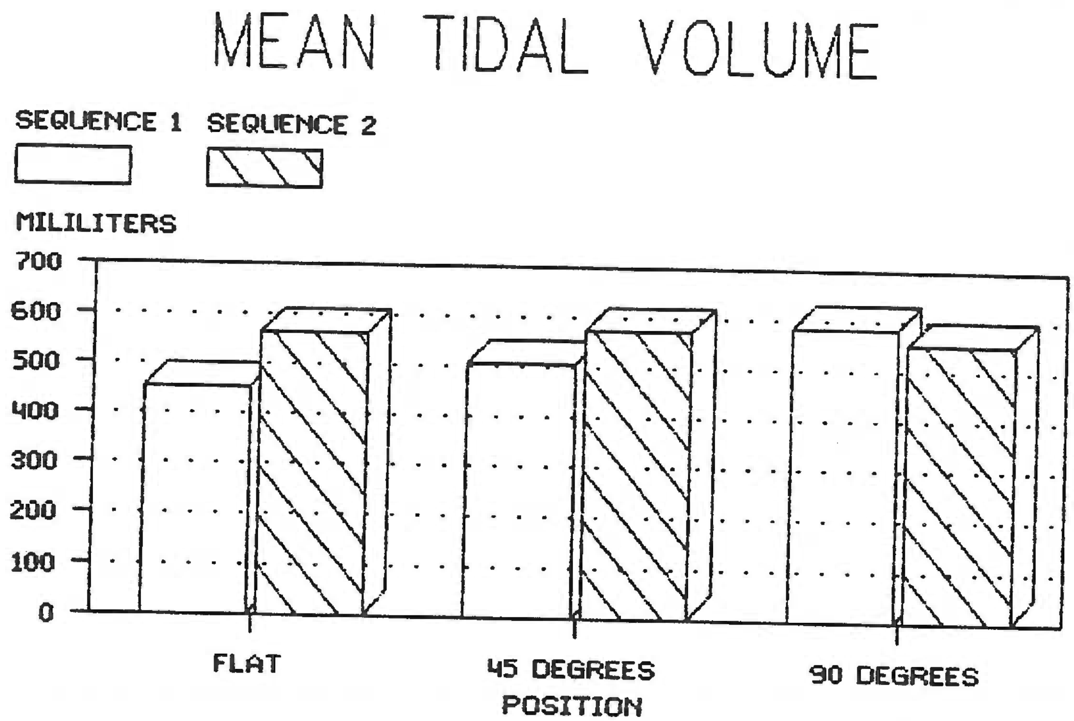



Figure 4. Comparison of the mean tidal volume of 34 subjects by sequence for three positions.

## Preoperative Factors

Age. Table 18 shows that 24 subjects were over age 50. The greatest increase in tidal volume occurred with the move from flat to 45 degrees for four subjects. The move from 45 degrees to 90 degrees was not notable.

Table 18

Twenty-four Subjects over Age 50 Grouped According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| Decreased Tidal Volume | 15 | 11 | 10 |
| Predicted Tidal Volume | 4 | 6 | 8 |
| Increased Tidal Volume | 5 | 7 | 6 |
| | 24 | 24 | 24 |

When subjects over age 50 were separated by incisional type, the combination incisional group was most successful in increasing tidal volume with positioning (see Table 19). The move from flat to 45 degrees was the best position change for increasing the value for three of these subjects.

Table 19

Twenty-four Subjects over Age 50 Separated by Incisional Type According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| UPPER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 6 | 5 | 6 |
| Predicted Tidal Volume | 2 | 3 | 2 |
| Increased Tidal Volume | 1 | 1 | 1 |
| | 9 | 9 | 9 |
| LOWER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 2 | 2 | 1 |
| Predicted Tidal Volume | 1 | 0 | 1 |
| Increased Tidal Volume | 2 | 3 | 3 |
| | 5 | 5 | 5 |
| COMBINATION SUBJECTS | | | |
| Decreased Tidal Volume | 7 | 4 | 3 |
| Predicted Tidal Volume | 1 | 3 | 5 |
| Increased Tidal Volume | 2 | 3 | 2 |
| | 10 | 10 | 10 |

All subjects over the age of fifty separated according to sequence of position, improved tidal volume in the move from flat to head elevated to 45 degrees. Sequence 1 subjects, however, continued to improve tidal volume with the move to 90 degrees (see Table 20). A similar improvement in tidal volume with the flat to 45 degree move position change was seen with combination subjects who were over age 50.

Table 20

Twenty-four Subjects over Age 50 Separated by Sequence According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| SEQUENCE 1 SUBJECTS | | | |
| Decreased Tidal Volume | 9 | 7 | 6 |
| Predicted Tidal Volume | 3 | 4 | 5 |
| Increased Tidal Volume | 4 | 5 | 5 |
| | 16 | 16 | 16 |
| SEQUENCE 2 SUBJECTS | | | |
| Decreased Tidal Volume | 6 | 4 | 4 |
| Predicted Tidal Volume | 1 | 2 | 3 |
| Increased Tidal Volume | 1 | 2 | 1 |
| | 8 | 8 | 8 |

*Weight/Height Ratios*. Table 19 shows that 15 subjects were greater than 10% overweight. Overweight subjects were able to increase tidal volume measures in the move from flat to 45 degrees with only a minimal increase in the move from 45 to 90 degrees. Six underweight subjects in the sample did not demonstrate any trends in tidal volume measures with positioning.

Table 21

*Fifteen Overweight Subjects and Six Underweight Subjects Grouped According to Mean Tidal Volume in Three Positions*

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| OVERWEIGHT SUBJECTS | | | |
| Decreased Tidal Volume | 10 | 8 | 7 |
| Predicted Tidal Volume | 3 | 4 | 4 |
| Increased Tidal Volume | 2 | 3 | 4 |
| | 15 | 15 | 15 |
| UNDERWEIGHT SUBJECTS | | | |
| Decreased Tidal Volume | 4 | 4 | 3 |
| Predicted Tidal Volume | 1 | 0 | 1 |
| Increased Tidal Volume | 1 | 2 | 2 |
| | 6 | 6 | 6 |

The separation of the subjects into incisional types showed that the lower abdominal incision subjects and combination subjects who were overweight improved tidal volume with the move from flat to 90 degrees. The upper abdominal subjects had higher tidal volume measures in the 45 degree position (see Table 22).

Table 22

Fifteen Overweight Subjects Separated by Incisional Type According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| UPPER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 4 | 2 | 4 |
| Predicted Tidal Volume | 1 | 3 | 2 |
| Increased Tidal Volume | 1 | 1 | 0 |
| | 6 | 6 | 6 |
| LOWER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 3 | 3 | 1 |
| Predicted Tidal Volume | 1 | 0 | 2 |
| Increased Tidal Volume | 1 | 2 | 2 |
| | 5 | 5 | 5 |
| COMBINATION SUBJECTS | | | |
| Decreased Tidal Volume | 4 | 3 | 2 |
| Predicted Tidal Volume | 0 | 1 | 2 |
| Increased Tidal Volume | 0 | 0 | 0 |
| | 4 | 4 | 4 |

The overweight subjects categorized by sequence are presented in Table 23. Sequence 1 subjects improved tidal volume values as the head of the bed was raised. The greater increase was in the move from 45 to 90 degrees. No trends were seen with the sequence 2 subjects.

Table 23

*Fifteen Overweight Subjects Separated by Sequence According to Mean Tidal Volume in Three Positions*

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| SEQUENCE 1 SUBJECTS | | | |
| Decreased Tidal Volume | 7 | 6 | 4 |
| Predicted Tidal Volume | 2 | 2 | 3 |
| Increased Tidal Volume | 2 | 3 | 4 |
| | 11 | 11 | 11 |
| SEQUENCE 2 SUBJECTS | | | |
| Decreased Tidal Volume | 3 | 2 | 3 |
| Predicted Tidal Volume | 1 | 2 | 1 |
| Increased Tidal Volume | 0 | 0 | 0 |
| | 4 | 4 | 4 |

*Concurrent Disease Entities*. Sixteen subjects with cardiac disease, seven with pulmonary disease, and three with neuromuscular disease were in the sample population (see Table 24). The subjects with cardiac disease supported the trend of improvement in tidal volume as the head of the bed was elevated with each positional change. The subjects with pulmonary disease supported the trend for tidal volume improvement in the move from 45 to 90 degrees. Three subjects had neuromuscular disease. Due to the small number of subjects in the category no trends were seen with positioning and the data was not included in the table.

Table 24

Sixteen Subjects with Cardiac Disease and Seven Subjects with Pulmonary Disease Grouped According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| CARDIAC SUBJECTS | | | |
| Decreased Tidal Volume | 11 | 8 | 6 |
| Predicted Tidal Volume | 3 | 3 | 6 |
| Increased Tidal Volume | 2 | 5 | 4 |
| | 16 | 16 | 16 |
| PULMONARY SUBJECTS | | | |
| Decreased Tidal Volume | 4 | 5 | 2 |
| Predicted Tidal Volume | 2 | 1 | 4 |
| Increased Tidal Volume | 1 | 1 | 1 |
| | 7 | 7 | 7 |

Table 25 and Table 26 show the distribution of concurrent disease entities for the three incisional types. The tidal volume measurements support the expected trend of an increase as the head of the bed is elevated from flat to 45 to 90 degrees for the combination incision subjects (greatest increase in flat to 45 degree change) and sequence 1 subjects (a gradual increase in tidal volume with the three positional changes) with cardiac disease. Subjects with pulmonary and neuromuscular disease in the three incisional types and two sequences showed no trends (see Tables E-1, E-2, and E-3).

Perioperative Factors

Operative Complications. Because of the small number of subjects with complications no trends could be determined. Two subjects had perioperative complications.

Surgical Length. Four out of nineteen subjects with operative times greater than two hours increased tidal volume to normal or greater when the position was changed from flat to head of bed 90 degrees (see Table 27). The change in tidal volume occurred with the move to 45 degrees but no further change occurred with the move to 90 degrees. The trend of gradual increase in tidal volume was only supported to the 45 degree position. Three of the four subjects were in the combination incisional group (see Table 28). When separated according to sequence two

Table 25

Sixteen Subjects with Cardiac Disease Separated by Incisional Type According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| UPPER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 1 | 1 | 2 |
| Predicted Tidal Volume | 2 | 2 | 1 |
| Increased Tidal Volume | 1 | 1 | 1 |
| | 4 | 4 | 4 |
| LOWER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 3 | 3 | 2 |
| Predicted Tidal Volume | 1 | 0 | 1 |
| Increased Tidal Volume | 1 | 2 | 2 |
| | 5 | 5 | 5 |
| COMBINATION SUBJECTS | | | |
| Decreased Tidal Volume | 7 | 4 | 2 |
| Predicted Tidal Volume | 0 | 1 | 4 |
| Increased Tidal Volume | 0 | 2 | 1 |
| | 7 | 7 | 7 |

Table 26

Subjects with Concurrent Cardiac, Pulmonary, and Neuromuscular Disease Separated According to Mean Tidal Volume in Three Positions for Sequence 1

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| CARDIAC SUBJECTS | | | |
| Decreased Tidal Volume | 8 | 6 | 4 |
| Predicted Tidal Volume | 2 | 2 | 4 |
| Increased Tidal Volume | 2 | 4 | 4 |
| | 12 | 12 | 12 |
| PULMMONARY SUBJECTS | | | |
| Decreased Tidal Volume | 3 | 4 | 2 |
| Predicted Tidal Volume | 2 | 1 | 3 |
| Increased Tidal Volume | 0 | 0 | 0 |
| | 5 | 5 | 5 |
| NEUROMUSCULAR SUBJECTS | | | |
| Decreased Tidal Volume | 1 | 1 | 1 |
| Predicted Tidal Volume | 1 | 1 | 1 |
| Increased Tidal Volume | 0 | 0 | 0 |
| | 2 | 2 | 2 |

Table 27

*Subjects with Surgical Traits Grouped According to Mean Tidal Volume in Three Positions*

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| OPERATIVE TIME[a] | | | |
| Decreased Tidal Volume | 14 | 10 | 10 |
| Predicted Tidal Volume | 2 | 5 | 5 |
| Increased Tidal Volume | 3 | 4 | 4 |
| | 19 | 19 | 19 |
| BLOOD LOSS[b] | | | |
| Decreased Tidal Volume | 4 | 2 | 2 |
| Predicted Tidal Volume | 0 | 1 | 1 |
| Increased Tidal Volume | 1 | 2 | 2 |
| | 5 | 5 | 5 |
| COMPLICATIONS[c] | | | |
| Decreased Tidal Volume | 0 | 1 | 1 |
| Predicted Tidal Volume | 1 | 0 | 0 |
| Increased Tidal Volume | 1 | 1 | 1 |
| | 2 | 2 | 2 |

*Note*. Operative time = > two hours.

Blood loss = > 500 cc.

[a]$n$ = 19. [b]$n$ = 5. [c]$n$ = 2.

Table 28

Nineteen Subjects with Operative Time Greater than Two Hours Separated by Incisional Type According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| UPPER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 6 | 5 | 5 |
| Predicted Tidal Volume | 1 | 2 | 1 |
| Increased Tidal Volume | 0 | 0 | 1 |
| | 7 | 7 | 7 |
| LOWER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 3 | 3 | 3 |
| Predicted Tidal Volume | 0 | 0 | 0 |
| Increased Tidal Volume | 0 | 0 | 0 |
| | 3 | 3 | 3 |
| COMBINATION SUBJECTS | | | |
| Decreased Tidal Volume | 5 | 2 | 2 |
| Predicted Tidal Volume | 1 | 3 | 4 |
| Increased Tidal Volume | 3 | 4 | 3 |
| | 9 | 9 | 9 |

Table 29

Nineteen Subjects with Operative Times Greater than Two Hours Separated by Sequence According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| SEQUENCE 1 SUBJECTS | | | |
| Decreased Tidal Volume | 9 | 7 | 7 |
| Predicted Tidal Volume | 2 | 4 | 3 |
| Increased Tidal Volume | 2 | 2 | 3 |
| | 13 | 13 | 13 |
| SEQUENCE 2 SUBJECTS | | | |
| Decreased Tidal Volume | 5 | 4 | 3 |
| Predicted Tidal Volume | 0 | 1 | 2 |
| Increased Tidal Volume | 1 | 2 | 1 |
| | 6 | 6 | 6 |

subjects were in sequence 1 and two subjects were in sequence 1 (see Table 29).

Estimated Blood Loss. Five subjects had estimated blood loss greater than 500 cc. The small number of subjects with large blood loss makes this variable of limited value.

Postoperative Factors

Use of Incentive Spirometer. The incentive spirometer was the most common intervention used to assist the postoperative patient in improving ventilatory ability. Twenty-one subjects had the intervention ordered in the postoperative period. Again, changes in tidal volume occurred with the move from flat to 45 degrees with no further increase in the value as the head of the bed was elevated to 90 degrees. Table 30 shows that the greatest change in tidal volume with positioning occurred with subjects in the combination incisional group who used the intervention. No trends in tidal volume values were seen when subjects were separated into sequence (see Table E-4).

Ambulation and Repositioning. Table 31 shows the tidal volume measurements in the three positions with subjects who had ambulated or been repositioned in the postoperative period. Thirteen subjects were ambulated. Little improvement in tidal volume was seen in the move from flat to 45 degrees but four subjects improved with the move from 45 to 90 degrees. Ten subjects were repositioned. No trends in tidal volume measurement were seen with this group of subjects.

The subjects who had ambulated before testing were divided into upper abdominal incision subjects (1), lower abdominal incision subjects (10), and combination incision

Table 30

Twenty-one Subjects Who Used the Incentive Spirometer Separated by Incisional Type According to Mean Tidal Volume in Three Positions

| | Position | | |
| --- | --- | --- | --- |
| | Flat | 45 | 90 |
| UPPER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 5 | 5 | 5 |
| Predicted Tidal Volume | 3 | 3 | 2 |
| Increased Tidal Volume | 1 | 1 | 2 |
| | 9 | 9 | 9 |
| LOWER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 2 | 3 | 2 |
| Predicted Tidal Volume | 1 | 0 | 1 |
| Increased Tidal Volume | 1 | 1 | 1 |
| | 4 | 4 | 4 |
| COMBINATION SUBJECTS | | | |
| Decreased Tidal Volume | 4 | 1 | 2 |
| Predicted Tidal Volume | 1 | 3 | 3 |
| Increased Tidal Volume | 3 | 4 | 3 |
| | 8 | 8 | 8 |

Table 31

Thirteen Ambulated and Ten Repositioned Subjects in the Postoperative Period Grouped According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| AMBULATED SUBJECTS | | | |
| Decreased Tidal Volume | 8 | 8 | 5 |
| Predicted Tidal Volume | 2 | 1 | 4 |
| Increased Tidal Volume | 2 | 3 | 3 |
| | 13 | 13 | 13 |
| REPOSITIONED SUBJECTS | | | |
| Decreased Tidal Volume | 5 | 5 | 3 |
| Predicted Tidal Volume | 3 | 2 | 4 |
| Increased Tidal Volume | 2 | 3 | 3 |
| | 10 | 10 | 10 |

subjects (2). The subjects who had been repositioned were four upper abdominal incision subjects, two lower abdominal incision subjects, and three combination incision subjects. No trends in tidal volume were seen with positioning in these groups of subjects. The separation of subjects who ambulated and were repositioned in the two sequences is presented in Appendix E-5 and E-6. The number of subjects who changed tidal volume with positioning were too small to discover any trends for the two sequences.

The combination incision subjects supported the t-test result of the significance in the move from flat to 45 degrees. The control variables that seemed to effect the result were presence of cardiac disease, extended operative times, and incentive spirometer usage. The presence of pulmonary disease most influenced the tidal volume change 45 to 90 degrees. The t-test that demonstrated the significance of the move 45 to 90 degrees for upper abdominal incision subjects could not be explained. Only two upper abdominal incision subjects had concurrent pulmonary disease.

## Respiratory Rate

The respiratory rate is the number of breaths taken per minute. The rate is voluntarily and involuntarily controlled by the patient. Rates vary from minute to minute. The normal adult rate is 12 to 18 per minute.

### Effect of Positioning Upon Respiratory Rate

The means for the respiratory rate were (a) 17.1 breaths per minute with the head of the bed flat, (b) 17.3 breaths per minute with the head of the bed elevated 45 degrees, and (c) 17.7 breaths per minute with the head ofthe bed elevated 90 degrees (see Figure 5). The F statistic was 0.56 (p = .571) to describe the relationship between positioning and the respiratory rate (see Table F-1). The t-test and Tukey tests did not show any significant differences between means (see Table F-2).

## Effect of Positioning Upon Respiratory Rate for Three Incisional Types

The means for the respiratory rate were (a) 19.4 breaths per minute with the head of the bed flat, (b) 18.8 breaths per minute with the head of the bed elevated 45 degrees, (c) 17.8 breaths per minute with the head of the bed elevated 90 degrees for the upper abdominal incision group. The means for the lower abdominal incision group were (a) 17.2 breaths per minute with the head of the bed flat, (b) 17.5 breaths per minute with the head of the bed elevated 45 degrees, and (c) 18.5 breaths per minute with the head of bed elevated 90 degrees. The combination incision group had respiratory rate means of (a) 14.9 breaths per minute with the head of the bed flat, (b) 15.6 breaths per minute with the head of the bed elevated 45 degrees, and (c) 16.6 breaths per minute with the head of the bed elevated 90 degrees (see Figure 6). The F statistic to describe the relationship of positioning and

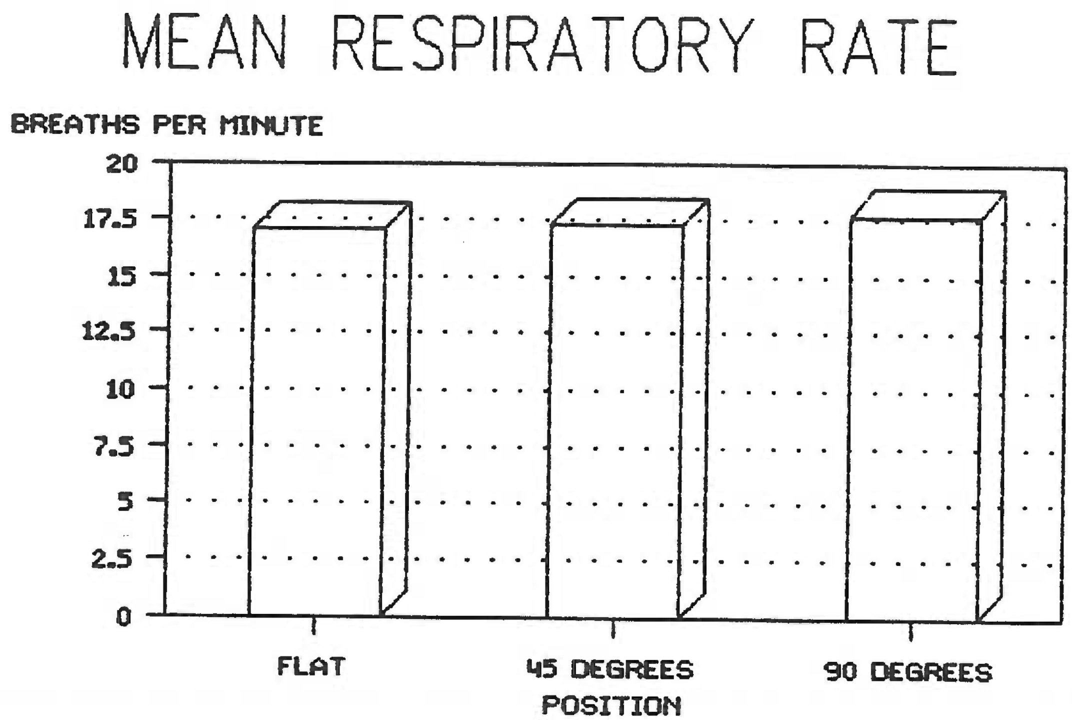



Figure 5. Comparison of the mean respiratory rate of 34 subjects for three positions.

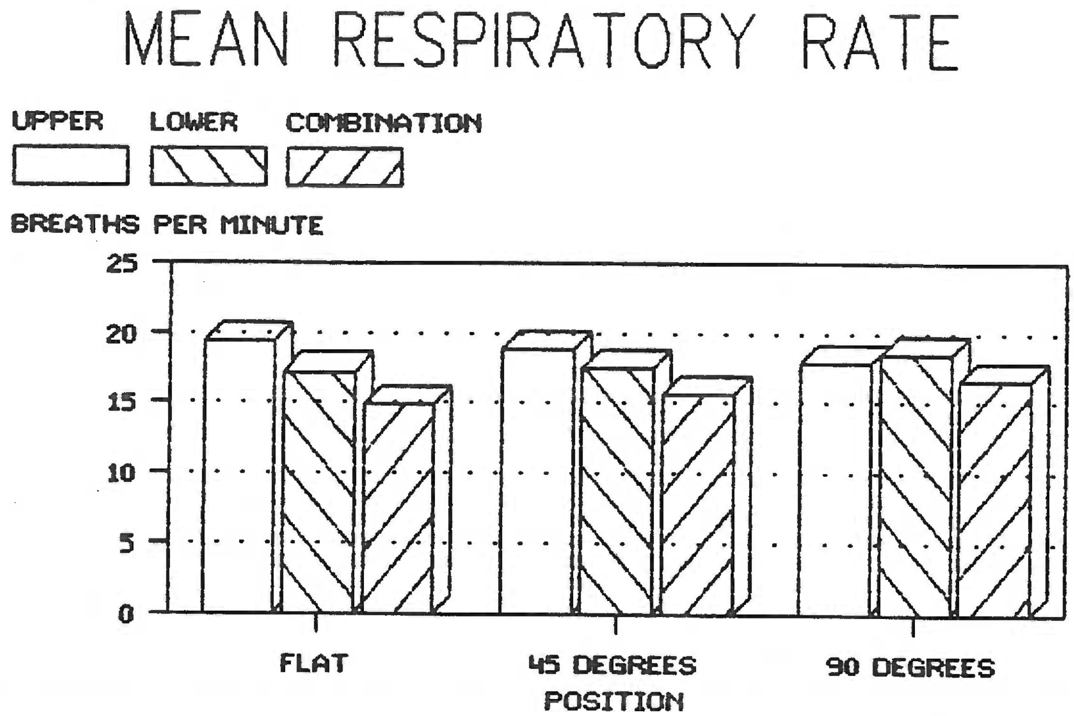



Figure 6. Comparison of the mean respiratory rate of 34 subjects by incisional type for three positions.

respiratory rate for the incisional types was 1.10 ($p = .354$) for the upper abdominal incision group, 1.10 ($p = .352$) for the lower abdominal incision group, and 2.53 ($p = .105$) for the combination incision group (see Table F-1). A t-test comparing the means for the flat position to the 90 degree position was significant for the combination incisional group ($t = 2.25$, $p \leq .05$) (see Table F-2). The t-test value follows one seen with tidal volume in combination incsion subjects.

## Effect of Positioning Upon Respiratory Rate for Two Sequences

The means for the respiratory rate for sequence 1 were (a) 16.9 breaths per minute with the head of the bed flat, (b) 17.5 breaths per minute with the head of the bed elevated 45 degrees, and (c) 17.8 breaths per minute with the head of the bed elevated 90 degrees. The means for the respiratory rate for sequence 2 were (a) 17.5 breaths per minute with the head of the bed flat, (b) 16.8 breaths per minute with the head of the bed elevated 45 degrees, and (c) 17.4 breaths per minute with the head of the bed elevated 90 degress (see Figure 7). The F statistic to describe the relationship between positioning and respiratory rate for the two sequences was 1.29 ($p = .286$) for sequence 1 and 0.22 ($p = .807$) for sequence 2 (see

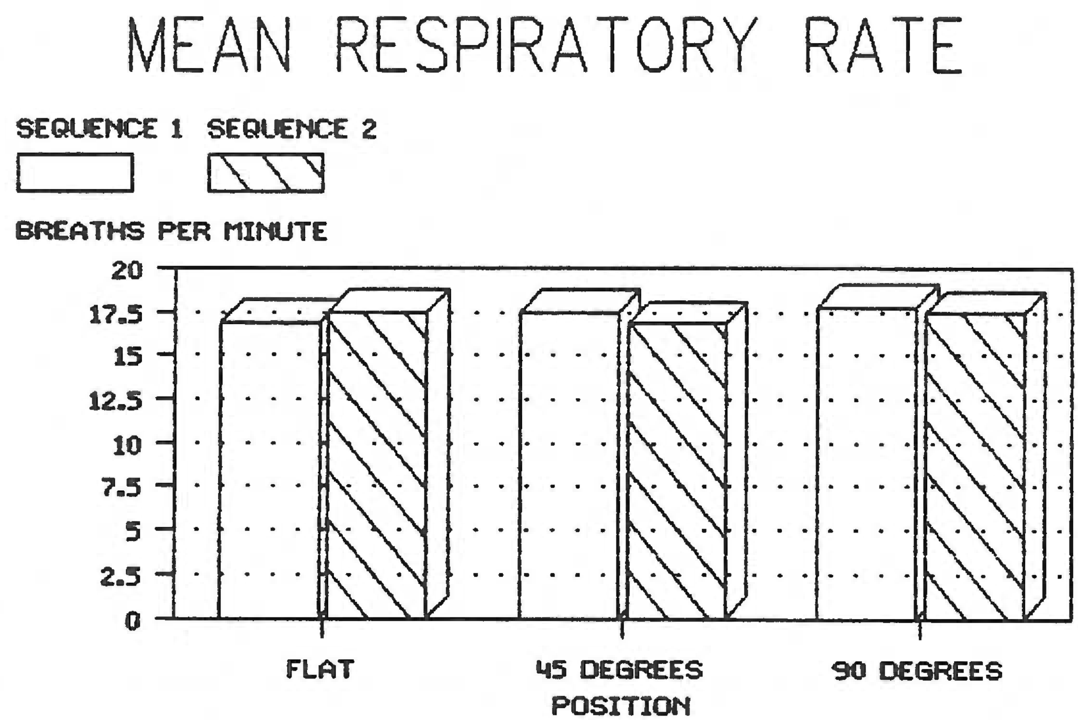



Figure 7. Comparison of the mean respiratory rate of 34 subjects by sequence for three positions.

Table F-1). T-tests and Tukey tests to compare the difference in means between the three positions for the two sequence were not significant (see Table F-2).

## Effect of Control Variables Upon Positioning and Respiratory Rate

One significant value was calculated with the statistical analyses for respiratory rate. This one value made comparisons of the relationships of respiratory rate and the control variables difficult. Additionally, the analyses of respiratory rate is limited. One of the limitations of measuring increasing respiratory rate with positioning was that subjects had been given anesthetic and pharmacological agents. Both of these agents are known depressants to respiratory rate. Another limitation was that the value of subjects increasing respiratory rate with positioning is unknown. The increase in volumes of breaths is important to assure adequate aeration to all lung areas but the value of increasing rate has not been documented.

## Minute Ventilation

The minute ventilation is the total volume of gas expired in one minute by a subject. The normal minute ventilation for an adult is five to ten liters per minute.

## Effect of Positioning Upon Minute Ventilation

The means for the minute ventilation were (a) 7978 ml with the head of the bed flat, (b) 8650 ml with the head of the bed at 45 degrees, and (c) 9876 ml with the head of the bed at 90 degrees (see Figure 8). The minute ventilation increased as the head of the bed was raised from flat to 45 degrees to 90 degrees. Table 32 shows that the F statistic for a relationship between positioning and the minute ventilation was 6.86 ($p = .002$). The t-statistic was significant for the difference in group means between the head of bed flat and the head of the bed 90 degrees ($t = 3.65$, $p \leq .05$). The q-statistic supported the significant difference in the two means ($q = 5.17$, $p \leq .01$). The t-statistic was also significant for the difference in group means between the head of the bed at 45 degrees and the head of the bed at 90 degrees ($t = 2.35$, $p \leq .01$) (see table 33). The statistics indicate that significant differences in minute ventilation were seen when the head of the bed was moved from 45 degrees to 90 degrees and when the head of the bed was moved from flat to 90 degrees.

## Effect of Positioning Upon Minute Ventilation for Three Incisional Types

The means for the minute ventilation for the upper abdominal incisional group were (a) 8814 ml with the head of the bed flat, (b) 8628 ml with the head of the bed at 45

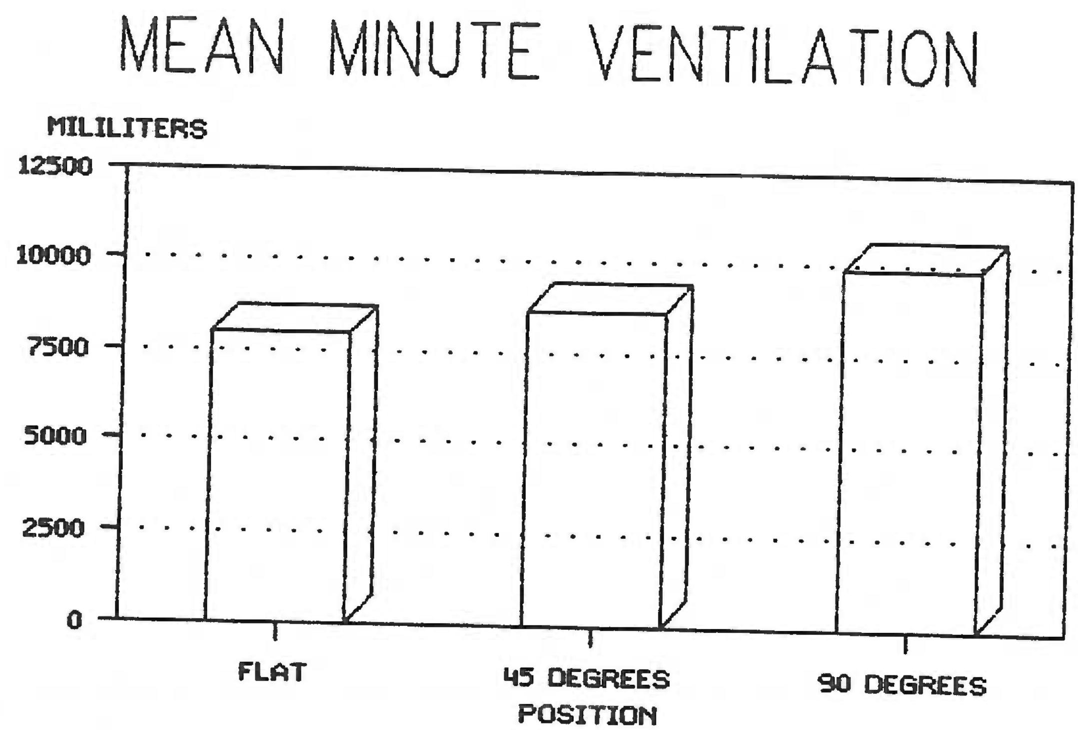



Figure 8. Comparison of the mean minute ventilation of 34 subjects for three positions.

Table 32

Analysis of Variance Summaries for the

Minute Ventilation

| | Sum of Squares | df | Mean Square | Grand Mean | F | Probability |
|---|---|---|---|---|---|---|
| **Total** | | | | | | |
| Sample | | | | | | |
| Between | ******* | 33 | 52,436,455 | | | |
| Within | 365,897,867 | 68 | 5,380,851 | | | |
| Between Measures | 62,960,855 | 2 | 31,480,427 | 8,836 | 6.86 | .002 |
| Residual | 302,937,012 | 66 | 4,589,955 | | | |
| Total | ******* | 101 | 20,755,454 | | | |
| **Incision** | | | | | | |
| Upper Abdominal | | | | | | |
| Between | 339,395,147 | 9 | 37,710,572 | | | |
| Within | 64,220,533 | 20 | 3,211,027 | | | |
| Between Measures | 15,840,240 | 2 | 7,920,120 | 9,232 | 2.95 | .078 |
| Residual | 48,380,293 | 18 | 2,687,794 | | | |
| Total | 403,615,680 | 29 | 13,917,782 | | | |
| Lower Abdominal | | | | | | |
| Between | 723,610,256 | 12 | 60,300,855 | | | |
| Within | 94,538,933 | 26 | 3,636,113 | | | |
| Between Measures | 12,496,759 | 2 | 6,248,380 | 9,159 | 1.83 | .182 |
| Residual | 82,042,174 | 24 | 3,418,424 | | | |
| Total | 818,149,190 | 38 | 21,530,242 | | | |
| Combination | | | | | | |
| Between | 640,529,406 | 10 | 64,052,941 | | | |
| Within | 207,138,400 | 22 | 9,415,382 | | | |
| Between Measures | 58,119,442 | 2 | 29,059,721 | 8,096 | 3.90 | .037 |
| Residual | 149,018,958 | 20 | 7,450,948 | | | |
| Total | 847,667,806 | 32 | 26,489,619 | | | |
| **Sequence** | | | | | | |
| Sequence 1 | | | | | | |
| Between | ******* | 21 | 60,158,345 | | | |
| Within | 303,602,933 | 44 | 6,900,067 | | | |
| Between Measures | 88,678,630 | 2 | 44,339,315 | 8,404 | 8.66 | .001 |
| Residual | 21,492,303 | 42 | 5,117,245 | | | |
| Total | ******* | 65 | 24,106,587 | | | |
| Sequence 2 | | | | | | |
| Between | 432,061,467 | 11 | 39,278,315 | | | |
| Within | 62,294,933 | 24 | 2,595,622 | | | |
| Between Measures | 466,200 | 5 | 233,100 | 9,630 | 0.08 | .921 |
| Residual | 61,828,733 | 22 | 2,810,397 | | | |
| Total | 494,356,400 | 35 | 14,124,469 | | | |

******* = too large a number for the computer

Table 33

*Comparison of the Minute Ventilation Means for the Three Positions of Flat, 45 Degrees, and 90 Degrees Using a Planned T-test and Tukey Test*

| | $\bar{x}_1 - \bar{x}_2$ | | | | $\bar{x}_2 - \bar{x}_3$ | | | | $\bar{x}_1 - \bar{x}_3$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}_1$ | $\bar{x}_2$ | t | q | $\bar{x}_2$ | $\bar{x}_3$ | t | q | $\bar{x}_1$ | $\bar{x}_3$ | t | q |
| Sample Population | 7978 | 8656 | 1.30 | 1.85 | 8656 | 9876 | 2.35* | 3.32 | 7978 | 9876 | 3.65* | 5.17* |
| Upper Abdominal Incisions | 8814 | 8628 | -0.25 | 0.36 | 8628 | 10254 | 2.22** | 3.14 | 8814 | 10254 | 1.96** | 2.78 |
| Lower Abdominal Incisions | 8765 | 8754 | -0.02 | -0.02 | 8754 | 9960 | 1.66 | 2.35 | 8764 | 9960 | 1.65 | 2.33 |
| Combination Incisions | 6287 | 8565 | 2.48** | 2.77 | 8565 | 9435 | 2.47** | 1.06 | 6287 | 9435 | 8.97* | 3.82** |
| Sequence 1 | 7112 | 8176 | 2.21 | 1.56 | 8176 | 9924 | 3.62** | 2.56* | 7112 | 9924 | 5.83* | 4.12* |
| Sequence 2 | 9565 | 9535 | -0.04 | -0.06 | 9535 | 9790 | 0.37 | 0.53 | 9565 | 9790 | 0.33 | 0.46 |

$\bar{x}_1$ = Head of Bed Flat

$\bar{x}_2$ = Head of Bed 45 Degrees

$\bar{x}_3$ = Head of Bed 90 Degrees

* $p < .01$

** $p < .05$

degrees, and (c) 10,254 ml with the head of the bed at 90 degrees. The lower abdominal incisional group had minute ventilation means of (a) 8765 ml with the head of the bed flat, (b) 8754 ml with the head of the bed 45 degrees, and (c) 9960 ml with the head of the bed 90 degrees. The combination incisional group had minute ventilation means of (a) 6287 ml with the head of the bed flat, (b) 8565 ml with the head of the bed 45 degrees, and (c) 9435 ml with the head of the bed 90 degrees (see Figure 9). The F statistic was 2.95 ($p = .078$) for subjects with upper abdominal incisions, 1.83 ($p = .182$) for subjects with lower abdominal incisions, and 3.90 ($p = .037$) for subjects with combination incisions (see Table 32). The statistic suggests that subjects with combination incisions significantly change minute ventilation measurements with positioning.

The t-tests showed significant differences in means between head of bed 45 degrees and 90 degrees ($t = 2.22$, $p \leq .05$) and between head of bed flat and elevated 90 degrees ($t = 1.96$, $p \leq .05$) for the upper abdominal incision subjects (see Table 33). The t-tests also showed significant values for the difference between means for combination incision subjects for head of bed flat and 45 degrees ($t = 2.48$, $p \leq .05$), head of bed 45 degrees and 90 degrees ($t = 2.47$, $p \leq .05$), and head of bed flat and 90 degrees ($t = 8.97$,

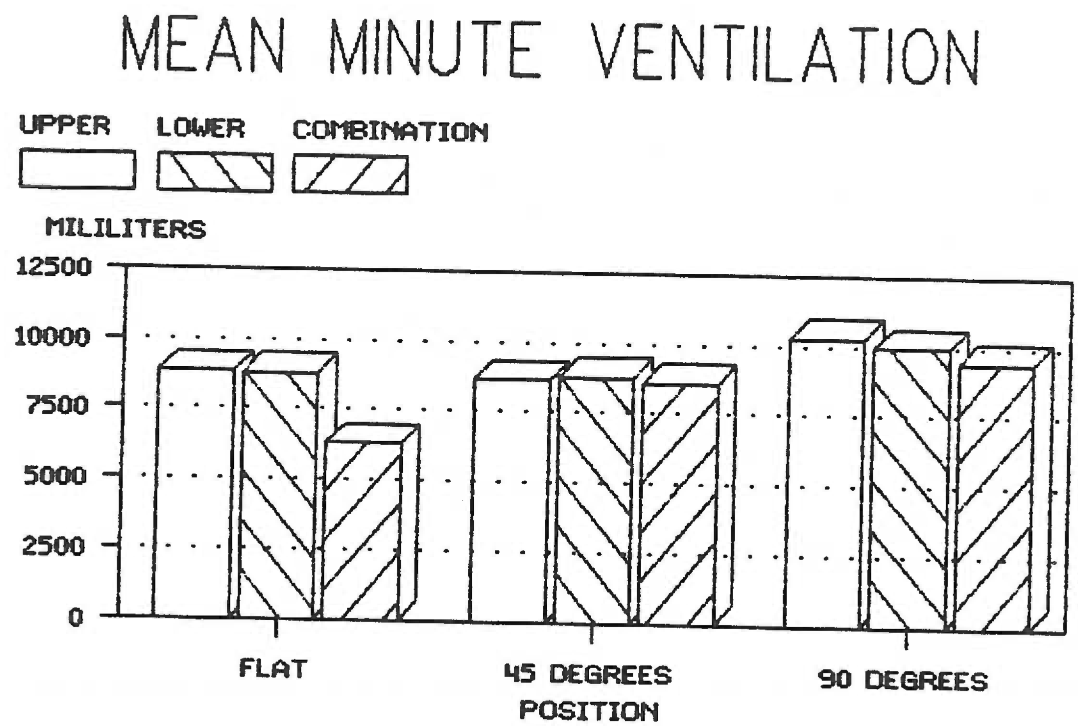



Figure 9. Comparison of the mean minute ventilation of 34 subjects by incisional type for three positions.

$p \leq .01$). The Tukey test supported the t scores for combination incision subjects for the differences between means for head of bed flat and 90 degrees ($q = 3.82$, $p \leq .05$).

## Effect of Positioning Upon Minute Ventilation for Two Sequences

Sequence 1 subjects had minute ventilation means of (a) 7112 ml with the head of the bed flat, (b) 8176 ml with the head of the bed 45 degrees, and (c) 9924 ml with the head of the bed 90 degrees. The minute ventilation measurements for sequence 2 subjects was (a) 9565 ml with the head of the bed flat, (b) 9535 ml with the head of the bed 45 degrees, and (c) 9790 ml with the head of the bed 90 degrees (see Figure 10). Table 32 shows that the F statistic for the effect of sequencing upon minute ventilation was 8.66 ($p = .007$) for subjects in sequence 1 and 0.08 ($p = .921$) for subjects in sequence 2. Some relationships do exist between sequence 1 and the three positions for the measurement of minute ventilation. The t-tests were significant for the differences between means for head of bed flat and 45 degrees ($t = 3.62$, $p \leq .05$) and between head of bed flat and 90 degrees ($t = 5.83$, $p \leq .01$) for sequence 1 subjects (see Table 33). No significant mean differences were found in sequence 2 subjects. The

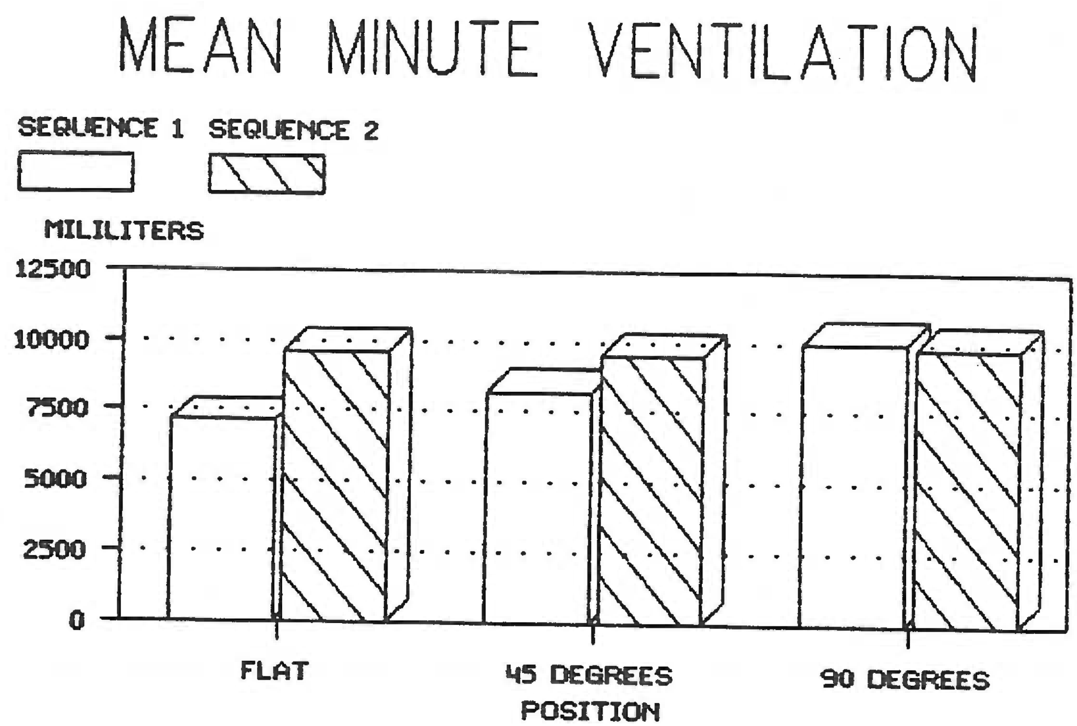



Figure 10. Comparison of the mean minute ventilation of 34 subjects by sequence for three positions.

Tukey test supported the significant differences in means for sequence 1 subjects between head of bed flat and 90 degrees ($q = 4.12$, $p \leq .01$).

## Effect of Control Variables, Positioning and Minute Ventilation

### Preoperative Factors

Concurrent Disease Entities. Table 1 identifies the presence of concurrent pulmonary disease as the preoperative factor that would influence minute ventilation. Seven subjects had pulmonary disease in the sample. Table 34 shows the minute ventilation measurements for the sample population. Table 34 and 35 show the distribution of measurements for subjects separated according to sequence and incisional type. The sample had a gradual increase in minute ventilation as the head of the bed was raised to 90 degrees. No trends were seen with the incisional groups or the sequence groups. The presence of pulmonary disease in the sample did not produce notable changes in minute ventilation measurements with positioning as was documented by research.

Other control variables seen in the sample population were evaluated for trends. For subjects over 50 years of age in the study, notable increases in minute ventilation occurred in the move from 45 to 90 degrees for upper

Table 34

Seven Subjects with Pulmonary Disease for Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Decreased Minute Ventilation | 2 | 1 | 0 |
| Predicted Minute Ventilation | 4 | 5 | 4 |
| Increased Minute Ventilation | 1 | 1 | 3 |
| | 7 | 7 | 7 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Decreased Minute Ventilation | 1 | 0 | 0 |
| Predicted Minute Ventilation | 4 | 5 | 3 |
| Increased Minute Ventilation | 0 | 0 | 2 |
| | 5 | 5 | 5 |
| Sequence 2 Subjects | | | |
| Decreased Minute Ventilation | 0 | 0 | 0 |
| Predicted Minute Ventilation | 1 | 1 | 1 |
| Increased Minute Ventilation | 1 | 1 | 1 |
| | 2 | 2 | 2 |

Table 35

Seven Subjects with Pulmonary Disease Separated by Incisional Type According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 1 | 1 | 0 |
| Predicted Minute Ventilation | 1 | 1 | 2 |
| Increased Minute Ventilation | 0 | 0 | 0 |
| | 2 | 2 | 2 |
| **Combination Subjects** | | | |
| Decreased Minute Ventilation | 0 | 0 | 0 |
| Predicted Minute Ventilation | 1 | 1 | 1 |
| Increased Minute Ventilation | 0 | 0 | 0 |
| | 1 | 1 | 1 |
| **Lower Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 1 | 0 | 0 |
| Predicted Minute Ventilation | 2 | 3 | 1 |
| Increased Minute Ventilation | 1 | 1 | 3 |
| | 4 | 4 | 4 |

abdominal, and sequence 1 subjects (see Table G-1 and G-2). For overweight subjects, notable increases in minute ventilation occurred in sequence 1 subjects with the move from 45 to 90 degrees. No other trends were seen in the overweight subjects (see Table G-3 and G-4). No trends in minute ventilation values were seen in smoking subjects (see Table G-5 and G-6). A gradual increase in minute ventilation with positioning occurred in subjects with concurrent cardiac disease who were in sequence 1 or who had combination incisions with positioning (see Table G-7 and G-8). The influence of these other variables upon minute ventilation measures is not suppported by research data. Although changes in minute ventilation were seen with subjects possessing these characteristics, the changes were not great enough to document their influence upon minute ventilation.

Perioperative Factors

Surgical Length. Nineteen subjects had operative times greater than two hours. A long operative time is thought to influence minute ventilation. The increase in minute ventilation occurred in the move from flat to 45 degrees and 45 to 90 degrees for the sequence 1 subjects. Sequence 2 subjects decreased minute ventilation with the move from flat to 45 degrees but increased again as the head of the bed was elevated to 90 degrees. When separated into incisional types, the notable increase in minute ventilation occurred with the move from 45 to 90 degrees for combination and upper abdominal incision subjects. The sequence 1 and 2 subjects with increasing minute ventilation in the move from 45 to 90 degrees may be reflective of the combination and upper abdominal incision subjects in both sequences. The increase in minute ventilation from flat to 45 degrees with sequence 1 subjects is related to some other factor. The findings support an increase in VE as the head of the bed is elevated from the 45 degree position.(see Table 36 and 37).

Estimated Blood Loss. Five subjects had perioperative blood loss greater than 500 cc. All five subjects had an increase in minute ventilation to normal range or higher when the head of the bed was elevated to 90 degree but not in the position change flat to 45 degrees. Three of the subjects had combination incisions and one each had an upper and lower abdominal incision. Sequence of position was not notable. Subjects with combination incisions improved minute ventilation on the move 45 to 90 degrees to support the trend (see Table G-9 and G-10).

Postoperative Factors

Use of Incentive Spirometer. The twenty-one subjects who used this intervention improved minute ventilation the greatest when repositioned from 45 to 90 degrees. The

Table 36

Nineteen Subjects with Operative Time Greater than Two Hours of Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Decreased Minute Ventilation | 6 | 6 | 2 |
| Predicted Minute Ventilation | 10 | 10 | 11 |
| Increased Minute Ventilation | 3 | 3 | 6 |
| | 19 | 19 | 19 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Decreased Minute Ventilation | 6 | 5 | 2 |
| Predicted Minute Ventilation | 6 | 7 | 7 |
| Increased Minute Ventilation | 1 | 1 | 4 |
| | 13 | 13 | 13 |
| Sequence 2 Subjects | | | |
| Decreased Minute Ventilation | 0 | 1 | 0 |
| Predicted Minute Ventilation | 4 | 3 | 4 |
| Increased Minute Ventilation | 2 | 2 | 2 |
| | 6 | 6 | 6 |

Table 37

Nineteen Subjects with Operative Times Greater than Two Hours Separated by Incisional Type According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 2 | 2 | 0 |
| Predicted Minute Ventilation | 3 | 3 | 4 |
| Increased Minute Ventilation | 2 | 2 | 3 |
| | 7 | 7 | 7 |
| **Combination Subjects** | | | |
| Decreased Minute Ventilation | 3 | 3 | 1 |
| Predicted Minute Ventilation | 5 | 5 | 5 |
| Increased Minute Ventilation | 1 | 1 | 3 |
| | 9 | 9 | 9 |
| **Lower Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 1 | 1 | 1 |
| Predicted Minute Ventilation | 2 | 2 | 2 |
| Increased Minute Ventilation | 0 | 0 | 0 |
| | 3 | 3 | 3 |

trend was seen with upper abdominal and combination incision subjects as well as with the sequence 1 subjects. The result may indicated that more upper and combination incision subjects were in sequence one. Another example of minute ventilation being greater in the 90 degree position and not increasing until the move from 45 to 90 degrees occurs (see Table 38 and 39).

Ambulation and Repositioning. Ambulation and repositioning of subjects did not improve minute ventilation to a notable value for subjects in the three positions. Most of the lower abdominal incision subjects had ambulated prior to testing. The VE values of the lower abdominal incision subjects were higher in all three positions than the other two incisional types. The lower abdominal incision subjects, however, did not improve VE with positioning. The higher VE values may be related to the ability of these subjects to take deeper breaths due to the placement of their incision or the ambulation of these subjects made some impact upon VE. The number of upper abdominal and combination subjects who had experienced the intervention was too small to see any trends (see Table 40 and G-11). Sequencing of positions did not influence the minute ventilation for subjects with these interventions (see Table 41 and 42).

Table 38

Twenty-one Subjects Using the Incentive Spirometer for Sample and Separated by Sequence According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Decreased Minute Ventilation | 3 | 3 | 1 |
| Predicted Minute Ventilation | 12 | 13 | 11 |
| Increased Minute Ventilation | 6 | 5 | 9 |
| | 21 | 21 | 21 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Decreased Minute Ventilation | 3 | 2 | 0 |
| Predicted Minute Ventilation | 7 | 9 | 7 |
| Increased Minute Ventilation | 3 | 2 | 6 |
| | 13 | 13 | 13 |
| Sequence 2 Subjects | | | |
| Decreased Minute Ventilation | 0 | 1 | 1 |
| Predicted Minute Ventilation | 5 | 4 | 4 |
| Increased Minute Ventilation | 3 | 3 | 3 |
| | 8 | 8 | 8 |

Table 39

Twenty-one Subjects Using the Incentive Spirometer Separated by Incisional Type According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| Upper Abdominal Subjects | | | |
| Decreased Minute Ventilation | 2 | 2 | 0 |
| Predicted Minute Ventilation | 3 | 4 | 5 |
| Increased Minute Ventilation | 4 | 3 | 4 |
| | 9 | 9 | 9 |
| Combination Subjects | | | |
| Decreased Minute Ventilation | 1 | 1 | 0 |
| Predicted Minute Ventilation | 6 | 6 | 5 |
| Increased Minute Ventilation | 1 | 1 | 3 |
| | 8 | 8 | 8 |
| Lower Abdominal Subjects | | | |
| Decreased Minute Ventilation | 0 | 0 | 0 |
| Predicted Minute Ventilation | 2 | 2 | 1 |
| Increased Minute Ventilation | 2 | 2 | 3 |
| | 4 | 4 | 4 |

Table 40

Thirteen Subjects Ambulated After Surgery Separated by Incisional Type According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| Upper Abdominal Subjects | | | |
| Decreased Minute Ventilation | 0 | 0 | 0 |
| Predicted Minute Ventilation | 1 | 1 | 0 |
| Increased Minute Ventilation | 0 | 0 | 1 |
| | 1 | 1 | 1 |
| Combination Subjects | | | |
| Decreased Minute Ventilation | 1 | 1 | 0 |
| Predicted Minute Ventilation | 1 | 1 | 2 |
| Increased Minute Ventilation | 0 | 0 | 0 |
| | 2 | 2 | 2 |
| Lower Abdominal Subjects | | | |
| Decreased Minute Ventilation | 3 | 2 | 3 |
| Predicted Minute Ventilation | 5 | 6 | 3 |
| Increased Minute Ventilation | 2 | 2 | 4 |
| | 10 | 10 | 10 |

Table 41

Thirteen Subjects Ambulated After Surgery for Sample and Separated by Sequence According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Decreased Minute Ventilation | 4 | 3 | 3 |
| Predicted Minute Ventilation | 7 | 8 | 5 |
| Increased Minute Ventilation | 2 | 2 | 5 |
| | 13 | 13 | 13 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Decreased Minute Ventilation | 1 | 1 | 4 |
| Predicted Minute Ventilation | 3 | 4 | 2 |
| Increased Minute Ventilation | 4 | 3 | 2 |
| | 8 | 8 | 8 |
| Sequence 2 Subjects | | | |
| Decreased Minute Ventilation | 1 | 1 | 1 |
| Predicted Minute Ventilation | 4 | 4 | 3 |
| Increased Minute Ventilation | 0 | 0 | 1 |
| | 5 | 5 | 5 |

Table 42

Ten Subjects Repositioned After Surgery for Sample and Separated by Sequence According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **TOTAL SAMPLE** | | | |
| Decreased Minute Ventilation | 1 | 2 | 1 |
| Predicted Minute Ventilation | 4 | 3 | 3 |
| Increased Minute Ventilation | 5 | 5 | 6 |
| | 10 | 10 | 10 |
| **SEQUENCE** | | | |
| Sequence 1 Subjects | | | |
| Decreased Minute Ventilation | 1 | 1 | 1 |
| Predicted Minute Ventilation | 3 | 3 | 2 |
| Increased Minute Ventilation | 3 | 3 | 4 |
| | 7 | 7 | 7 |
| Sequence 2 Subjects | | | |
| Decreased Minute Ventilation | 0 | 1 | 0 |
| Predicted Minute Ventilation | 1 | 0 | 1 |
| Increased Minute Ventilation | 2 | 2 | 2 |
| | 3 | 6 | 6 |

## Forced Vital Capacity

The forced vital capacity is the volume of gas that can be expired as forcefully and rapidly as possible after a maximal inspiration. The maneuver requires an intact respiratory musculature to inhale and exhale. Surgical procedures of the abdominal and surrounding areas are thought to limit the inhalation and exhalation process thus decreasing the volume. Normal predicted values are calculated from nomograms for height and age. One nomogram is for men and one is for women (see Appendix H-1 and H-2). The percentage of predicted normal is thought to give an indication of airway obstruction. Table 43 shows the amount of airway obstruction according to the percentage of predicted normal FVC value.

Table 43

Percentage of Predicted Values of Forced Vital Capacity and Degree of Airway Obstruction

| Airway Obstruction | Forced Vital Capacity Percentage of Predicted Normal |
|---|---|
| Normal | Greater than 80% |
| Mild | 65 to 80% |
| Moderate | 50 to 64% |
| Severe | 35 to 49% |
| Very Severe | Less than 35% |

## Effect of Positioning Upon Forced Vital Capacity

The mean for the FVC was (a) 1.61 liters with the head of the bed flat, (b) 1.71 liters with the head of the bed at 45 degrees, and (c) 1.82 liters with the head of the bed at 90 degrees (see Figure 11). Table 44 shows the F statistic for the relationship between positioning and FVC ($F = 6.73$, $p = .002$). The statistic suggests that positioning does have a significant impact upon the FVC in the sample population. Table 45 shows that differences in means for the three positions. Significant differences in means were present between the head of bed flat and at 45 degrees ($t = 1.71$, $p \leq .05$), between head of bed at 45 degrees and 90 degrees ($t = 1.90$, $p \leq .05$), and between head of bed flat and at 90 degrees ($t = 3.63$, $p \leq .01$). The q-statistic supported the difference between means for the head of the bed flat and the head of the bed at 90 degrees ($q = 5.25$, $p \leq .01$). The t-tests clarified that all positional changes produced significant variations for FVC in the sample population.

## Effect of Positioning Upon FVC for the Three Incisional Types

The means for the upper abdominal incisional group were (a) 1.23 liters with the head of the bed flat, (b) 1.27 liters with the head of the bed at 45 degrees, and

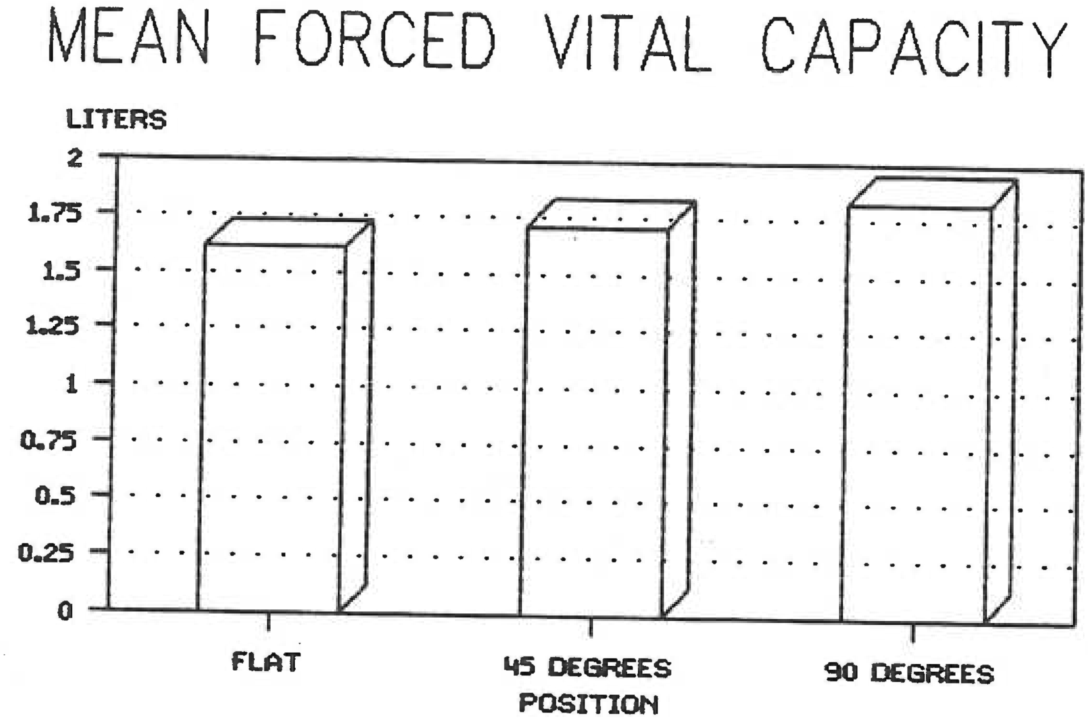



Figure 11. Comparison of the mean forced vital capacity of 34 subjects for three positions.

Table 44

Analysis of Variance Summaries for the

Forced Vital Capacity

| Total | Sum of Squares | df | Mean Square | Grand Mean | F | Probability |
|---|---|---|---|---|---|---|
| Sample | | | | | | |
| Between | 68.34 | 33 | 2.07 | | | |
| Within | 4.56 | 68 | 0.07 | | | |
| Between Measures | 0.77 | 2 | 0.39 | 1.72 | 6.73 | .002 |
| Residual | 3.79 | 66 | 0.06 | | | |
| Total | 72.91 | 101 | 0.72 | | | |
| Incision | | | | | | |
| Upper Abdominal | | | | | | |
| Between | 11.96 | 9 | 1.33 | | | |
| Within | 0.51 | 20 | 0.03 | | | |
| Between Measures | 0.27 | 2 | 0.13 | 1.32 | 9.96 | .001 |
| Residual | 0.24 | 18 | 0.01 | | | |
| Total | 12.47 | 29 | 0.43 | | | |
| Lower Abdominal | | | | | | |
| Between | 15.26 | 12 | 1.27 | | | |
| Within | 2.96 | 26 | 0.11 | | | |
| Between Measures | 0.53 | 2 | 0.27 | 2.42 | 2.63 | .09 |
| Residual | 2.43 | 24 | 0.10 | | | |
| Total | 18.22 | 38 | 0.48 | | | |
| Combination | | | | | | |
| Between | 9.30 | 10 | 0.93 | | | |
| Within | 1.10 | 22 | 0.05 | | | |
| Between Measures | 0.20 | 2 | 0.10 | 1.24 | 2.19 | .138 |
| Residual | 0.90 | 20 | 0.04 | | | |
| Total | 10.39 | 32 | 0.32 | | | |
| Sequence | | | | | | |
| Sequence 1 | | | | | | |
| Between | 29.89 | 21 | 1.42 | | | |
| Within | 3.41 | 44 | 0.08 | | | |
| Between Measures | 0.76 | 2 | 0.38 | 1.46 | 6.03 | .005 |
| Residual | 2.65 | 42 | 0.06 | | | |
| Total | 33.30 | 65 | 0.51 | | | |
| Sequence 2 | | | | | | |
| Between | 25.94 | 11 | 2.36 | | | |
| Within | 1.15 | 24 | 0.05 | | | |
| Between Measures | 0.19 | 5 | 0.10 | 2.19 | 2.20 | .135 |
| Residual | 0.96 | 22 | 0.04 | | | |
| Total | 27.09 | 35 | 0.77 | | | |

Table 45

Comparison of the Forced Vital Capacity Means for the Three Positions of Flat, 45 Degrees, and 90 Degrees Using a Planned T-test and Tukey Test

| | $\bar{x}_1 - \bar{x}_2$ | | | | $\bar{x}_2 - \bar{x}_3$ | | | | $\bar{x}_1 - \bar{x}_3$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}_1$ | $\bar{x}_2$ | t | q | $\bar{x}_2$ | $\bar{x}_3$ | t | q | $\bar{x}_1$ | $\bar{x}_3$ | t | q |
| Sample Population | 1.61 | 1.71 | 1.71** | 2.50 | 1.71 | 1.82 | 1.90** | 2.75 | 1.61 | 1.82 | 3.62* | 5.25* |
| Upper Abdominal Incisions | 1.23 | 1.27 | 0.77 | 1.00 | 1.27 | 1.45 | 3.46* | 4.50** | 1.23 | 1.45 | 4.23* | 5.50* |
| Lower Abdominal Incisions | 2.31 | 2.38 | 0.56 | 0.78 | 2.38 | 2.58 | 1.60 | 2.22 | 2.31 | 2.58 | 2.24** | 3.00 |
| Combination Incisions | 1.14 | 1.32 | 2.00** | 3.00 | 1.32 | 1.27 | -0.56 | -0.83 | 1.14 | 1.27 | 1.44 | 2.17 |
| Sequence 1 | 1.35 | 1.42 | 0.87 | 1.40 | 1.42 | 1.60 | 2.25** | 3.60** | 1.35 | 1.60 | 3.13* | 5.00* |
| Sequence 2 | 2.09 | 2.25 | 1.78** | 2.67 | 2.25 | 2.23 | 0.22 | -0.33 | 2.09 | 2.23 | 1.56 | 2.33 |

$\bar{x}_1$ = Head of Bed Flat

$\bar{x}_2$ = Head of Bed 45 Degrees

$\bar{x}_3$ = Head of Bed 90 Degrees

* $p < .01$

** $p < .05$

(c) 1.45 liters with the head of the bed at 90 degrees. The lower abdominal incisional group had FVC means of (a) 2.31 liters with the head of the bed flat, (b) 2.38 liters with the head of the bed at 45 degrees, and (c) 2.58 liters with the head of the bed at 90 degrees. The combination incisional group had FVC of (a) 1.14 liters with the head of the bed flat, (b) 1.32 liters with the head of the bed at 45 degrees, (c) 1.27 liters with the head of the bed at 90 degrees (see Figure 12). Table 44 shows the F statistics for the relationships between incisional type, positioning, and the FVC. The F statistic was 9.96 ($p = .001$) for subjects with upper abdominal incisions, 2.63 ($p = .09$) for subjects with lower abdominal incisions, and 2.19 ($p = .138$) for subjects with combination incisions. The statistic suggests that the FVC of subjects with upper abdominal incisions is significantly changed with positioning. The t-test was significant for the difference between the means for head of bed 45 and 90 degrees ($t = 4.46$, $p \leq .01$) and for the difference between the means for head of bed flat and 90 degrees ($t = 4.23$, $p \leq .05$) for the upper abdominal incisional group. For the lower abdominal incisional group, the difference in means between head of bed flat and at 90 degrees was significant ($t = 2.24$, $p \leq .05$). The combination incisional group had a

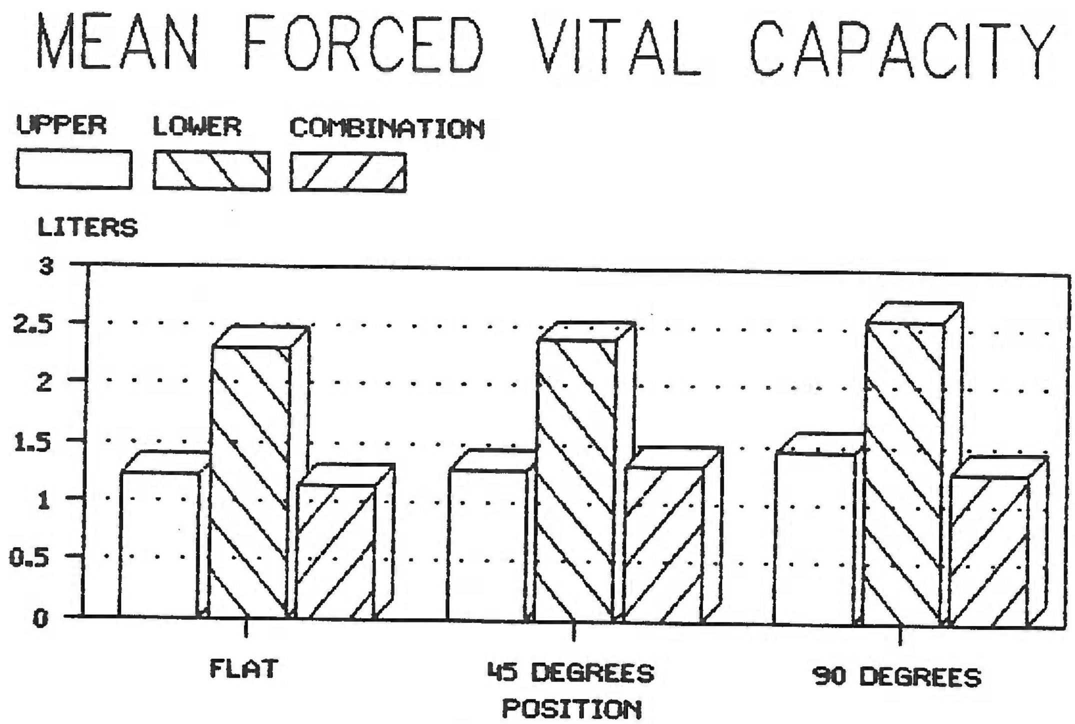



Figure 12. Comparison of the mean forced vital capacity of 34 subjects by incisional type for three positions.

significant difference in means between head of bed flat and at 45 degrees ($t = 2$, $p \leq .05$). The Tukey tests were significant for the differences in means between head of bed 45 degrees and 90 degrees ($q = 4.5$, $p \leq .05$) and the differences in means between head of bed flat and head of bed 90 degrees ($q = 5.5$, $p \leq .01$) for the upper abdominal inicision subjects. Table 45 shows the values for each of the incisional groups for both tests.

<u>Effect of Positioning Upon FVC for Two Sequences</u>

Sequence 1 subjects had FVC means of (a) 1.35 liters with the head of the bed flat, (b) 1.42 liters with the head of the bed at 45 degrees, and (c) 1.60 liters with the head of the bed at 90 degrees. The FVC means for sequence 2 subjects was (a) 2.09 liters with the head of the bed flat, (b) 2.25 liters with the head of the bed at 45 degrees, and (c) 2.23 liters with the head of the bed at 90 degrees (see Figure 13). Note the higher liter volumes for sequence 2 subjects. The FVC changes between the three positions were significant for sequence 1 subjects only. The F statistic was 6.03 ($p = .005$) for subjects in sequence 1 and 2.20 ($p = .135$) for subjects in sequence 2 (see Table 44). The t-test showed significant values for the sequence 1 subjects for the differences in means for the FVC between head of bed at 45 degrees and

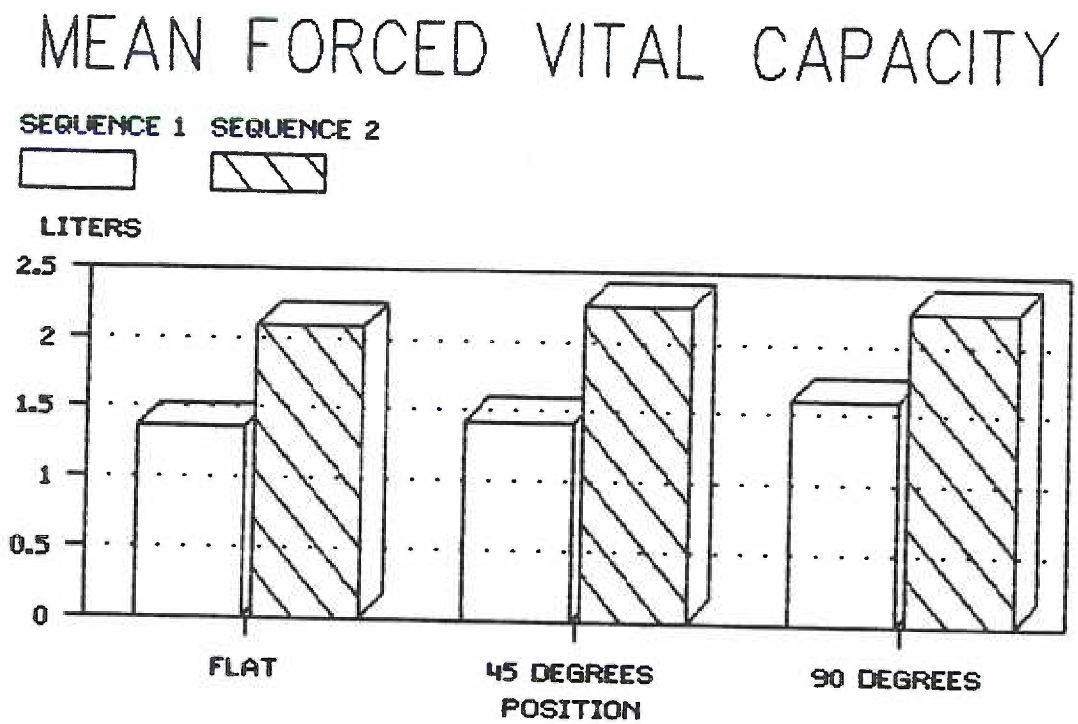



Figure 13. Comparison of the mean forced vital capacity of 34 subjects by sequence for three positions.

head of bed 90 degrees ($t = 2.25$, $p \leq .05$) and between head of bed flat and 90 degrees ($t = 3.13$, $p \leq .01$). Significant values for the sequence 2 subjects were seen between the means for the head of the bed flat and at 45 degrees ($t = 1.78$; $p \leq .05$). The Tukey test supported the significance for the difference in means between the head of the bed 45 degrees and 90 degrees ($q = 3.60$, $p \leq .05$) and between the head of the bed flat and 90 degrees ($q = 5$, $p \leq .01$) for sequence 1 only (see Table 45).

## Effect of Control Variables Upon Positioning and FVC

### Preoperative Factors

**Age** Age greater than fifty years decreases FVC. Age is used in the nomograms with height to determine the predicted values of the FVC (see Table H-1 and H-2). The decreasing FVC measures with aging are built into the overall FVC value.

**Weight-Height Ratios**. Fifteen overweight subjects and six underweight subjects were in the sample. The combination and upper abdominal incision subjects who were overweight or underweight had severe to very severe ventilatory impairment in all three positions. The lower abdminal incision subjects had varied ventilatory impairment in the three positions. Positioning did not change FVC values (see Table H-4 and H-6). Sequence 1 subjects did have higher FVC values in the 45 degree position (see Table H-3 and H-5).

Smoking. Sixteen subjects (67%) with severe to very severe impairment in ventilatory ability as measured by the FVC were smokers. The combination and upper abdominal subjects and those in the two sequences had decreased FVC measures in all three positions. The lower abdominal incision subjects had higher FVC values in the three positions. No trends of increasing or decreasing FVC was seen with positioning (see Table H-7 and H-8).

Concurrent Disease Entities. The presence of pulmonary, neuromuscular, and cardiac disease can influence FVC values. The three neuromuscular disease subjects were unable to increase ventilatory ability with positioning (see Table H-13 and H-14). Subjects with pulmonary disease were also unable to increase ventilatory ability with positioning (see Table H-11 and H-12). The subjects with cardiac disease, had a notable increase in ventilatory ability with the elevation of the head of the bed from 45 to 90 degrees (see Table H-9 and H-10).

Perioperative Factors

Surgical Length. Of the nineteen subjects with operative times greater than two hours, sixteen subjects had severe to very severe impairment of ventilatory ability in the three positions (see Table H-15). The combination and upper abdominal incision subjects more often had very decreased FVC values in the three positions than the lower abdominal incision subjects (see Table H-16). The two sequences varied in degree of ventilatory impairment with sequence 1 having the greater number of subjects in the severe to very severe range (see Table H-15). Again no trend in FVC values was seen with positioning.

Estimated Blood Loss. The five subjects who had estimated blood loss greater than 500 cc were divided with four subjects with severe to very severe ventilatory impairment and one subject with mild to moderate impairment. This variable can be combined with the long operative length as all five subjects had operative times greater than two hours. No trends in FVC values with positioning were seen (see Table H-17 and H-18).

Postoperative Factors

Use of Incentive Spirometer. Seventeen subjects who used the intervention had severe to very severe impairment in FVC in the three positions (see Table H-19). Only four lower abdominal incision subjects used the intervention but three had mild to moderate impairment in FVC in the three positions (see Table H-20). Four sequence 2 subjects also used the intervention (see Table H-19). No improvement in FVC values with positioning occurred with the various subjects. Of note is the small number of subjects with lower abdominal incisions and sequence 2 subjects who used the intervention. These two groups also had the higher FVC measures in the three positions.

Ambulation and Repositioning. FVC did not change to any degree with the elevation of the head of the bed from flat to 45 degrees to 90 degrees for subjects who had ambulated or been repositioned in the postoperative period (see Table H-21, H-22, H-23, and H-24).Seventy-seven percent of the lower abdominal incision subjects had ambulated in the postoperative period. The repositioned subjects were more likely to be in the combination or upper abdominal incision groups.

## Forced Expired Volume in 1 Second

Forced expired volume in one second (FEV1) is the volume of air forcefully expelled in the first second of a forced vital capacity maneuver. FEV1 measurements are thought to indicate the amount of ventilatory impairment that is present in subjects. The categories of ventilatory impairment are calculated from the percentage of predicted FEV1 values that a subject is able to obtain. The categories of impairment are the same as those for the FVC that are presented in Table 43.

## Effect of Positioning Upon FEV1

The means of the FEV1 were (a) 1.25 liters with the head of the bed flat, (b) 1.36 liters with the head of the bed at 45 degrees, and (c) 1.42 liters with the head of the bed at 90 degrees (see Figure 14). The FEV1 increased as the head of the bed was elevated from flat to 45 degrees to 90 degrees. Table 46 shows that the F statistic for such a relationship was 3.64 ($p = .032$). The statistic suggests that positioning does have a significant impact upon the FEV1 in the sample population. Table 47 shows that significant F score was related to the difference in means between head of the bed flat and at 45 degrees ($t = 1.69$, $p \leq .05$) and the difference in means between head of the bed flat and head of the bed elevated 90 degrees ($t = 2.62$, $p \leq .05$). The q-statistic supported the significance for the difference between the means for the head of the bed flat and the head of the bed elevated to 90 degrees ($q = 3.4$, $p \leq .05$).

## Effect of Positioning Upon FEV1 for Three Incisional Types

The means for the FEV1 for the upper abdominal incisional group were (a) 0.98 liters with the head of the bed flat, (b) 1.01 liters with the head of the bed elevated 45 degrees, and (c) 1.19 liters with the head of

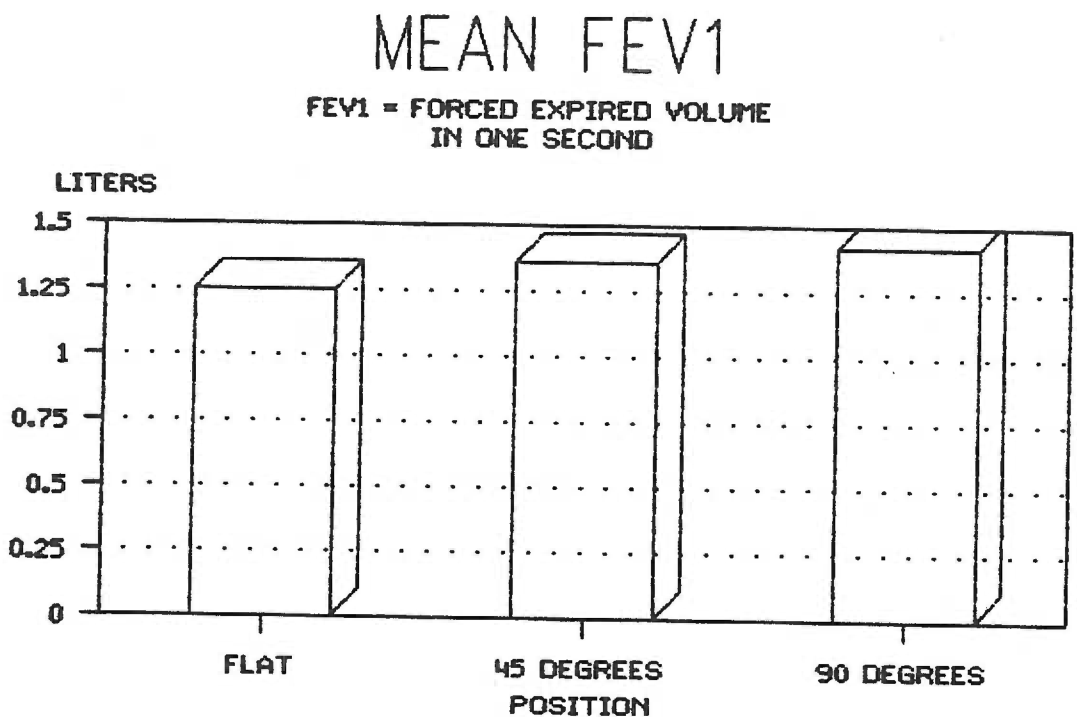



Figure 14. Comparison of the mean forced expired volume in one second of 34 subjects for three positions.

Table 46

Analysis of Variance Summaries for the

Forced Expired Volume in One Second

| | Sum of Squares | df | Mean Square | Grand Mean | F | Probability |
|---|---|---|---|---|---|---|
| **Total** | | | | | | |
| Sample | | | | | | |
| Between | 51.55 | 33 | 1.56 | | | |
| Within | 5.18 | 68 | 0.08 | | | |
| Between Measures | 0.51 | 2 | 0.26 | 1.35 | 3.64 | .032 |
| Residual | 4.67 | 66 | 0.07 | | | |
| Total | 56.74 | 101 | 0.56 | | | |
| **Incision** | | | | | | |
| Upper Abdominal | | | | | | |
| Between | 13.21 | 9 | 1.47 | | | |
| Within | 0.45 | 20 | 0.02 | | | |
| Between Measures | 0.27 | 2 | 0.13 | 1.06 | 12.92 | .0003 |
| Residual | 0.19 | 18 | 0.10 | | | |
| Total | 13.66 | 29 | 0.47 | | | |
| Lower Abdominal | | | | | | |
| Between | 10.84 | 12 | 0.90 | | | |
| Within | 2.18 | 26 | 0.08 | | | |
| Between Measures | 0.57 | 2 | 0.28 | 1.94 | 4.21 | .027 |
| Residual | 1.61 | 24 | 0.07 | | | |
| Total | 13.02 | 38 | 0.34 | | | |
| Combination | | | | | | |
| Between | 4.58 | 10 | 0.46 | | | |
| Within | 2.55 | 22 | 0.12 | | | |
| Between Measures | 0.29 | 2 | 0.14 | 0.90 | 1.26 | .305 |
| Residual | 2.26 | 20 | 0.11 | | | |
| Total | 7.13 | 32 | 0.22 | | | |
| **Sequence** | | | | | | |
| Sequence 1 | | | | | | |
| Between | 22.99 | 21 | 1.09 | | | |
| Within | 4.39 | 44 | 0.10 | | | |
| Between Measures | 0.41 | 2 | 0.20 | 1.15 | 2.16 | .128 |
| Residual | 3.98 | 42 | 0.09 | | | |
| Total | 27.38 | 65 | 0.42 | | | |
| Sequence 2 | | | | | | |
| Between | 21.58 | 11 | 1.92 | | | |
| Within | 0.79 | 24 | 0.03 | | | |
| Between Measures | 0.12 | 5 | 0.06 | 1.70 | 1.89 | .175 |
| Residual | 0.98 | 22 | 0.03 | | | |
| Total | 22.38 | 35 | 0.64 | | | |

Table 47

Comparison of the Forced Expired Volume in One Second Means for the Three Positions of Flat, 45 Degrees, and 90 Degrees Using a Planned T-test and Tukey Test

| | $\bar{x}_1 - \bar{x}_2$ | | | | $\bar{x}_2 - \bar{x}_3$ | | | | $\bar{x}_1 - \bar{x}_3$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}_1$ | $\bar{x}_2$ | t | q | $\bar{x}_2$ | $\bar{x}_3$ | t | q | $\bar{x}_1$ | $\bar{x}_3$ | t | q |
| Sample Population | 1.25 | 1.36 | 1.69** | 2.20 | 1.36 | 1.42 | 0.92 | 1.20 | 1.25 | 1.42 | 2.62** | 3.40** |
| Upper Abdominal Incisions | 0.98 | 1.01 | 0.87 | 0.97 | 1.01 | 1.19 | 3.91* | 5.81* | 0.98 | 1.19 | 4.78* | 6.77* |
| Lower Abdominal Incisions | 1.82 | 1.91 | 0.90 | 1.29 | 1.91 | 2.11 | 2.00** | 2.71 | 1.82 | 2.11 | 2.80* | 4.00** |
| Combination Incisions | 0.84 | 1.03 | 1.43 | 2.00 | 1.03 | 0.83 | -1.43 | -2.00 | 0.84 | 0.83 | 0.00 | 0.00 |
| Sequence 1 | 1.05 | 1.17 | 1.29 | 1.71 | 1.17 | 1.24 | 0.75 | 1.00 | 1.05 | 1.24 | 2.04** | 2.71* |
| Sequence 2 | 1.62 | 1.72 | 1.39 | 2.00 | 1.72 | 1.76 | 0.55 | 0.80 | 1.62 | 1.76 | 1.94** | 2.80 |

$\bar{x}_1$ = Head of Bed Flat

$\bar{x}_2$ = Head of Bed 45 Degrees

$\bar{x}_3$ = Head of Bed 90 Degrees

* $p < .01$

** $p < .05$

the bed elevated 90 degrees. The lower abdominal incisional group had FEV1 means of (a) 1.82 liters with the head of the bed flat, (b) 1.91 liters with the head of the bed elevated 45 degrees, and (c) 2.11 liters with the head of the bed elevated 90 degrees. The combination incisional group had FEV1 means of (a) 0.84 liters with the head of the bed flat, (b) 1.03 liters with the head of the bed elevated 45 degrees, and (c) 0.83 liters with the head of the bed elevated 90 degrees (see Figure 15). The F statistic for a relationship between positioning and incisional type was 12.92 ($p = .003$) for subjects with upper abdominal incisions, 4.21 ($p = .027$) for subjects with lower abdominal incisions, and 1.26 ($p = .305$) for subjects with combination incisions (see Table 46). The statistics suggest that subjects with upper abdominal and lower abdominal incisions are likely to experience changes in FEV1 with moving. Significant differences in means were seen for the upper abdominal incision subjects between head of bed at 45 degrees and head of bed at 90 degrees ($t = 3.91$, $p \leq .01$) and between head of bed flat and head of bed at 90 degrees ($t = 4.78$, $p \leq .01$). Significant differences in means were also seen for the lower abdominal incision subjects between head of bed flat and head of the bed at 90 degrees ($t = 2$, $p \leq .05$) and between head of bed flat and head of bed at 90 degrees ($t = 2.8$,

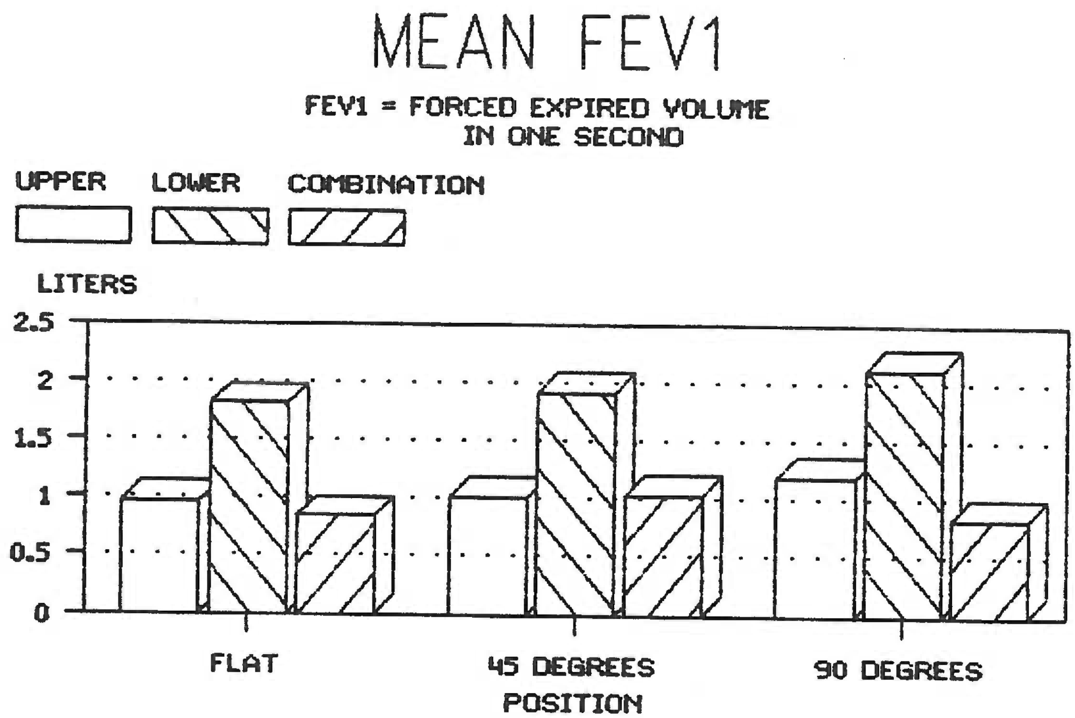



Figure 15. Comparison of the mean forced expired volume in one second of 34 subjects by incision for three positions.

$p \leq .01$). The Tukey test showed significant values for the difference in meansbetween head of bed at 45 degrees and head of bed at 90 degrees ($q = 5.81$, $p \leq .01$) and between head of bed flat and head of bed at 90 degrees ($q = 6.77$, $p \leq .01$) for the upper incisional group and for the difference between means for head of bed flat and head of bed 90 degrees ($q = 4$, $p \leq .05$) for the lower abdominal incisional group (see Table 47).

Effect of Positioning Upon FEV1 for Two Sequences

Sequence 1 subjects had FEV1 means of (a) 1.05 liters with the head of the bed flat, (b) 1.17 liters with the head of the bed at 45 degrees, and (c) 1.24 liters with the head of the bed at 90 degrees. The FEV1 means for sequence 2 subjects were (a) 1.62 liters with the head of the bed flat, (b) 1.72 liters with the head of the bed at 45 degrees, and (c) 1.76 liters with the head of the bed at 90 degrees (see Figure 16). The FEV1 changes with positioning were not significant for either of the two sequences. The F statistic was 2.16 ($p = .128$) for subjects in sequence 1 and 1.89 ($p = .175$) for subjects in sequence 2 (see Table 46). The t-test results showed significant values for the difference between means for head of bed flat and head of bed at 90 degrees. The

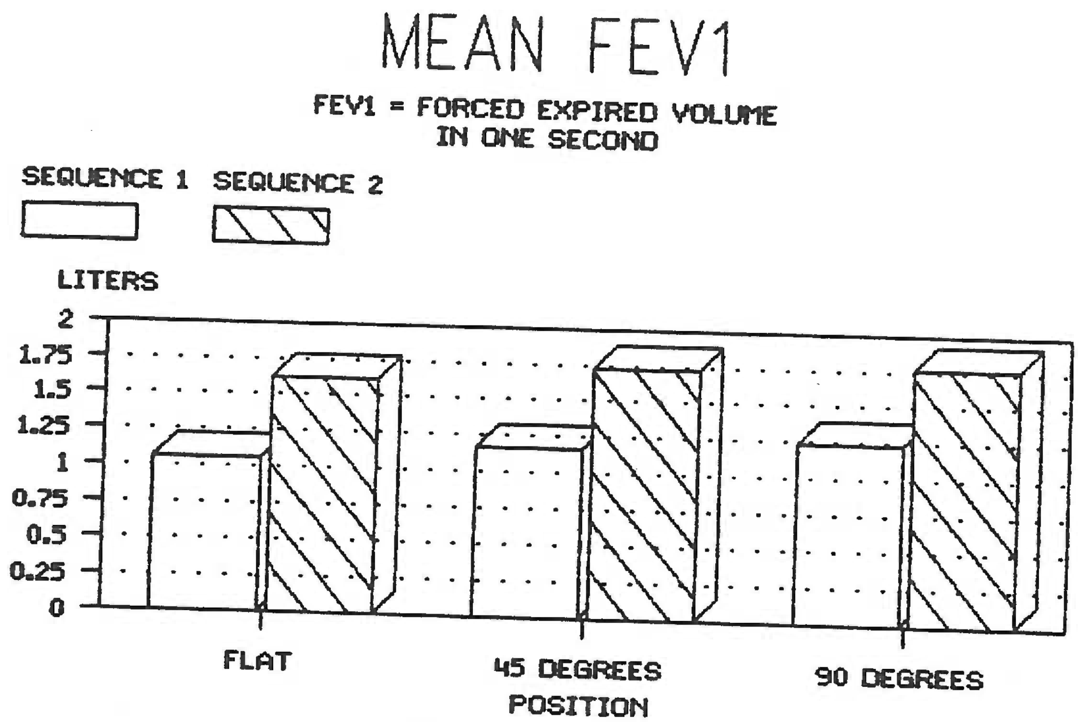



Figure 16. Comparison of the mean forced volume in one second of 34 subjects by sequence for three positions.

t-statistic for sequence 1 was t = 2.04 ($p \leq .05$) and for sequence 2 was t = 1.94 ($p \leq .05$) (see Table 47).

## Effect of Control Variables Upon Positioning and FEV1

### Preoperative Factors

Weight/Height Ratios. The overweight and underweight subjects were unable to improve ventilatory ability with positioning from flat to 90 degrees as measured by the FEV1 (see Table I-1, I-2, I-3, and I-4). Most subjects had severe to very severe impairment of the measusre in the three positions regardless of incisional type or sequence.

Smoking History. Smoking increases the likelihood of some ventilatory impairment. Smokers in the combination and upper abdominal incision groups had the greatest impairment in function but virtually no change or improvement in FEV1 with positioning (see Table I-6). Sequence 1 subjects which had a greater number of upper abdominal and combination incision subjects had decreased FEV1 in the positions with no improvement with positioning (see Table I-5).

Concurrent Disease Entities. The subjects with pulmonary disease were divided between lower abdominal incisional subjects and the other two categories. This may be why about half of the subjects had severe to very severe impairment in ventilatory ability and half had mild to moderate impairment (see Table I-9 and I-10). The subjects with cardiac disease had the greater number of subjects with severe to very severe impairment in the combination and upper abdominal incision groups. Again little change was seen in the measurement with positioning (see Table I-7 and I-8).

Perioperative_Factors

Surgical_Length. Fifteen subjects with long operative times had severe to very severe ventilatory impairment in the three positions (see Table I-13_. Most of the subjects with long operative times had upper abdominal or combination incisions. Both of these incisional types would have more difficulty with the forced breathing maneuvers and would have lower FEV1 measures (see Table I-14). Again minimal changes in FEV1 occurred with positioning.

Estimated_Blood_Loss. Five subjects had estimated blood loss during the operative procedure of 500 cc or more. All had severe to very severe ventilatory impairment in all three positions. No change in FEV1 occurred with positioning (see Table I-15 and I-16).

Postoperative_Factors

Use_of_Incentive_Spirometer. The subjects who used the incentive spirometry intervention were most likely to be subjects with upper abdominal and combination incisions. For this reason, the FEV1 values were in the severe to very severe category. The subjects in the mild to moderate impairment were most likely to have lower abdominal incisions. This intervention did not produce any noteworthy changes in the FEV1 values as the head of the bed was repositioned into the three positions (see Table I-17 and I-18).

Ambulation and Repositioning. The ambulated subjects were equally distributed into the severe to very severe ventilatory impairment and to the mild to moderate ventilatory impairment. The increase in the number of mild to moderate impaired subjects may be related to the large number of lower abdominal incision subjects in the group. The results of FEV1 measures are again disappointing as no notable changes occurred with positioning (see Table I-19 and I-20).

Ten subjects had been repositioned in the postoperative period. Nine subjects had severe to very severe impairment in the three positions. More subjects in this group were in the upper abdominal and combination incisional groups. No trends could be seen in the changes in FEV1 with positioning (see Table I-21 and I-22).

# CHAPTER V

# SUMMARY AND CONCLUSIONS

## Summary

The present study used a quasi-experimental design to explore the relationships between positioning of the postoperative patient and the measurements of tidal volume, respiratory rate, minute ventilation, forced vital capacity, and forced expired volume in one second. Hypotheses were proposed that stated in the first twenty-four hours after a surgical procedure under general anesthesia, postoperative patients with all incision types would have the highest pulmonary function tests in the head of bed 90 degree position and the lowest pulmonary function tests in the head of bed flat position.

A sample population of thirty-four subjects scheduled for an operative procedure requiring an upper abdominal, a lower abdominal, or a combination incision were included in the study. Subjects meeting the study criteria were asked to sign a permit and were instructed in carrying out pulmonary function testing procedures in the preoperative period. The morning after the surgical procedure, subjects were placed into the three positions and pulmonary function measures were carried out in each position. The sequence of the three positions was determined by the subjects' bed position prior to the testing procedure. The pulmonary function data was analyzed using a one-way analysis of variance with repeated measures to determine relationships between positioning and the pulmonary function measures. Two analyses of variance with repeated measures were used to determine the relationships between incisional type and pulmonary function tests, and between positioning sequence and pulmonary function tests. Finally, a 2 x 3 analysis of variance was computed to determine if a relationship existed between incisional type and sequence of position. The later analysis produced no significant values or relationships. Therefore, a detailed explanation of the analysis was not included in the discussion of the results. The effect of control variables or factors in the preoperative, perioperative, and postoperative period that might influence pulmonary function tests were analysed using crosstabulations.

# Conclusions

## Hypotheses

### Position

The hypothesis that subjects in the first twenty-four hours after a surgical procedure would have highest pulmonary function tests when the head of the bed was in the 90 degree position and lowest values when the head of the bed was flat was supported by the data. The mean value of pulmonary function tests was highest with subjects in the 90 degree position and lowest in the flat position for all five of the measures. The values were significant for tidal volume ($F = 4.03$, $p = .022$), minute ventilation ($F = 6.86$, $p = .002$), FVC ($F = 6.73$, $p = .002$), and FEV1 ($F = 3.64$, $p = .032$). The lack of significance of respiratory rate may be related to the small variation or change of respiratory rate seen in the sample population as repositioning occurred.

Subjects in the study changed the depth of breathing as the head of the bed was raised but not the rate of breathing. Control variables for the tidal volume that supported the increase as the head of the bed was elevated from flat to 45 degrees were age greater than 50 years, greater than 10% overweight, a surgical length greater than two hours, an operative blood loss greater than 500 cc, and the use of the incentive spirometer in the postoperative period. The variables that supported an increase in the tidal volume with the move from 45 to 90 degrees were the presence of pulmonary disease and the practive of ambulation or repositioning in the postoperative period. Subjects with cardiac disease had a gradual increase in tidal volume as the head of the bed was elevated from flat to 45 to 90 degrees.

Control variables that supported the increase in minute ventilation with positioning could not be found for the flat to 45 degree elevation. For the 45 to 90 degree elevation, the variables of weight greater than 10% over ideal body weight and the use of the incentive spirometer in the postoperative period seemed to increase minute ventilation. Subjects over the age of 50 and with pulmonary disease had a gradual increase in minute ventilation as the head of the bed was raised. Smoking and the practice of ambulation and being repositioned in the postoperative period did not have a notable effect upon minute ventilation values.

The position change flat to head of bed 45 degrees was significant for the forced vital capacity ($t = 1.71$, $p \leq .05$), and forced expired volume in one minute ($t = 1.69$, $p \leq .05$). The change in FVC and FEV1 values reflects the difficulty in doing these forced breathing maneuvers in the flat position. Spirometry literature suggests that subjects be placed in an upright posture to measure these volumes. The significant increase in the FVC and FEV1 as the head of the bed was raised from flat indicates that (1) the sample population had difficulty performing the maneuvers in the flat position, and (2) values of FVC and FEV1 were lowest in the flat position.

The position change 45 degrees to 90 degrees was significant for minute ventilation ($t = 2.35$, $p \leq .01$) and the FVC ($t = 1.90$, $p \leq .05$). These results show that (1) subjects in the study were able to move more air in and out of the lungs in the upright position than in the flat or 45 degree position, and (2) subjects were able to take deeper forced breaths in the 90 degree position than in the other two positions.

The difference in means between the head of the bed flat and the head elevated to 90 degrees was significant for tidal volume ($t = 2.83$, $p \leq .01$; $q = 4.01$, $p \leq .05$), minute ventilation ($t = 3.65$, $p \leq .01$; $q = 5.17$, $p \leq .01$), FVC ($t = 3.62$, $p \leq .01$; $q = 5.25$, $p \leq .01$), and FEV1 ($t = 2.62$, $p \leq .05$; $q = 3.40$, $p \leq .05$). The significance of the measures indicates that pulmonary function mean values do increase when the head of the bed is raised from flat to 90 degrees. Not all of the measures increase significantly in the move from flat to 45 degrees or 45 to 90 degrees. The overall significance of the move from flat to 90 degrees for four of the five measures seems to related to either a gradual increase in the values as the head of the bed is elevated or a significant increase in the value with one of the smaller moves (flat to 45 degrees or 45 to 90 degrees).

The improvement in the pulmonary function measures as the head of the bed was raised from supine to 90 degrees in the postoperative patient was seen by Hsu and Hickey (1976). Their study looked at patients who were lying and sitting. No studies looked at the changes in pulmonary function measures that might occur in the move from flat to 45 degrees or 45 degrees to 90 degrees. The effect of the control variables upon pulmonary function measures in the literature did not equate the changes with positioning. The interrelationships seen in the present study require further study.

Incisions

The differences in pulmonary function tests with positioning was next compared between the incisional types. The hypothesis states that positioning of postoperative patients with upper and lower abdominal incisions will cause the highest pulmonary function tests to be in the head of the bed at 90 degrees and the lowest values to be in the head of the bed flat position.

*Upper Abdominal Incision*. The mean values of the tidal volume, FVC, and FEV1 increased as the head of the bed was raised from flat to 45 degrees to 90 degrees for subjects with upper abdominal incisions. The values were significant for FVC ($F = 9.96$, $p=.001$) and the FEV1 ($F = 12.92$, $p=.0003$). Subjects with upper abdominal incisions were able to take deeper breaths if encouraged to do so for FVC and FEV1 measurements but did not improve spontaneous breathing patterns as measured by tidal volume, respiratory rate, or minute ventilation with changes in positioning. Part of the reason for the inability to improve spontaneous breathing patterns with positioning is related to the restrictions to breathing imposed by bandages and the dysfunction of the abdominal muscles that occurs with upper abdominal incisions. The effects of postoperative pain medications depress breathing patterns. The depression of breathing is further increased by the anesthetic agents in the system that persist for several days after a surgical procedure. The subjects can be instructed to take deep breaths and are able to forcefully increase breathing volumes.

The differences in means of the pulmonary function measures between 45 and 90 degrees was significant for tidal volume ($t = 1.77$, $p \leq .05$), minute ventilation ($t =$

2.22, $p \leq .05$), FVC ($t = 3.46$, $p \leq .01$; $q = 4.50$, $p \leq .05$), and FEV1 ($t = 3.91$, $p \leq .01$; $q = 5.81$, $p \leq .01$). Significance was also seen in the move from flat to 90 degrees for tidal volume ($t = 1.98$, $p \leq .05$), minute ventilation ($t = 1.96$, $p \leq .05$), FVC ($t = 4.23$, $p \leq .01$; $q = 5.50$, $p \leq .01$), and FEV1 ($t = 4.78$, $p \leq .01$; $q = 6.77$, $p \leq .01$). The differences in means between the flat position and the 45 degree elevation was insignificant for all measures. The lack of significance of pulmonary function measures as the head of the bed was elevated from flat to 45 degrees shows that subjects with upper abdominal incisions are unable to improve ventilatory ability until the head of the bed is elevated higher than 45 degrees. Subjects with upper abdominal incisions were able to improve pulmonary function values of tidal volume, FVC, and FEV1 as the head of the bed was elevated. The FVC and FEV1 were the only significant values.

The decrease in pulmonary function measures for subjects with upper abdominal incisions is supported in the literature by Ali et al. (1974) for VC, tidal volume and functional reserve capacity; Meyers et al. (1975) for VC, RV, FEV1, and FRC; Ford et al. (1983) for FEV1 and FVC; Elman et al. (1981) for VC, and FEV1; Ali and Khan (1979) for VC; and Palmer and Gardiner (1964) for tidal volume, VC, FEV1, and expired reserve volume.

Subjects in these studies were evaluated in the semirecumbent or sitting positions. The effect of positioning upon the measures was not documented.

None of the control variables identified in the sample population made a notable change in the tidal volume or respiratory rate measures for subjects with upper abdominal incisions. The minute ventilation was increased with positioning from 45 to 90 degrees in subjects over age 50, in smoking subjects, and in those with long operative times. Smokers had a gradual increase in minute ventilation as the head of the bed was elevated from flat to 90 degrees. The effect of positioning upon FVC and FEV1 measures for upper abdominal incision subjects didnot appear to be related to any specific control variable. All of the upper abdominal incision subjects had decreased values in all three positions that indicated a severe to very severe impairment in ventilatory ability.

Lower Abdominal Incision. All of the five pulmonary function measures were highest for lower abdominal incision subjects when the head of the bed was elevated to 90 degrees. Only the FEV1 measures were significant ($F = 4.21$, $p = .027$). Subjects with lower abdominal incisions were not able to take significantly deeper breaths in one position over another nor were they able to improve spontaneous breathing patterns with positioning. The pulmonary function volumes of subjects with lower abdominal incisions, however, were higher than those with the other two types of incisisons and positioning did not impact upon improving the volumes.

The ability of subjects with lower abdominal incisions to increase spontaneous and forced breathing volumes to higher levels than the other two incisional types may be related to several factors. The first factor is that subjects in this incision category were ten years younger than subjects in the other two types of incisions with most under fifty years of age. Age is known to decrease pulmonary volumes particularly in subjects over fifty. The second factor is that the lower abdominal incision is thought to be less disruptive to breathing musculature that the other two incisional types. Lower abdominal incision subjects would be able to breath deeper and more forcefully than either subjects with upper abdominal or combination incisions. Most of the lower abdominal incisions subjects had ambulated prior to testing which also may have assisted in helping them take deep, forceful breaths. Subjects with lower abdominal incisions tended to be given minimal pain medications which decreased the incidence of depression to the respiratory system.

The difference in means for the pulmonary function measures from 45 degrees to 90 degrees was significant for the FEV1 ($t = 2.00$, $p \leq .05$). The difference in means for the flat to 90 degree position was significant for the FVC ($t = 2.24$, $p \leq .05$) and the FEV1 ($t = 2.80$, $p \leq .01$; $q = 4.00$, $p \leq .05$). The flat to 45 degree position produced no significant differences in means between the two groups. The differences in means between the three positions supported the concept that subjects with lower abdominal incisions maintained spontaneous breathing patterns with positioning. The FVC improved with the overall move of flat to 90 degrees. The lack of significance of the FEV1 increase with positioning from flat to 45 degrees demonstrates the inability to accomplish the maneuver in the flat position.

The documentation of changes in ventilatory measures with surgery of subjects with lower abdominal incisions was seen in the study by Ali et al. (1974). The subjects with lower abdominal incisions had decreased values of pulmonary function tests in the postoperative period but not as low as other incisional types. Szcepanski et al. (1973) showed that the lower abdominal incision group had statistically the same amount of postoperative pulmonary complications as subjects with intraperitoneal surgery patients. Neither study described the positions that subjects were placed into.

Combination Incision. A combination of the upper and lower abdominal incision was seen. The pulmonary function measures for the combination incision subjects were highest with the head of the bed elevated 90 degrees for the tidal volume, respiratory rate, and minute ventilation. The only significant value was the minute ventilation ($F = 3.90$, $p = .037$). The FVC and FEV1 were highest in the 45 degree position. The results demonstrate that for this group of subjects spontaneous breathing patterns improved as the head of the bed was elevated to 90 degrees. The slight increases of the respiratory rate and tidal volume with positioning created a significant increase in the minute ventilation.

The differences in means between the head of bed flat and elevated 45 degrees was significant for tidal volume ($t = 2.26$, $p \leq .05$), minute ventilation ($t = 2.48$, $p \leq .05$), and FVC ($t = 2.00$, $p \leq .05$). The difference in means for the 45 to 90 degree position was significant for the minute ventilation ($t = 2.47$, $p \leq .05$). The difference in means for the move flat to 90 degrees was significant for the tidal volume ($t = 2.07$, $p \leq .05$), the respiratory rate ($t = 2.25$, $p = \leq .05$), and the minute ventilation ($t = 8.97$, $p = \leq .01$; $q = 3.82$, $p \leq .05$). The results show that subjects with combination type incisions improve spontaneous breathing patterns significantly with the elevation of the head of the bed from flat to 45 to 90 degrees. These results support the hypothesis that postoperative subjects improve pulmonary function values as the head of the bed is elevated. Forced breathing patterns are more difficult for combination incision subjects to accomplish. The FEV1 measures were not effectively carried out in any position. The highest values were found in the 45 degree position but no values were significant. The FVC was significantly increased in the 45 degree position.

The inability of subjects with combination incisions to effectively carry out the forced breathing maneuvers may be related to several factors. The first factor is the placement of the incision. The combination incision extends beyond the limits of the upper abdominal incision. The flat position and 90 degree position place more tension upon the suture line and cause more discomfort for subjects in the combination group. The tension and pain make the forced breathing maneuvers more difficult. The 45 degree position may be a better position for these subjects. A second factor is related to the perioperative characteristics of the group. Subjects with combination incisions had longer surgical times and greater blood loss during the surgery. The 90 degree position may have been too severe for these sicker subjects the morning after surgery. The lack of significance of the FEV1 value and the inability of subjects to even complete the maneuver may be related to the smoking history of the subjects and to the length of the surgical procedure. While similar numbers of subjects who smoked were present in all incisional groups, the combination subjects smoked ten pack years more than the other groups. Smoking is known to decrease FVC and FEV1 measures. The lengthy surgical times for combination subjects made the anesthetic times longer. The effect of greater amounts of anesthetic agents in the system may have decreased the FEV1 measures. The varying results of pulmonary function values in combination incision subjects with positioning is worthy of further study.

None of the studies identified in the literature described an incision comparable to the combination types seen in the sample. Much of the research has been directed to the upper abdominal incision as subjects with this type of incision are thought to be more prone to the development of postoperative complications.

Sequencing

Sequencing of positions was done in the study to control for some unknown factors that might be related to positioning. The relationship of positioning to sequencing was measured. For sequence 1 subjects, all measures increased as the head of the bed was raised but only the tidal volume ($F = 6.58$, $p = .003$), minute ventilation ($F = 8.66$, $p = .001$), and FVC ($F = 6.03$, $p = .005$) were significant. The difference in means showed significance between flat and 45 degrees for no measures, between 45 degrees and 90 degrees for the tidal volume ($t = 2.10$, $p \leq .05$), the minute ventilation ($t = 3.62$, $p \leq .05$; $q = 2.56$, $p \leq .01$), and the FVC ($t = 2.25$, $p \leq .05$; $q = 3.60$, $p \leq .05$), and between flat and 90 degrees for the tidal volume ($t = 3.61$, $p \leq .01$), minute ventilation ($t = 5.83$, $p = \leq .01$; $q = 4.12$, $p = \leq .01$), FVC ($t = 3.13$, $p \leq .01$; $q = 5.00$, $p \leq .01$), and FEV1 ($t = 2.04$, $p \leq .05$; $q = 2.71$, $p \leq .01$).

The lack of significant F score for the above data for the FEV1 may be related to the large number of upper abdominal and combination incision subjects in sequence 1 (64%). Both of these groups have difficulty doing this maneuver. The t-score for the significant increase in FEV1 with the position change 45 to 90 degrees may indicate the influence of the eight lower abdominal incision subjects. The lack of significant t-scores with the move from flat to 45 degrees is unusual. The trend may be related to the the number of lower abdominal incision subjects who did not improve pulmonary function measures with positioning but had higher volume amounts. The trend also reflects the findings of the upper abdominal incision group who did not improve pulmonary function volumes until the head of the bed was elevated to 90 degrees.

For sequence 2 subjects, pulmonary function values did not increase for all measures as the head of the bed was raised from flat to 45 degrees to 90 degrees. No significant F scores were found. The differences in means between flat and 45 degrees was significant for the FVC ($t = 1.78$, $p \leq .05$), between 45 degrees and 90 degrees was significant for no values, and between flat and 90 degrees was significant for the FEV1 ($t = 1.94$, $p \leq .05$). The changes of pulmonary function measures and positioning with sequence 2 subjects did not follow any patterns. Part of this may be related to the number of subjects in each incisional type. Five subjects had lower abdominal incisions, four had upper abdominal incisions, and three had combination incisions. The small number of subjects in each type would not have shown overall significant values. Sequence 2 subjects were younger, less overweight, more apt to be nonsmokers or lighter smokers, less likely to have cardiac or pulmonary disease, more likely to have short operative procedures without large blood loss, and more likely to have been moving and ambulating prior to testing. These positive aspects of the group would have increased pulmonary function values and may have made positioning a lesser influence.

## Limitations

The first limitation of the present study was related to the sample. The sample was one of convenience rather than a randomly selected one. All subjects scheduled for an upper or lower abdominal incision were considered for participation in the study. However, a maximum of two subjects per day could be tested. Subjects could refuse to participate at any time before or during the testing. Therefore, many subjects having the surgical procedure during the stated time period were not included in the study. This made it difficult to generalize results to the greater population at large.

Another limitation is imposed by the type of pulmonary function measurement equipment that was employed for the study. The reliability of the Wright respirometer is low. Subjects using the device are able to voluntarily control respiratory rate and volume. While the researcher did instruct subjects in the correct breathing pattern, variations did occur. This device was used because it was the only tool available to the researcher to measure tidal volume and minute ventilation. Other devices to measure tidal volume and minute ventilation are also prone to error due to the reliance upon patient cooperation and the expertise of the tester.

The timing of the study was another limitation. Subjects were tested once in the three positions the morning after a surgical procedure. No attempt was made to standardize the time from the surgical procedure until the pulmonary function testing. The difference in amount of time between the surgical procedure and the actual testing varied from subject to subject. Therefore, some subjects had longer recovery times from the anesthetic effects than others.

Another limitation of the study was the inability to measure the perfusion component of respiration. While the ventilation component is important in the postoperative patient to assure aeration in all lobes and a decrease in atelectasis, the perfusion of the lungs helps to maintain adequate oxygenation. To thoroughly assess pulmonary function both components must be viewed together.

## Strengths of the Study

One of the strengths of the study was that actual postoperative patients in the clinical setting were interviewed and tested. All subjects were placed into the actual positions and tested on the pulmonary function measures. Another strength was that subjects served as their own controls. Various preoperative, perioperative, and postoperative traits of a subject remained the same as the subject carried out the pulmonary function measures in the three positions.

## Clinical Implications

The occurrence of postoperative pulmonary complications remains an area of concern for the nurse. The understanding of the physiological basis of ventilatory ability and the impact of preoperative, perioperative, and postoperative factors upon the development of pulmonary complications in the surgical patient helps to explain why the postoperative patient is at risk to develop ventilatory dysfunction. The identification of nursing interventions such as positioning to improve ventilatory ability and thereby prevent the occurrences of postoperative pulmonary complications is of major significance. The use of positioning as a respiratory intervention assists the nurse in defining and clarifying aspects of nursing practice.

The present study demonstrated that positioning has a definite influence upon the pulmonary function ability of the postoperative patient. The influence varies with subjects having different incisional types and with subjects who have identified preoperative, perioperative, and postoperative risk factors. The nurse is in a position to identify subjects at increased risk to develop postoperative pulmonary complications. By identifying these subjects, nurses can implement postoperative treatments to improve ventilatory ability. Standardization of the positioning interventions requires further study. Nurses can be involved in the research process to evaluate the interventions for specific operative procedures. The involvement of the nurse in the research process to define and refine positioning interventions assists in the upgrading of nursing practice by establishing an empirical base.

## Recommendations

1. The study needs to be replicated with a larger, randomly assigned sample including subjects with each incisional type to explore patient characteristics in detail that might be generalized to the population at large.

2. The study needs to be replicated with a nonsmoking population to determine the significance of this variable In the present study, fifty-three per cent of the subjects were smokers and another eighteen per cent had smoked in the past. Additionally, the mean pack years of smoking was 27 packs. The number and amount of smokers in the sample was exceptionally high.

3. The study needs to be replicated using other pulmonary assessment tools such as oxygen saturation, arterial blood gas measurements, and a portable spirometry unit that records the patients breathing patterns on a graph to more closely examine the type of breathing pattern in the postoperative patient.

4. The study needs to be replicated controlling for type of incisional pain relief such as continual epidural infusion of medication, or rigid intermittent parenteral administration of medication to determine if the decreased breathing ability is related to where the incision is or to the degree of pain caused by the incision.

5. The study needs to be replicated with specific postoperative interventions such as incentive spirometry given in a regimented manner at specific time intervals to more ably determine cause and effect.

## References

Ali, J. & Khan, T. (1979). The comparative effects of muscle transection and median upper abdominal incisions on postoperative pulmonary function. Surgery, Gynecology, and Obstetrics, 148, 863-866.

Ali, J., Weisel, R., Layug, A., Kripke, B., & Hechtman, H. (1974). Consequences of postoperative alterations in respiratory mechanics. The American Journal of Surgery, 128, 376-382.

American Thoracic Society. (1979). Statement: Snowbird Workshop on Standardization of Spirometry. American Review of Respiratory Disease, 119, 831-838.

Anthonisen, N. R., & Milic-Emili, J. (1966). Distribution of pulmonary perfusion in erect man. Journal of Applied Physiology, 21(3), 760-766.

Aspinall, M., & Tanner, C. (1981). Decision making for patient care: Applying the nursing process (pp.89-130). New York: Appleton-Century-Croft.

Bartlett, R. (1984). Respiratory therapy to prevent pulmonary complications of surgery. Respiratory Care, 29(6), 667-677.

Baum, G. (1983). Textbook of pulmonary disease (3rd ed.). Boston: Little Brown.

Black, L., & Hyatt, R. (1971). Maximal static respiratory pressures in generalized neuromuscular disease. American_Review_of_Respiratory_Disease, 103. 641-650.

Blalock, H.M., Jr. (1979). Social_statistics (Rev. 2nd. ed.). New York: McGraw-Hill.

Breslin, E. H. (1981). Prevention and treatment of pulmonary complications in patients after surgery of the upper abdomen. Heart_and_Lung, 10(3), 511-519.

Bryan, A., Bentivoglio, L., & Beerel, F., MacLeish, H., Zidulka, A., & Bates, D. (1964). Factors affecting regional distribution of ventilation and perfusion in the lung. Journal_of_Applied_Physiology, 19, 395-402.

Burki, N. (1982). The effects of posture on total respiratory compliance. American_Review_of_Respiratory Disease, 125, 262-263.

Burton, G., & Hodgkin, J. (1984). Respiratory_care:__A_ guide_to_clinical_practice (2nd ed., pp.231-258). Philadelphia: J. B. Lippincott.

Celli, B., Rodriguez, K., & Snider, G. (1984). A controlled trial of IPPB, IS, DB exercises in preventing pulmonary complications after abdominal surgery. American_Review_of_Respiratory_Disease, 130(1), 12-15.

Chesebrough-Ponds, Inc., Hospital Products Division. (No date). Cost effective patient monitoring for COPD patients. Brochure: Respiradyne pulmonary function monitor. Greenwich, CT: Author.

Cotes, J., Dabbs, J., Hall, A., & Heywood, C. (1979). Sitting height, fat-free mass, and body fat as reference variables for lung function in healthy British children: Comparison with stature. Annals of Human Biology. 6(4), 307-314.

Craig, D., Wahba, W., & Don, H. (1971). Airway closure and lung volumes in surgical positions. Canadian Anesthetist's Society Journal, 18(1), 92-99.

Craig, D., Wahba, W., Don, H., Couture, J., & Becklake, M. (1971). "Closing volume" and its relationship to gas exchange in seated and supine positions. Journal of Applied Physiology, 31(5), 717-720.

Dawson, A., Kaneko, K., & McGregor, M. (1965). Regional lung function in patients with mitral stenosis studied with Xenon-133 during air and oxygen breathing. Journal of Clinical Investigation, 44(1), 999-1008.

Douglas, W., Rehder, K., Beynen, F., Sessler, A., & Marsh, H. (1977). Improved oxygenation in patients with respiratory failure: The prone position. American Review of Respiratory Disease, 115, 559-566.

Drain, C. (1984). Comparison of two inspiratory maneuvers of increasing lung volumes in postoperative upper abdominal surgical patients. Journal of the American Association of Nurse Anesthetists, 52(4), 379-388.

Elman, A., Langonnet, G., Dixsaut, G., Hay, J., Guignard, J., Dazza, F., & Maillard, J. (1981). Respiratory function is impaired less by transverse than by median vertical supraumbilical incisions. Intensive Care Medicine, 7, 235-239.

Eriksen, J., Andersen, J., & Rasmussen, J. P. (1977). Postoperative pulmonary function in obese patients after upper abdominal surgery. Acta Anesthesia Scandinavia, 21, 336-341.

Ford, G., Whitelaw, W., Rosenal, T., Cruse, P., & Guenter, C. (1983). Diaphragm function after upper abdominal surgery in humans. American Review of Respiratory Disease, 127, 431-436.

Freedman, S. (1979). Lung volumes. British Journal of Clinical Pharmacology, 8(2). 99-107.

Gilman, A., Goodman, L., Rall, T., & Murad, F. (Eds.). (1985). The pharmacological basis of therapeutics (7th ed.). New York: MacMillan Publishing.

Greenfield, L. (Ed.). (1984). Complications in surgery and trauma. Philadelphia: J. B. Lippincott.

Guenter, C. (1977). Pulmonary medicine (1st ed., pp.72-123). Philadelphia: J. B. Lippincott.

Hales, C., & Kazemi, H. (1977). Pulmonary function after uncomplicated myocardial infarction. Chest, 72(3), 350-358.

Harper, R. A guide to respiratory care: Physiology and clinical applications (pp. 187-208). Philadelphia: J. B. Lippincott.

Heisterberg, L., Johansen, T., Larsen, H., Holm, M., & Andersen, B. (1979). Postoperative pulmonary complication in upper abdominal surgery. Acta Chir Scandinavica, 145, 505-507.

Helms, P., Hulse, M., & Hatch, D. (1982). Lung volume and lung mechanics in infancy lateral or supine posture? Pediatric Research, 16 943-947.

Hsu, H. O., & Hickey, R. F. (1976). Effect of posture on functional residual capacity postoperatively. Anesthesiology, 44(6), 520-521.

Hull, C., & Nie, N. (Eds.). (1981). SPSS update 7-9: New procedures and facilities for releases 7-9. New York: McGraw-Hill.

Hughes, J., Glazier, J., Maloney, J., & West, J. (1976). Effect of lung volume on the distribution of pulmonary blood flow in man. Respiration Physiology, 41, 58-72.

Hunter, P. (1981). Bedside monitoring of respiratory function. Nursing Clinics of North America, 16(2), 211-224.

Jung, R., Wight, J., Nisser, R., & Rosoff, L. (1980). Comparison of three methods of respiratory care following upper abdominal surgery. Chest, 78(1), 31-35.

Kaneko, K., Milic-Emili, J., Dolovich, M. B., Dawson, A., & Bates, D. V. (1966). Regional distribution of ventilation and perfusion as a function of body position. Journal of Applied Physiology, 21(3), 767-777.

Kauppinen-Walin, K., Sovij:arri, A., Muittari, A., & Uusitalo, A. (1980). Determination of functional residual capacity with Xenon-133 radiospirometry: Comparison with body plethysmography and helium spirometry. Effect of body position. Scandinavian Journal of Clinical Laboratory Investigations, 40(4), 347-354.

Kory, R., Callahan, R., Boren, H., & Syner, J. (1961). The Veterans Administration-Army cooperative study of pulmonary function: Clinical Spirometry in normal men. American Journal of Medicine, 30, 243-258.

Latimer, R., Dickman, M., Day, W., Gunn, M., & Schmidt, C. (1971). Ventilatory patterns and pulmonary complications after upper abdominal surgery determined by preoperative and postoperative computerized spirometry and blood gas analysis. The American Journal of Surgery, 122, 622-632.

Lawrence, R. (1971). Postoperative hypoxia: Causes, limits, and prevention. International Anesthesiology Clinics, 9(4), 31-83.

Lewis, M., & Christianson, L. (1978). Behavior of the human pulmonary circulation during head-up tilt. Journal of Applied Physiology, 45(2). 249-254.

Loether, H.J. & McTavish, D.G. (1974). Inferential statistics for sociologists: An introduction. Boston: Allyn and Bacon.

Lopez-Majano, V., & Renzi, G. (1978). Indications for pulmonary function testing. Respiration, 35, 53-63.

Luce, J. (1980). Respiratory complications of obesity. Chest, 78(4), 626-631.

Luce, J. (1984). Clinical risk factors for postoperative pulmonary complications. Respiratory Care, 29(5), 484-495.

Meyers, J., Lembeck, L., O'Kane, H., & Baue, A. (1975). Changes in functional residual capacity of the lung after operation. Archives of Surgery, 110, 576-583.

Moreno, F., & Lyons, H. (1961). Effect of body posture on lung volumes. Journal of Applied Physiology, 16(1), 27, 29.

Morran, C. G., Finlay, I. G., Mathieson, M., McKay, A. J., Wilson, N., & McArdle, C. S. (1983). Randomized controlled trial of physiotherapy for postoperative pulmonary complications. British Journal of Anesthesia, 55, 1113-1117.

Morris, J. (1976). Spirometry in the evaluation of pulmonary function. Western Journal of Medicine, 125(2), 110-117.

Morris, J., Koski, A., & Johnson, L. (1971). Spirometric standards for healthy nonsmoking adults. American Review of Respiratory Disease, 103, 57-67.

Morton, H. J. V. (1944). Tobacco smoking and pulmonary complications after operation. Lancet, 1, 368.

Neagley, S., Zwillich, C. (1985). The effect of positional changes on oxygenation in patients with pleural effusions. Chest, 88, 714-717.

Nie, N., Hull, C., Jenkins, J., Steinbrenner, K., & Bent, D. (1982). Statistical package for the social sciences (2nd ed.). New York: McGraw-Hill.

Ng, L., & McCormick, K. (1982). Position changes and their physiological consequences. Advances in Nursing Science, 4, 13-25.

Nunn, J. (1965). Influence of age and other factors on hypoxaemia in the postoperative period. Lancet, 2, 466-468.

Palmer, K., & Gardiner, A. (1964). Effect of partial gastrectomy on pulmonary physiology. The British Medical Journal, 1, 347-349.

Palmer, K., & Gardiner, A. (1962). Hypoxaemia after general anesthesia. Lancet, 2, 779-780.

Peters, R., Brimm, J., & Utley, J. (1979). Predicting the need for prolonged ventilatory support in adult cardiac patients. The Journal of Thoracic and Cardiovascular Surgery, 77(2), 175-182.

Piehl, H., & Brown, R. (1976). Use of extreme position changes in acute respiratory failure. Critical Care Medicine, 4(1), 13-14.

Pineda, H., Haas, F., Axen, K., & Haas, A. (1984). Accuracy of pulmonary function tests in predicting exercise tolerance in chronic obstructive pulmonary disease. Chest, 86(4), 565-567.

Purcell, J., White, S., & Fletcher, B. (1986). Heart attack: what's ahead (p. 51). Atlanta: Pritchett & Hull.

Rarey, K., & Youtsey, J. (1981). Respiratory patient care. Englewood Cliffs, New Jersey: Prentice-Hall.

Rehder, K., Knopp, T., Brusasco, V., & Didier, E. (1981). Inspiratory flow and intrapulmonary gas distribution. American Review of Respiratory Disease, 124, 392-396.

Ricksten, S., Bengtsson, A., Soderberg, C., Thorden, M., & Kvist, H. (1986). Effects of periodic positive airway pressure by mask on postoperative pulmonary function. Chest, 89(6), 774-781.

Rochester, D., & Enson, Y. (1974). Current concepts in the pathogenesis of the obesity-hypoventilation syndrome. The American Journal of Medicine, 57, 402-420.

Rudnikoff, I., & Headland, C. (1951). Pulmonary changes following cholecystectomy. Journal of the American Medical Association, 146(11), 989-991.

Ruppel, G. (1981). Manual of pulmonary function testing (2nd ed.). St. Louis: C. V. Mosby.

Russell, W. (1981). Position of patient and respiratory function in immediate postoperative period. British Medical Journal, 283, 1079-1080.

Schaanning, J., & Refsum, H. (1976). Influence of posture on pulmonary gas exchange and heart rate in chronic obstructive lung disease. Scandinavian Journal of Respiratory Disease, 57, 12-16.

Schwartz, S. (Ed.). (1983). Principles of surgery (4th ed.). New York: McGraw-Hill.

Schwieger, I., Gamulin, Z., Forster, A., Meyer, P., Gemperle, M., & Suter, P. M. (1986). Absence of benefit of incentive spirometry in low-risk patients undergoing elective cholecystectomy. Chest, 89(5), 652-656.

Sharp, J., Drutz, W., Moisan, T., Foster, T., & Machnach, W. (1980). Postural relief of dyspnea in severe chronic obstructive pulmonary disease. American Review of Respiratory Disease, 122, 201-211.

Slonim, N., & Hamilton, L. (1981). Respiratory Physiology (4th ed., pp. 11-65, 97-120). St. Louis: C. V. Mosby.

Spearmen, C., Sheldon, R., & Egan, D. Egan's fundamentals of respiratory therapy (4th ed.). St. Louis: C. V. Mosby.

Stock, M. C., Downs, J. B., Gauer, P. K., Alster, J. M., & Imrey, P. B. (1985). Prevention of postoperative pulmonary complications with CPAP, incentive spirometry, and conservative therapy. Chest, 87(2), 151-157.

Szczepanski, K., Skaarup, P., & Staehr-Johansen, T. (1973). Pleuropulmonary complications following major surgery (thoracic surgery excluded). Acta Chir Scandinavica, 139, 425-430.

Traver, G. (1974). The nurse's role in clinical testing of lung function. Nursing Clinics of North America, 9(1), 101-110.

Vastag, E., Matthys, H., Kohler, D., Gronbeck, L., & Daikeler, G. (1985). Mucociliary clearance and airways obstruction in smokers, ex-smokers, and normal subjects who never smoked. European Journal of Respiratory Disease, 66(suppl. 139), 93-100.

Vaughan, R., & Wise, L. (1975). Postoperative arterial blood gas measurements in obese patients: Effect of position on gas exchange. Annals of Surgery, 182(6), 705-709.

Wanner, A. (1985). A review of the effects of cigarette smoking on airway mucocal function. European Journal of Respiratory Disease, 66(Suppl. 139), 49-53.

Warren, C., & Grimwood, M. (1980). Pulmonary disorders and physiotherapy in patients who undergo cholecystectomy. The Canadian Journal of Surgery, 23(4), 384-386.

Watkins, J., & Salo, M. (1982). Trauma, stress, and immunity in anesthesia and surgery. London: Butterwork Scientific.

West, J. (1978). Regional differences in the lung. Chest, 74(4), 426-437.

Whipp, B., Ayers, L., & Ziment, I. A guide to the interpretation of pulmonary function tests (2nd ed.). New York: Roerig.

Wightman, J. (1968). A prospective survey of the incidence of postoperative pulmonary complications. The British Journal of Surgery, 55(2), 85-91.

Winer, B. J. (1962). Statistical principles in experimental design (pp. 105-139). New York: McGraw-Hill.

# APPENDIX A

## SUBJECT DATA SHEET

DATA SHEET

1. I. D. Number ____________________

2. Age (years last birthday) ____________

3. Sex 1. Male ______

2. Female _____

4. First Position 1. Flat _____

2. HOB 45 degrees _____

3. HOB 90 degrees _____

5. Tidal Volume one minute in Position 1

1. __________

2. __________

3. __________

6. Respiratory Rate one minute in Position 1

1. __________

2. __________

3. __________

7. Minute Ventilation in Position 1

1. __________

2. __________

3. __________

8. Forced Vital Capacity in Position 1

1. __________

2. __________

3. __________

9. Forced Expired Volume in one second in Position 1

1. ______________

2. ______________

3. ______________

10. Second Position 1. Flat _______

2. HOB 45 degrees _______

3. HOB 90 degrees _______

11. Tidal Volume one minute in Position 2

1. ______________

2. ______________

3. ______________

12. Respiratory Rate one minute in Position 2

1. ______________

2. ______________

3. ______________

13. Minute Ventilation in Position 2

1. ______________

2. ______________

3. ______________

14. Forced Vital Capacity in Position 2

1. ______________

2. ______________

3. ______________

15. Forced Expired Volume in one second in Position 2

1. ______________

2. ______________

3. ______________

16. Third Position 1. Flat ________

2. HOB 45 degrees ________

3. HOB 90 degrees ________

17. Tidal Volume one minute in Position 3

1. ______________

2. ______________

3. ______________

18. Respiratory Rate one minute in Position 3

1. ______________

2. ______________

3. ______________

19. Minute Ventilation in Position 3

1. ______________

2. ______________

3. ______________

20. Forced Vital Capacity in Position 3

1. ______________

2. ______________

3. ______________

21. Forced Expired Volume in one second in Position 3

1. ______________

2. ______________

3. ______________

22. Position Patient Found in ________________

23. Time of day of the study ________________

24. Type of Abdominal Incision 1. Upper Abdominal ____

2. Lower Abdominal ____

3. Combination ______

4. Other __________

25. Type of Surgery ______________________________

______________________________________________

______________________________________________

______________________________________________

26. Fourth Position 1. Flat ______

2. HOB 45 degrees ______

3. HOB 90 degrees ______

27. Tidal Volume one minute in Position 4

1. ____________

2. ____________

3. ____________

28. Respiratory Rate one minute in Position 4

1. ____________

2. ____________

3. ____________

29. Minute Ventilation in Position 4

1. ____________

2. ____________

3. ____________

30. Forced Vital Capacity in Position 4

1. ____________

2. ____________

3. ____________

31. Forced Expired Volume in one second in Position 4

1. ____________

2. ____________

3. ____________

32. Weight (to nearest whole kg.) ____________

33. Height (cm. to nearest whole number) ____________

34. Smoking History 1. Never Smoked ____________

2. Has Stopped Smoking ________

3. Smoker Currently ________

35. Packs Per Year Smoking ____________________

36. Systolic Blood Pressure (mm. Hg.) ______

37. Diastolic Blood Pressure (mm. Hg.) ______

38. Heartrate (beats per minute) __________

39. Temperature (converted to nearest Centigrade orally) ________

40. Is patient receiving sedatives? 1. Yes ____ 2. No ____

41. Time between administration of the sedative and the testing procedure in minutes.

____________________

42. Is patient receiving narcotics? 1. Yes ____ 2. No ____

43. Time between administration of the narcotic and the testing procedure in minutes.

____________________

44. Is patient receiving bronchodilators? 1. Yes ____ 2. No ____

45. Time between administration of the bronchodilators and the testing procedure in minutes.

____________________

46. Is patient receiving antibiotics? 1. Yes ____ 2. No ____

List the Current Medications and time schedule.

Does the patient have a medical diagnosis in the following systems?

1. Yes ____ 2. No ____

47. PULMONARY SYSTEM

Specify

48. CARDIOVASCULAR SYSTEM

Specify

49. GASTROINTESTINAL SYSTEM

Specify

50. RENAL SYSTEM

Specify

51. LIVER FAILURE

Specify

52. NEUROLOGICAL SYSTEM

Specify

53. MUSCOLOSKELETAL SYSTEM

Specify

54. EAR, NOSE, AND THROAT

Specify

55. CHEST TRAUMA

Specify

56. OTHER

Is there any indication in the record of the following pulmonary complications?

1. Yes ____ 2. No ____

57. Pneumonia

58. Pulmonary Emboli

59. Pleural Effusion

60. Congestive Heart Failure
(left or right heart failure)

61. Airway Obstruction

62. Atelectasis

63. Other

64. Type of anesthesia and premedications.

Anesthesia ________________________________

________________________________________

Premedications ______________________________

________________________________________

65. Length of surgical procedure in minutes. __________

________________________________________

66. Complications during the surgery

1. No complications ________

2. Hypotension ________

3. Arrhythmias ________

4. Excessive Blood Loss ________

5. Other ______________

67. Estimated blood loss in surgery in cc's ________________

Is patient receiving respiratory interventions?

1, Yes ____ 2. No ____.

68. Incentive Spirometer ____________

69. Ambulation/Chair ____________

70. Chest Physical Therapy __________

71. Postural Drainage __________

72. Other __________

# APPENDIX B

## INFORMED CONSENT

## OREGON HEALTH SCIENCES UNIVERISTY

OREGON HEALTH SCIENCES UNIVERSITY

School of Nursing

INFORMED CONSENT

I, ______________________________, herein agree to serve as a subject in the study, "The Influence of Body Positioning upon Pulmonary Function Tests in Postoperative Patients", by Carolyn Bawden, R.N., under the supervision of Christine Tanner, R.N., Ph.D. This study aims at the identification of an optimal breathing position from head of bed flat, head of bed elevated 45 degrees, and head of bed elevated 90 degrees on the basis of bedside breathing measurements.

In the study, I will be placed in the three positions of flat, head of bed elevated 45 degrees, and head of bed elevated 90 degrees. In each position, I will place a mouthpiece into my mouth and breathe normally for one full minute. I will also be asked to take a deep breath and to blow it out as much as I can for three times in each position. The positions may be in any order. I will be in each position for ten to fifteen minutes. It is my understanding that deep breathing and position changes are a usual part of my post-operative activity. Deep breathing and change of position can cause pain and discomfort, particularly over my incision. My blood pressure, pulse, and breathing rate will be measured and recorded.

There may be no direct benefit for me by participating in this study. It is anticipated that the study will contribute to the identification of an optimal position for breathing for someone with my medical problems.

The researcher will record information from my chart to clarify measurements. All the information will be kept confidential. My name will not appear on the records, and anonymity will be assured by the assignment of a code number to all my information.

Carolyn Bawden, the researcher, has offered to answer my questions about participation in the study. I understand that I may refuse to participate, or withdraw from this study at any time without affecting my relationship with, or treatment at the Oregon Health Sciences University.

I understand what will be required of me and agree to participate in the study.

The Oregon Health Sciences University, as an agency of the State, is covered by the State Liability Fund. I understand that if I suffer any injury from the research project, compensation will be available to me only if I can establish that the injury occurred through the fault of the University, its officers, or employees. If you have further questions, please call Dr. Michael Baird at (503)225-8014.

SUBJECT ______________________________ Date ____________

RESEARCHER ______________________________ Date ____________

# APPENDIX C

## GENERAL CONSENT FORM

## VETERANS ADMINISTRATION HOSPITAL

## PART I-AGREEMENT TO PARTICIPATE IN RESEARCH BY OR UNDER THE DIRECTION OF THE VETERANS ADMINISTRATION

DATE

1. I, ______________________________ ,voluntarily consent to participate as a subject
(Type or print subject's name)

in the investigation entitled The Influence of Body Positions upon Pulmonary Function Tests in Postoperative Patients
(Title of study)

2. I have signed one or more information sheets with this title to show that I have read the description including the purpose and nature of the investigation, the procedures to be used, the risks, inconveniences, side effects and benefits to be expected, as well as other courses of action open to me and my right to withdraw from the investigation at any time. Each of these items has been explained to me by the investigator in the presence of a witness. The investigator has answered my questions concerning the investigation and I believe I understand what is intended.

3. I understand that no guarantees or assurances have been given me since the results and risks of an investigation are not always known beforehand. I have been told that this investigation has been carefully planned, that the plan has been reviewed by knowledgeable people, and that every reasonable precaution will be taken to protect my well-being.

4. In the event I sustain physical injury as a result of participation in this investigation, if I am eligible for medical care as a veteran, all necessary and appropriate care will be provided. If I am not eligible for medical care as a veteran, humanitarian emergency care will nevertheless be provided.

5. I realize I have not released this institution from liability for negligence. Compensation may or may not be payable, in the event of physical injury arising from such research, under applicable federal laws.

6. I understand that all information obtained about me during the course of this study will be made available only to doctors who are taking care of me and to qualified investigators and their assistants where their access to this information is appropriate and authorized. They will be bound by the same requirements to maintain my privacy and anonymity as apply to all medical personnel within the Veterans Administration.

7. I further understand that, where required by law, the appropriate federal officer or agency will have free access to information obtained in this study should it become necessary. Generally, I may expect the same respect for my privacy and anonymity from these agencies as is afforded by the Veterans Administration and its employees. The provisions of the Privacy Act apply to all agencies.

8. In the event that research in which I participate involves certain new drugs, information concerning my response to the drug(s) will be supplied to the sponsoring pharmaceutical house(s) that made the drug(s) available. This information will be given to them in such a way that I cannot be identified.

I ______________________________
NAME OF VOLUNTEER

HAVE READ THIS CONSENT FORM. ALL MY QUESTIONS HAVE BEEN ANSWERED, AND I FREELY AND VOLUNTARILY CHOOSE TO PARTICIPATE. I UNDERSTAND THAT MY RIGHTS AND PRIVACY WILL BE MAINTAINED. I AGREE TO PARTICIPATE AS A VOLUNTEER IN THIS PROGRAM.

9. Nevertheless, I wish to limit my participation in the investigation as follows:

| | |
|---|---|
| VA FACILITY<br>Portland Veterans Adminis. Hospital | SUBJECT'S SIGNATURE |
| WITNESS'S NAME AND ADDRESS (Print or type) | WITNESS'S SIGNATURE |
| INVESTIGATOR'S NAME (Print or type) | INVESTIGATOR'S SIGNATURE |

☐ Signed information sheets attached. ☐ Signed information sheets available at:

| | | |
|---|---|---|
| SUBJECT'S IDENTIFICATION (I.D. plate or give name - last, first, middle) | SUBJECT'S I.D. NO. | WARD |

AGREEMENT TO PARTICIPATE IN RESEARCH BY OR UNDER THE DIRECTION OF THE VETERANS ADMINISTRATION

VA FORM SEP 1979 10-1086 SUPERSEDES VA FORM 10-1086 JUN 1975, WHICH WILL NOT BE USED.

APPENDIX D

NURSING CONSENT FORM

VETERANS ADMINISTRATION HOSPITAL

Standard Form 507 648—10—81472-3 GPO

| CLINICAL RECORD | Report on ______ or Continuation of S. F. ______ (Strike out one line) (Specify type of examination or data) |
|---|---|

(Sign and date)

Portland Veterans Administrative Hospital

I, ________________________________, am willing to be a subject in the study, "Influence of Body Positions upon Pulmonary Function Tests in Postoperative Patients", by Carolyn Bawden, R.N., under the supervision of Carol Duncan, R.N., M.N. The study will determine my best position for breathing.

The night before my surgery I will sign a permit. I will be given an opportunity to practice breathing with two instruments. With one instrument, I will place a mouthpiece into my mouth and breath into it for one minute while my respiratory rate is counted. With the other instrument, I will exhale into the mouthpiece after taking a deep breath. I will do each breathing test three times in a sitting position. The morning after my surgery, I will be placed in the three positions of flat in bed, head of bed elevated forty-five degrees, and head of bed elevated ninety degrees. In each position, I will perform the two types of breathing three times. Measurements will be recorded from the equipment to determine my best position for breathing. My blood pressure, pulse, and breathing rate will be recorded during the test. The testing the morning after surgery will occur between 6 A.M. and 8 A.M. There is no known risk to this procedure. The actual measurements will take fifteen to twenty minutes. Ten minutes will be spent on the actual measurements and five minutes to rest between position changes.

All information gathered will be kept confidential.

The benefit of the study for me is to find my best position for breathing. This knowledge may also help patients with similar health problems.

I understand that I may refuse to participate in, or withdraw from the study at any time without affecting my relationship with, or treatment at the Portland Veterans Administrative Hospital.

I understand what will be required of me and agree to participate in the study as described above.

(Continue on reverse side)

| PATIENT'S IDENTIFICATION (For typed or written entries give: Name—last, first, middle; grade; date; hospital or medical facility) | REGISTER NO. | WARD NO. |
|---|---|---|

REPORT ON ______ or CONTINUATION OF ______

STANDARD FORM 507
General Services Administration and
Interagency Committee on Medical Records
FPMR 101-11.80 6-8
October 1975 507-106

Standard Form 507 — 043—16—81472p-3 GPO

| CLINICAL RECORD | Report on ________ or Continuation of S. F. ________ (Strike out one line) (Specify type of examination or data) |
|---|---|

*(Sign and date)*

Signature of Subject ______________________ Date ____________

Researcher ______________________

Witness ______________________

*(Continue on reverse side)*

| PATIENT'S IDENTIFICATION *(For typed or written entries give: Name—last, first, middle; grade; date; hospital or medical facility)* | REGISTER NO. | WARD NO. |
|---|---|---|

REPORT ON ________ or CONTINUATION OF ________

STANDARD FORM 507
General Services Administration and
Interagency Committee on Medical Records
FPMR 101-11.80 6-8
October 1975 507-106

# APPENDIX E

# TIDAL VOLUME TABLES FOR CONTROL VARIABLES

Table E-1

Seven Subjects with Pulmonary Disease Separated by Incisional Type According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| UPPER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 2 | 2 | 1 |
| Predicted Tidal Volume | 0 | 0 | 1 |
| Increased Tidal Volume | 0 | 0 | 0 |
| | 2 | 2 | 2 |
| LOWER ABDOMINAL SUBJECTS | | | |
| Decreased Tidal Volume | 2 | 3 | 1 |
| Predicted Tidal Volume | 1 | 0 | 2 |
| Increased Tidal Volume | 1 | 1 | 1 |
| | 4 | 4 | 4 |
| COMBINATION SUBJECTS | | | |
| Decreased Tidal Volume | 0 | 0 | 0 |
| Predicted Tidal Volume | 1 | 1 | 1 |
| Increased Tidal Volume | 0 | 0 | 0 |
| | 1 | 1 | 1 |

Table E-2

Three Subjects with Neuromuscular Disease Separated by Incisional Type According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **UPPER ABDOMINAL SUBJECTS** | | | |
| Decreased Tidal Volume | 1 | 1 | 1 |
| Predicted Tidal Volume | 1 | 1 | 1 |
| Increased Tidal Volume | 0 | 0 | 0 |
| | 2 | 2 | 2 |
| **LOWER ABDOMINAL SUBJECTS** | | | |
| Decreased Tidal Volume | 0 | 0 | 0 |
| Predicted Tidal Volume | 0 | 0 | 0 |
| Increased Tidal Volume | 0 | 0 | 0 |
| | 0 | 0 | 0 |
| **COMBINATION SUBJECTS** | | | |
| Decreased Tidal Volume | 1 | 0 | 0 |
| Predicted Tidal Volume | 0 | 0 | 1 |
| Increased Tidal Volume | 0 | 1 | 0 |
| | 1 | 1 | 1 |

Table E-3

Subjects with Concurrent Cardiac, Pulmonary, and Neuromuscular Disease Separated According to Mean Tidal Volume in Three Positions for Sequence 2

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| CARDIAC SUBJECTS | | | |
| Decreased Tidal Volume | 3 | 3 | 3 |
| Predicted Tidal Volume | 1 | 1 | 1 |
| Increased Tidal Volume | 0 | 0 | 0 |
| | 4 | 4 | 4 |
| PULMMONARY SUBJECTS | | | |
| Decreased Tidal Volume | 1 | 1 | 0 |
| Predicted Tidal Volume | 0 | 0 | 1 |
| Increased Tidal Volume | 1 | 1 | 1 |
| | 2 | 2 | 2 |
| NEUROMUSCULAR SUBJECTS | | | |
| Decreased Tidal Volume | 1 | 0 | 0 |
| Predicted Tidal Volume | 0 | 0 | 1 |
| Increased Tidal Volume | 0 | 1 | 0 |
| | 1 | 1 | 1 |

Table E-4

Twenty-one Subjects Using the Incentive Spirometer Separated by Sequence According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| SEQUENCE 1 SUBJECTS | | | |
| Decreased Tidal Volume | 6 | 5 | 6 |
| Predicted Tidal Volume | 4 | 5 | 3 |
| Increased Tidal Volume | 3 | 3 | 4 |
| | 13 | 13 | 13 |
| SEQUENCE 2 SUBJECTS | | | |
| Decreased Tidal Volume | 5 | 4 | 3 |
| Predicted Tidal Volume | 1 | 1 | 3 |
| Increased Tidal Volume | 2 | 3 | 2 |
| | 8 | 8 | 8 |

Table E-5

Thirteen Subjects Ambulated Prior to Testing Separated by Sequence According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| SEQUENCE 1 SUBJECTS | | | |
| Decreased Tidal Volume | 3 | 2 | 2 |
| Predicted Tidal Volume | 3 | 4 | 1 |
| Increased Tidal Volume | 2 | 2 | 5 |
| | 8 | 8 | 8 |
| SEQUENCE 2 SUBJECTS | | | |
| Decreased Tidal Volume | 0 | 0 | 1 |
| Predicted Tidal Volume | 4 | 4 | 3 |
| Increased Tidal Volume | 1 | 1 | 1 |
| | 5 | 5 | 5 |

Table E-6

Ten Subjects Repositioned Prior to Testing Separated by Sequence According to Mean Tidal Volume in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| SEQUENCE 1 SUBJECTS | | | |
| Decreased Tidal Volume | 1 | 2 | 1 |
| Predicted Tidal Volume | 3 | 2 | 2 |
| Increased Tidal Volume | 2 | 2 | 3 |
| | 6 | 6 | 6 |
| SEQUENCE 2 SUBJECTS | | | |
| Decreased Tidal Volume | 0 | 1 | 0 |
| Predicted Tidal Volume | 2 | 1 | 2 |
| Increased Tidal Volume | 2 | 2 | 2 |
| | 4 | 4 | 4 |

# APPENDIX F

## ANALYSIS OF VARIANCE SUMMARY AND PLANNED COMPARISONS DATA FOR RESPIRATORY RATE

Table F-1

Analysis of Variance Summaries for the Respiratory Rate

| | Sum of Squares | df | Mean Square | Grand Mean | F | Probability |
|---|---|---|---|---|---|---|
| **Total** | | | | | | |
| Sample | | | | | | |
| Between | 2,474 | 33 | 74.96 | | | |
| Within | 330 | 68 | 4.85 | | | |
| Between Measures | 6 | 2 | 2.77 | 17.36 | 0.56 | .571 |
| Residual | 324 | 66 | 4.92 | | | |
| Total | 2,804 | 101 | 27.76 | | | |
| **Incision** | | | | | | |
| Upper Abdominal | | | | | | |
| Between | 1,211 | 9 | 134.52 | | | |
| Within | 120 | 20 | 6.00 | | | |
| Between Measures | 13 | 2 | 6.53 | 18.67 | 1.10 | .354 |
| Residual | 107 | 18 | 5.94 | | | |
| Total | 1,331 | 29 | 45.89 | | | |
| Lower Abdominal | | | | | | |
| Between | 634 | 12 | 52.79 | | | |
| Within | 128 | 26 | 4.92 | | | |
| Between Measures | 11 | 2 | 5.33 | 17.74 | 1.10 | .352 |
| Residual | 117 | 24 | 4.89 | | | |
| Total | 761 | 38 | 20.04 | | | |
| Combination | | | | | | |
| Between | 485 | 10 | 48.45 | | | |
| Within | 82 | 22 | 3.73 | | | |
| Between Measures | 17 | 2 | 8.27 | 15.73 | 2.53 | .105 |
| Residual | 65 | 20 | 3.27 | | | |
| Total | 567 | 32 | 17.70 | | | |
| **Sequence** | | | | | | |
| Sequence 1 | | | | | | |
| Between | 2,009 | 21 | 95.66 | | | |
| Within | 165 | 44 | 3.76 | | | |
| Between Measures | 10 | 2 | 4.79 | 17.42 | 1.29 | .286 |
| Residual | 156 | 42 | 3.71 | | | |
| Total | 2,174 | 65 | 33.45 | | | |
| Sequence 2 | | | | | | |
| Between | 464 | 11 | 42.19 | | | |
| Within | 165 | 24 | 6.86 | | | |
| Between Measures | 3 | 5 | 1.58 | 17.25 | 0.22 | .807 |
| Residual | 162 | 22 | 7.34 | | | |
| Total | 629 | 35 | 17.96 | | | |

Table F-2

Comparison of the Respiratory Rate Means for the Three Positions of Flat, 45 Degrees, and 90 Degrees Using a Planned T-test and Tukey Test

| | $\bar{x}_1 - \bar{x}_2$ | | | | $\bar{x}_2 - \bar{x}_3$ | | | | $\bar{x}_1 - \bar{x}_3$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}_1$ | $\bar{x}_2$ | t | q | $\bar{x}_2$ | $\bar{x}_3$ | t | q | $\bar{x}_1$ | $\bar{x}_3$ | t | q |
| Sample Population | 17.1 | 17.3 | 0.30 | 0.53 | 17.3 | 17.7 | 0.70 | 1.05 | 17.1 | 17.7 | 1.01 | 1.55 |
| Upper Abdominal Incisions | 19.4 | 18.8 | -0.55 | -0.78 | 18.8 | 17.8 | -0.92 | -1.30 | 19.4 | 17.8 | -1.47 | -2.08 |
| Lower Abdominal Incisions | 17.2 | 17.5 | 0.36 | 0.51 | 17.5 | 18.5 | 1.06 | 1.51 | 17.2 | 18.5 | 1.41 | 2.02 |
| Combination Incisions | 14.9 | 15.6 | 0.95 | 1.27 | 15.6 | 16.6 | 1.30 | 1.82 | 14.9 | 16.6 | 2.25** | 3.09 |
| Sequence 1 | 16.9 | 17.5 | 1.10 | 1.56 | 17.5 | 17.8 | 0.47 | 0.66 | 16.9 | 17.8 | 1.57 | 2.22 |
| Sequence 2 | 17.5 | 16.8 | -0.60 | -0.86 | 16.8 | 17.4 | 0.52 | 0.76 | 17.5 | 17.4 | -0.08 | -0.10 |

$\bar{x}_1$ = Head of Bed Flat

$\bar{x}_2$ = Head of Bed 45 Degrees

$\bar{x}_3$ = Head of Bed 90 Degrees

* $p \leq .01$

** $p \leq .05$

# APPENDIX G

## MINUTE VENTILATION TABLES FOR

## CONTROL VARIABLES

Table G-1

Twenty-four Subjects Over Age 50 for Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions

| | Position | | |
| --- | --- | --- | --- |
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Decreased Minute Ventilation | 5 | 4 | 2 |
| Predicted Minute Ventilation | 10 | 11 | 10 |
| Increased Minute Ventilation | 9 | 9 | 12 |
| | 24 | 24 | 24 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Decreased Minute Ventilation | 5 | 4 | 1 |
| Predicted Minute Ventilation | 7 | 8 | 8 |
| Increased Minute Ventilation | 4 | 4 | 7 |
| | 16 | 16 | 16 |
| Sequence 2 Subjects | | | |
| Decreased Minute Ventilation | 0 | 0 | 1 |
| Predicted Minute Ventilation | 3 | 3 | 2 |
| Increased Minute Ventilation | 5 | 5 | 5 |
| | 8 | 8 | 8 |

Table G-2

Twenty-four Subjects Over Age 50 Separated by Incisional Type According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 2 | 2 | 0 |
| Predicted Minute Ventilation | 2 | 3 | 5 |
| Increased Minute Ventilation | 5 | 4 | 4 |
| | 9 | 9 | 9 |
| **Combination Subjects** | | | |
| Decreased Minute Ventilation | 3 | 2 | 1 |
| Predicted Minute Ventilation | 5 | 6 | 5 |
| Increased Minute Ventilation | 2 | 2 | 4 |
| | 10 | 10 | 10 |
| **Lower Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 0 | 0 | 1 |
| Predicted Minute Ventilation | 3 | 2 | 0 |
| Increased Minute Ventilation | 2 | 3 | 4 |
| | 5 | 5 | 5 |

Table G-3

Fifteen Overweight Subjects for Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Decreased Minute Ventilation | 2 | 2 | 0 |
| Predicted Minute Ventilation | 7 | 7 | 5 |
| Increased Minute Ventilation | 6 | 6 | 10 |
| | 15 | 15 | 15 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Decreased Minute Ventilation | 2 | 2 | 0 |
| Predicted Minute Ventilation | 7 | 6 | 5 |
| Increased Minute Ventilation | 2 | 3 | 6 |
| | 11 | 11 | 11 |
| Sequence 2 Subjects | | | |
| Decreased Minute Ventilation | 0 | 0 | 0 |
| Predicted Minute Ventilation | 0 | 0 | 0 |
| Increased Minute Ventilation | 4 | 4 | 4 |
| | 4 | 4 | 4 |

Table G-4

Fifteen Overweight Subjects Separated by Incisional Type According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 0 | 1 | 0 |
| Predicted Minute Ventilation | 2 | 1 | 1 |
| Increased Minute Ventilation | 4 | 4 | 5 |
| | 6 | 6 | 6 |
| **Combination Subjects** | | | |
| Decreased Minute Ventilation | 1 | 1 | 0 |
| Predicted Minute Ventilation | 2 | 2 | 2 |
| Increased Minute Ventilation | 1 | 1 | 2 |
| | 4 | 4 | 4 |
| **Lower Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 1 | 0 | 0 |
| Predicted Minute Ventilation | 3 | 3 | 2 |
| Increased Minute Ventilation | 1 | 2 | 3 |
| | 5 | 5 | 5 |

Table G-5

Twenty-four Smoking Subjects for Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **TOTAL SAMPLE** | | | |
| Decreased Minute Ventilation | 4 | 4 | 3 |
| Predicted Minute Ventilation | 13 | 13 | 10 |
| Increased Minute Ventilation | 7 | 7 | 11 |
| | 24 | 24 | 24 |
| **SEQUENCE** | | | |
| Sequence 1 Subjects | | | |
| Decreased Minute Ventilation | 4 | 4 | 2 |
| Predicted Minute Ventilation | 8 | 8 | 6 |
| Increased Minute Ventilation | 3 | 3 | 7 |
| | 15 | 15 | 15 |
| Sequence 2 Subjects | | | |
| Decreased Minute Ventilation | 0 | 0 | 1 |
| Predicted Minute Ventilation | 5 | 5 | 4 |
| Increased Minute Ventilation | 4 | 4 | 4 |
| | 9 | 9 | 9 |

Table G-6

Twenty-four Smoking Subjects Separated by Incisional Type According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 1 | 2 | 0 |
| Predicted Minute Ventilation | 3 | 3 | 4 |
| Increased Minute Ventilation | 4 | 3 | 4 |
| | 8 | 8 | 8 |
| **Combination Subjects** | | | |
| Decreased Minute Ventilation | 2 | 1 | 1 |
| Predicted Minute Ventilation | 4 | 5 | 4 |
| Increased Minute Ventilation | 1 | 1 | 2 |
| | 7 | 7 | 7 |
| **Lower Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 1 | 1 | 2 |
| Predicted Minute Ventilation | 6 | 5 | 2 |
| Increased Minute Ventilation | 2 | 3 | 5 |
| | 9 | 9 | 9 |

Table G-7

Sixteen Subjects with Cardiac Disease for Total Sample and Separated by Sequence According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Decreased Minute Ventilation | 5 | 3 | 3 |
| Predicted Minute Ventilation | 6 | 8 | 6 |
| Increased Minute Ventilation | 5 | 5 | 8 |
| | 16 | 16 | 16 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Decreased Minute Ventilation | 4 | 3 | 2 |
| Predicted Minute Ventilation | 4 | 5 | 4 |
| Increased Minute Ventilation | 4 | 4 | 6 |
| | 12 | 12 | 12 |
| Sequence 2 Subjects | | | |
| Decreased Minute Ventilation | 0 | 0 | 1 |
| Predicted Minute Ventilation | 2 | 2 | 1 |
| Increased Minute Ventilation | 2 | 2 | 2 |
| | 4 | 4 | 4 |

Table G-8

Sixteen Subjects with Cardiac Disease Separated by Incisional Type According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 1 | 0 | 0 |
| Predicted Minute Ventilation | 0 | 2 | 2 |
| Increased Minute Ventilation | 3 | 2 | 2 |
| | 4 | 4 | 4 |
| **Combination Subjects** | | | |
| Decreased Minute Ventilation | 3 | 2 | 2 |
| Predicted Minute Ventilation | 3 | 4 | 3 |
| Increased Minute Ventilation | 1 | 1 | 3 |
| | 7 | 7 | 7 |
| **Lower Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 1 | 1 | 2 |
| Predicted Minute Ventilation | 3 | 2 | 0 |
| Increased Minute Ventilation | 1 | 2 | 2 |
| | 5 | 5 | 5 |

Table G-9

Five Subjects with Operative Blood Loss Greater than 500 cc for Total Sample and Sequence According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **TOTAL SAMPLE** | | | |
| Decreased Minute Ventilation | 2 | 2 | 0 |
| Predicted Minute Ventilation | 3 | 3 | 3 |
| Increased Minute Ventilation | 0 | 0 | 2 |
| | 5 | 5 | 5 |
| **SEQUENCE** | | | |
| Sequence 1 Subjects | | | |
| Decreased Minute Ventilation | 2 | 1 | 0 |
| Predicted Minute Ventilation | 2 | 3 | 2 |
| Increased Minute Ventilation | 0 | 0 | 2 |
| | 4 | 4 | 4 |
| Sequence 2 Subjects | | | |
| Decreased Minute Ventilation | 0 | 1 | 0 |
| Predicted Minute Ventilation | 1 | 0 | 1 |
| Increased Minute Ventilation | 0 | 0 | 0 |
| | 1 | 1 | 1 |

Table G-10

Five Subjects with Operative Blood Loss Greater than 500 cc Separated by Incisional Type According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 1 | 1 | 0 |
| Predicted Minute Ventilation | 0 | 0 | 1 |
| Increased Minute Ventilation | 0 | 0 | 0 |
| | 1 | 1 | 1 |
| **Combination Subjects** | | | |
| Decreased Minute Ventilation | 1 | 1 | 0 |
| Predicted Minute Ventilation | 2 | 2 | 1 |
| Increased Minute Ventilation | 0 | 0 | 2 |
| | 3 | 3 | 3 |
| **Lower Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 0 | 0 | 0 |
| Predicted Minute Ventilation | 1 | 1 | 1 |
| Increased Minute Ventilation | 0 | 0 | 0 |
| | 1 | 1 | 1 |

Table G-11

Ten Subjects Repositioned After Surgery Separated by Incisional Type According to Minute Ventilation in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 0 | 0 | 0 |
| Predicted Minute Ventilation | 1 | 2 | 2 |
| Increased Minute Ventilation | 3 | 2 | 2 |
| | 4 | 4 | 4 |
| **Combination Subjects** | | | |
| Decreased Minute Ventilation | 1 | 2 | 1 |
| Predicted Minute Ventilation | 1 | 0 | 1 |
| Increased Minute Ventilation | 2 | 2 | 2 |
| | 4 | 4 | 4 |
| **Lower Abdominal Subjects** | | | |
| Decreased Minute Ventilation | 0 | 0 | 0 |
| Predicted Minute Ventilation | 2 | 1 | 0 |
| Increased Minute Ventilation | 0 | 1 | 2 |
| | 2 | 2 | 2 |

# APPENDIX H

## NOMOGRAMS FOR NORMAL MEN AND WOMEN

## FOR FVC AND FEV1 PREDICTIONS

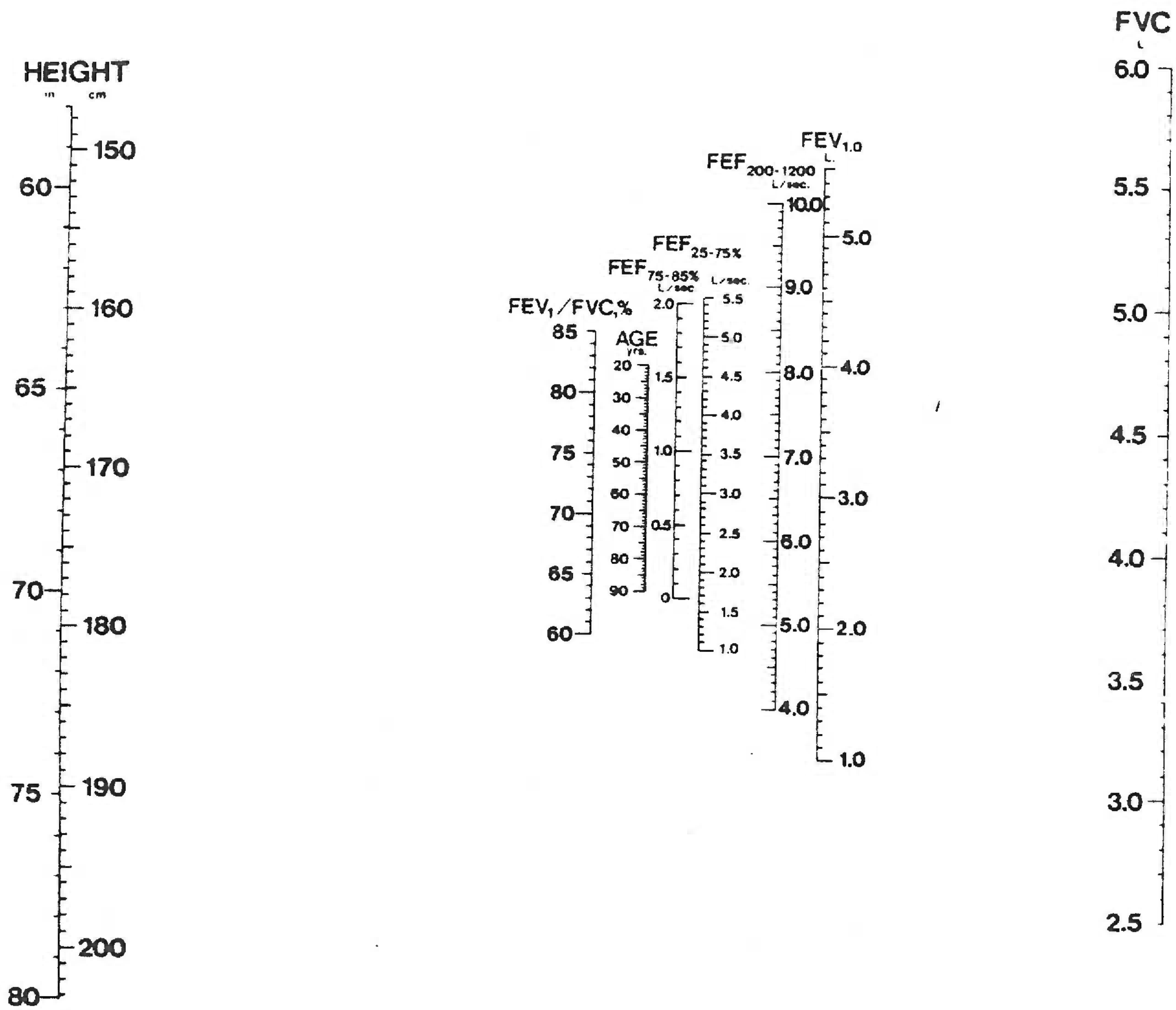
## AND

## FVC TABLES FOR

## CONTROL VARIABLES

Appendix H-1

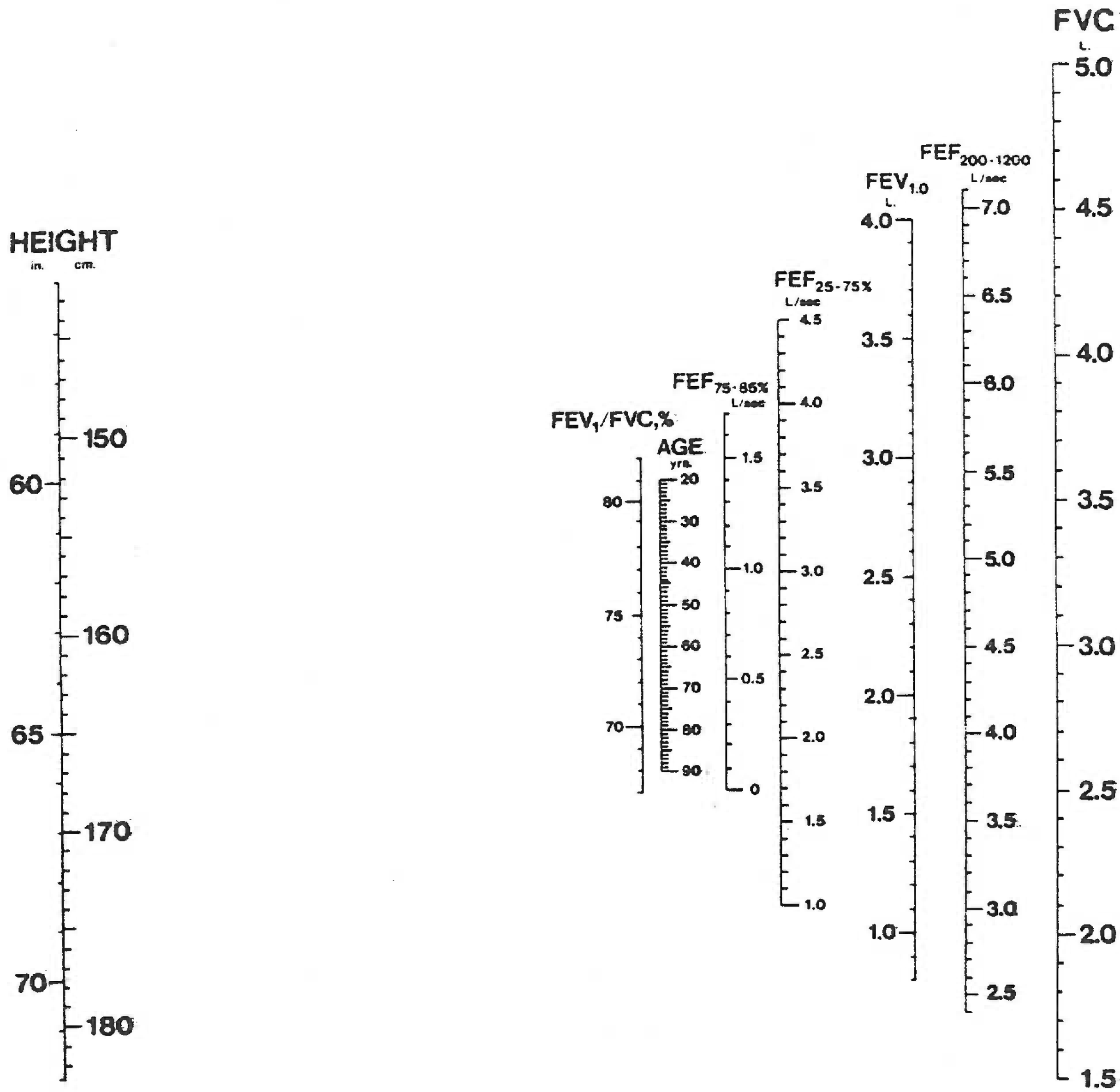
Prediction nomogram for normal men.




Morris, J., Koski, A., & Johnson, L. (1971). Spirometric standards for healthy nonsmoking adults. American Review of Respiratory Disease. 103, 57-67.

Appendix H-2

Prediction nomogram for normal women.




Morris, J., Koski, A., & Johnson, L. (1971). Spirometric standards for healthy nonsmoking adults. American Review of Respiratory Disease. 103, 57-67.

Table H-3

Fifteen Overweight Subjects Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 2 | 1 | 4 |
| Severe Impairment | 1 | 2 | 4 |
| Very Severe Impairment | 11 | 11 | 6 |
| | 15 | 15 | 15 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 2 | 1 | 3 |
| Severe Impairment | 0 | 1 | 3 |
| Very Severe Impairment | 7 | 7 | 3 |
| | 10 | 10 | 10 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 1 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 4 | 4 | 3 |
| | 5 | 5 | 5 |

Table H-4

Fifteen Overweight Subjects Classified According to Ventilatory Ability as Measured by FVC for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 1 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 4 | 4 | 3 |
| | 5 | 5 | 5 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 1 | 1 | 1 |
| Severe Impairment | 0 | 0 | 3 |
| Very Severe Impairment | 5 | 5 | 2 |
| | 6 | 6 | 6 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 2 | 1 | 3 |
| Severe Impairment | 0 | 1 | 0 |
| Very Severe Impairment | 2 | 2 | 1 |
| | 4 | 4 | 4 |

Table H-5

Six Underweight Subjects Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **TOTAL SAMPLE** | | | |
| Normal or Mild Impairment | 0 | 1 | 0 |
| Moderate Impairment | 1 | 1 | 1 |
| Severe Impairment | 1 | 1 | 2 |
| Very Severe Impairment | 4 | 3 | 3 |
| | 6 | 6 | 6 |
| **SEQUENCE** | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 1 | 1 |
| Very Severe Impairment | 3 | 2 | 2 |
| | 3 | 3 | 3 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 1 | 0 |
| Moderate Impairment | 1 | 1 | 1 |
| Severe Impairment | 1 | 0 | 1 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 3 | 3 | 3 |

Table H-6

Six Underweight Subjects Classified According to Ventilatory Ability as Measured by FVC for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 1 | 1 | 1 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 3 | 3 | 3 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 1 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 1 | 2 |
| Very Severe Impairment | 1 | 0 | 0 |
| | 2 | 2 | 2 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 1 | 1 | 1 |

Table H-7

Twenty-four Smoking Subjects Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 4 | 3 | 5 |
| Moderate Impairment | 4 | 4 | 4 |
| Severe Impairment | 3 | 5 | 4 |
| Very Severe Impairment | 13 | 12 | 11 |
| | 24 | 24 | 24 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 2 | 1 | 3 |
| Severe Impairment | 1 | 3 | 2 |
| Very Severe Impairment | 11 | 10 | 9 |
| | 15 | 15 | 15 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 2 | 1 | 3 |
| Moderate Impairment | 3 | 4 | 2 |
| Severe Impairment | 2 | 2 | 2 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 9 | 9 | 9 |

Table H-8

Twenty-four Smoking Subjects Classified According to Ventilatory Ability as Measured by FVC for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| Upper Abdominal Subjects | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 0 | 0 | 1 |
| Severe Impairment | 1 | 1 | 0 |
| Very Severe Impairment | 6 | 6 | 6 |
| | 8 | 8 | 8 |
| Combination Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 2 | 3 | 3 |
| Very Severe Impairment | 5 | 4 | 4 |
| | 7 | 7 | 7 |
| Lower Abdominal Subjects | | | |
| Normal or Mild Impairment | 3 | 2 | 4 |
| Moderate Impairment | 4 | 4 | 3 |
| Severe Impairment | 0 | 1 | 1 |
| Very Severe Impairment | 2 | 2 | 1 |
| | 9 | 9 | 9 |

Table H-9

Sixteen Subjects with Cardiac Disease Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 2 | 2 | 2 |
| Moderate Impairment | 2 | 1 | 4 |
| Severe Impairment | 2 | 4 | 6 |
| Very Severe Impairment | 10 | 9 | 4 |
| | 16 | 16 | 16 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 2 | 1 | 3 |
| Severe Impairment | 0 | 2 | 4 |
| Very Severe Impairment | 9 | 8 | 4 |
| | 12 | 12 | 12 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 0 | 0 | 1 |
| Severe Impairment | 2 | 2 | 2 |
| Very Severe Impairment | 1 | 1 | 0 |
| | 4 | 4 | 4 |

Table H-10

Sixteen Subjects with Cardiac Disease Classified According to Ventilatory Ability as Measured by FVC for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 1 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 3 | 3 | 2 |
| | 4 | 4 | 4 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 2 | 5 |
| Very Severe Impairment | 6 | 5 | 2 |
| | 7 | 7 | 7 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 2 | 2 | 2 |
| Moderate Impairment | 2 | 1 | 3 |
| Severe Impairment | 0 | 1 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 5 | 5 | 5 |

Table H-11

Seven Subjects with Pulmonary Disease Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 3 | 2 | 2 |
| Severe Impairment | 1 | 1 | 2 |
| Very Severe Impairment | 2 | 3 | 2 |
| | 7 | 7 | 7 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 1 | 0 | 1 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 2 | 3 | 2 |
| | 5 | 5 | 5 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 2 | 2 | 1 |
| Severe Impairment | 0 | 0 | 1 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 2 | 2 | 2 |

Table H-12

Seven Subjects with Pulmonary Disease Classified According to Ventilatory Ability as Measured by FVC for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 1 | 1 | 1 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 2 | 2 | 2 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 0 | 1 |
| Very Severe Impairment | 0 | 1 | 0 |
| | 1 | 1 | 1 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 2 | 1 | 1 |
| Severe Impairment | 0 | 1 | 1 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 4 | 4 | 4 |

Table H-13

Three Subjects with Neuromuscular Disease Classified According to Ventilatory Ability as Measured by FVC for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 3 | 3 | 3 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 2 | 2 | 2 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 1 | 1 | 1 |

Table H-14

Three Subjects with Neuromuscular Disease Classified According to Ventilatory Ability as Measured by FVC for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 2 | 2 | 2 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 1 | 1 | 1 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 0 | 0 | 0 |

Table H-15

Nineteen Subjects with Operative Time Greater than Two Hours for Total Sample and Separated by Sequence According to FVC in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **TOTAL SAMPLE** | | | |
| Normal or Mild Impairment | 1 | 1 | 2 |
| Moderate Impairment | 2 | 3 | 1 |
| Severe Impairment | 3 | 3 | 6 |
| Very Severe Impairment | 13 | 12 | 10 |
| | 19 | 19 | 19 |
| **SEQUENCE** | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 2 | 4 |
| Very Severe Impairment | 11 | 10 | 8 |
| | 13 | 13 | 13 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 2 | 3 | 1 |
| Severe Impairment | 2 | 1 | 2 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 6 | 6 | 6 |

Table H-16

Nineteen Subjects with Operative Times Greater than Two Hours Separated by Incisional Type According to FVC in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 1 | 1 | 1 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 6 | 6 | 6 |
| | 7 | 7 | 7 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 3 | 3 | 6 |
| Very Severe Impairment | 6 | 5 | 3 |
| | 9 | 9 | 9 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 1 | 1 | 2 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 3 | 3 | 3 |

Table H-17

Five Subjects with Operative Blood Loss Greater than 500 cc for Total Sample and Sequence According to FVC in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **TOTAL SAMPLE** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 1 | 1 | 3 |
| Very Severe Impairment | 4 | 3 | 2 |
| | 5 | 5 | 5 |
| **SEQUENCE** | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 1 | 2 |
| Very Severe Impairment | 4 | 3 | 2 |
| | 4 | 4 | 4 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 1 | 0 | 1 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 1 | 1 | 1 |

Table H-18

Five Subjects with Operative Blood Loss Greater than 500 cc Separated by Incisional Type According to FVC in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 1 | 1 | 1 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 1 | 1 | 3 |
| Very Severe Impairment | 2 | 1 | 0 |
| | 3 | 3 | 3 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 1 | 1 | 1 |

Table H-19

Twenty-one Subjects Using the Incentive Spirometer for Sample and Separated by Sequence According to FVC in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 2 | 1 | 2 |
| Moderate Impairment | 2 | 4 | 2 |
| Severe Impairment | 4 | 4 | 7 |
| Very Severe Impairment | 13 | 12 | 10 |
| | 21 | 21 | 21 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 2 | 4 |
| Very Severe Impairment | 12 | 11 | 9 |
| | 13 | 13 | 13 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 2 | 1 | 2 |
| Moderate Impairment | 2 | 4 | 2 |
| Severe Impairment | 3 | 2 | 3 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 8 | 8 | 8 |

Table H-20

Twenty-one Subjects Using the Incentive Spirometer Separated by Incisional Type According to FVC in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 1 | 1 | 2 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 7 | 7 | 6 |
| | 9 | 9 | 9 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 3 | 3 | 5 |
| Very Severe Impairment | 5 | 4 | 3 |
| | 8 | 8 | 8 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 2 | 1 | 2 |
| Moderate Impairment | 1 | 2 | 0 |
| Severe Impairment | 0 | 0 | 1 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 4 | 4 | 4 |

Table H-21

Twelve Subjects Ambulated After Surgery for Sample and Separated by Sequence According to FVC in Three Positions

| | Position | | |
| --- | --- | --- | --- |
| | Flat | 45 | 90 |
| **TOTAL SAMPLE** | | | |
| Normal or Mild Impairment | 4 | 3 | 5 |
| Moderate Impairment | 4 | 4 | 2 |
| Severe Impairment | 1 | 2 | 3 |
| Very Severe Impairment | 3 | 3 | 2 |
| | 12 | 12 | 12 |
| **SEQUENCE** | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 2 | 2 | 2 |
| Moderate Impairment | 2 | 1 | 2 |
| Severe Impairment | 0 | 1 | 1 |
| Very Severe Impairment | 3 | 3 | 2 |
| | 7 | 7 | 7 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 2 | 1 | 0 |
| Moderate Impairment | 2 | 3 | 3 |
| Severe Impairment | 1 | 1 | 2 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 5 | 5 | 5 |

*Note*. One subject who ambulated in the postoperative period had missing FVC data.

Table H-22

Twelve Subjects Ambulated After Surgery Separated by Incisional Type According to FVC in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 1 | 1 | 1 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 1 | 2 |
| Very Severe Impairment | 1 | 1 | 0 |
| | 2 | 2 | 2 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 4 | 3 | 5 |
| Moderate Impairment | 4 | 4 | 2 |
| Severe Impairment | 0 | 1 | 1 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 9 | 9 | 9 |

*Note*. One subject who ambulated in the postoperative period had missing FVC data.

Table H-23

Ten Subjects Repositioned After Surgery for Sample and Separated by Sequence According to FVC in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 1 | 4 | 3 |
| Severe Impairment | 3 | 1 | 3 |
| Very Severe Impairment | 6 | 5 | 4 |
| | 10 | 10 | 10 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 2 | 1 |
| Severe Impairment | 1 | 0 | 1 |
| Very Severe Impairment | 4 | 3 | 3 |
| | 5 | 5 | 5 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 1 | 2 | 2 |
| Severe Impairment | 2 | 1 | 2 |
| Very Severe Impairment | 2 | 2 | 1 |
| | 5 | 5 | 5 |

Table H-24

Ten Subjects Repositioned After Surgery Separated by Incisional Type According to FVC in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 1 | 1 | 2 |
| Severe Impairment | 1 | 1 | 0 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 4 | 4 | 4 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 2 | 0 |
| Severe Impairment | 1 | 0 | 2 |
| Very Severe Impairment | 3 | 2 | 2 |
| | 4 | 4 | 4 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 1 |
| Severe Impairment | 1 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 2 | 2 | 2 |

# APPENDIX I

## FEV1 TABLES FOR

## CONTROL VARIABLES

Table I-1

Fifteen Overweight Subjects Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **TOTAL SAMPLE** | | | |
| Normal or Mild Impairment | 2 | 2 | 4 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 5 | 6 | 7 |
| Very Severe Impairment | 7 | 6 | 4 |
| | 15 | 15 | 15 |
| **SEQUENCE** | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 2 | 2 | 3 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 5 | 6 | 6 |
| Very Severe Impairment | 4 | 3 | 2 |
| | 11 | 11 | 11 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 0 | 0 | 1 |
| Very Severe Impairment | 3 | 3 | 2 |
| | 4 | 4 | 4 |

Table I-2

Fifteen Overweight Subjects Classified According to Ventilatory Ability as Measured by FEV1 for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 1 | 1 | 2 |
| Very Severe Impairment | 4 | 4 | 3 |
| | 6 | 6 | 6 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 3 | 2 | 3 |
| Very Severe Impairment | 1 | 2 | 1 |
| | 4 | 4 | 4 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 2 | 2 | 3 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 3 | 2 |
| Very Severe Impairment | 2 | 0 | 0 |
| | 5 | 5 | 5 |

Table I-3

Six Underweight Subjects Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 1 | 2 | 2 |
| Very Severe Impairment | 4 | 3 | 3 |
| | 6 | 6 | 6 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 1 | 1 |
| Very Severe Impairment | 3 | 2 | 2 |
| | 3 | 3 | 3 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 3 | 3 | 3 |

Table I-4

Six Underweight Subjects Classified According to Ventilatory Ability as Measured by FEV1 for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 3 | 3 | 3 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 2 | 2 |
| Very Severe Impairment | 1 | 0 | 0 |
| | 2 | 2 | 2 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 1 | 1 | 1 |

Table I-5

Twenty-four Smoking Subjects Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 4 | 4 | 7 |
| Moderate Impairment | 4 | 5 | 2 |
| Severe Impairment | 4 | 5 | 5 |
| Very Severe Impairment | 12 | 10 | 10 |
| | 24 | 24 | 24 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 2 | 2 | 3 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 3 | 4 | 4 |
| Very Severe Impairment | 10 | 8 | 8 |
| | 15 | 15 | 15 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 2 | 2 | 4 |
| Moderate Impairment | 4 | 4 | 2 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 9 | 9 | 9 |

Table I-6

Twenty-four Smoking Subjects Classified According to Ventilatory Ability as Measured by FEV1 for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| Upper Abdominal Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 2 |
| Moderate Impairment | 2 | 2 | 0 |
| Severe Impairment | 0 | 0 | 1 |
| Very Severe Impairment | 6 | 6 | 5 |
| | 8 | 8 | 8 |
| Combination Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 3 | 3 | 3 |
| Very Severe Impairment | 4 | 3 | 4 |
| | 7 | 7 | 7 |
| Lower Abdominal Subjects | | | |
| Normal or Mild Impairment | 4 | 4 | 5 |
| Moderate Impairment | 2 | 2 | 2 |
| Severe Impairment | 1 | 2 | 1 |
| Very Severe Impairment | 2 | 1 | 1 |
| | 9 | 9 | 9 |

Table I-7

Sixteen Subjects with Cardiac Disease Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 3 | 3 | 5 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 6 | 7 | 7 |
| Very Severe Impairment | 6 | 5 | 4 |
| | 16 | 16 | 16 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 2 | 2 | 3 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 5 | 6 | 5 |
| Very Severe Impairment | 5 | 4 | 4 |
| | 12 | 12 | 12 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 1 | 1 | 2 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 1 | 1 | 2 |
| Very Severe Impairment | 1 | 1 | 0 |
| | 4 | 4 | 4 |

Table I-8

Sixteen Subjects with Cardiac Disease Classified According to Ventilatory Ability as Measured by FEV1 for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 4 | 4 | 4 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 4 | 4 | 5 |
| Very Severe Impairment | 3 | 3 | 2 |
| | 7 | 7 | 7 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 3 | 3 | 4 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 2 | 1 |
| Very Severe Impairment | 1 | 0 | 0 |
| | 5 | 5 | 5 |

Table I-9

Seven Subjects with Pulmonary Disease Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 1 | 2 | 2 |
| Moderate Impairment | 2 | 1 | 1 |
| Severe Impairment | 2 | 2 | 2 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 7 | 7 | 7 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 2 | 2 | 2 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 5 | 5 | 5 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 1 | 1 |
| Moderate Impairment | 2 | 1 | 1 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 2 | 2 | 2 |

Table I-10

Seven Subjects with Pulmonary Disease Classified According to Ventilatory Ability as Measured by FEV1 for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 2 | 2 | 2 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 1 | 1 | 1 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 1 | 2 | 1 |
| Moderate Impairment | 1 | 0 | 1 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 4 | 4 | 4 |

Table I-11

Three Subjects with Neuromuscular Disease Classified According to Ventilatory Ability as Measured by FEV1 for the Sample Population and Two Sequences

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 3 | 3 | 3 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 2 | 2 | 2 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 1 | 1 | 1 |

Table I-12

Three Subjects with Neuromuscular Disease Classified According to Ventilatory Ability as Measured by FEV1 for Three Incisional Types

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 2 | 2 | 2 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 1 | 1 | 1 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 0 | 0 | 0 |

Table I-13

Nineteen Subjects with Operative Time Greater than Two Hours for Total Sample and Separated by Sequence According to FEV1 in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 1 | 1 | 2 |
| Moderate Impairment | 2 | 3 | 1 |
| Severe Impairment | 5 | 7 | 8 |
| Very Severe Impairment | 11 | 8 | 8 |
| | 19 | 19 | 19 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 1 | 2 | 1 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 3 | 5 | 6 |
| Very Severe Impairment | 9 | 6 | 6 |
| | 13 | 13 | 13 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 2 |
| Moderate Impairment | 2 | 2 | 0 |
| Severe Impairment | 2 | 2 | 2 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 6 | 6 | 6 |

Table I-14

Nineteen Subjects with Operative Time Greater than Two Hours Separated by Incisional Type According to FEV1 in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 1 | 1 | 0 |
| Severe Impairment | 0 | 0 | 1 |
| Very Severe Impairment | 6 | 6 | 5 |
| | 7 | 7 | 7 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 5 | 6 | 6 |
| Very Severe Impairment | 4 | 2 | 3 |
| | 9 | 9 | 9 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 1 | 1 | 1 |
| Moderate Impairment | 1 | 1 | 1 |
| Severe Impairment | 0 | 1 | 1 |
| Very Severe Impairment | 1 | 0 | 0 |
| | 3 | 3 | 3 |

Table I-15

Five Subjects with Operative Blood Loss Greater than 500 cc for Total Sample and Sequence According to FEV1 in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 2 | 4 | 4 |
| Very Severe Impairment | 3 | 1 | 1 |
| | 5 | 5 | 5 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 3 | 3 |
| Very Severe Impairment | 3 | 1 | 1 |
| | 4 | 4 | 4 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 1 | 1 | 1 |

Table I-16

Five Subjects with Operative Blood Loss Greater than 500 cc Separated by Incisional Type According to FEV1 in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 1 | 1 | 1 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 2 | 3 | 3 |
| Very Severe Impairment | 1 | 0 | 0 |
| | 3 | 3 | 3 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 1 | 1 |
| Very Severe Impairment | 1 | 0 | 0 |
| | 1 | 1 | 1 |

Table I-17

Twenty-one Subjects Using the Incentive Spirometer for Sample and Separated by Sequence According to FEV1 in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 2 | 2 | 3 |
| Moderate Impairment | 3 | 4 | 2 |
| Severe Impairment | 6 | 5 | 7 |
| Very Severe Impairment | 10 | 10 | 9 |
| | 21 | 21 | 21 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 3 | 3 | 5 |
| Very Severe Impairment | 10 | 9 | 8 |
| | 13 | 13 | 13 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 2 | 2 | 3 |
| Moderate Impairment | 3 | 3 | 2 |
| Severe Impairment | 2 | 2 | 2 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 8 | 8 | 8 |

Table I-18

Twenty-one Subjects Using the Incentive Spirometer Separated by Incisional Type According to FEV1 in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 2 | 2 | 1 |
| Severe Impairment | 0 | 0 | 2 |
| Very Severe Impairment | 7 | 7 | 5 |
| | 9 | 9 | 9 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 5 | 5 | 5 |
| Very Severe Impairment | 3 | 2 | 3 |
| | 8 | 8 | 8 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 2 | 2 | 2 |
| Moderate Impairment | 1 | 1 | 1 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 4 | 4 | 4 |

Table I-19

Twelve Subjects Ambulated After Surgery for Sample and Separated by Sequence According to FEV1 in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 5 | 5 | 5 |
| Moderate Impairment | 2 | 2 | 2 |
| Severe Impairment | 3 | 3 | 4 |
| Very Severe Impairment | 2 | 2 | 1 |
| | 12 | 12 | 12 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 3 | 3 | 3 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 2 | 2 | 3 |
| Very Severe Impairment | 2 | 2 | 1 |
| | 7 | 7 | 7 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 2 | 2 | 2 |
| Moderate Impairment | 2 | 2 | 2 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 5 | 5 | 5 |

Note. One subject who ambulated in the postoperative period had missing FEV1 data.

Table I-20

*Twelve Subjects Ambulated After Surgery Separated by Incisional Type According to FEV1 in Three Positions*

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| *Upper Abdominal Subjects* | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 0 | 0 | 1 |
| Very Severe Impairment | 1 | 1 | 0 |
| | 1 | 1 | 1 |
| *Combination Subjects* | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 0 | 0 |
| Severe Impairment | 2 | 2 | 2 |
| Very Severe Impairment | 0 | 0 | 0 |
| | 2 | 2 | 2 |
| *Lower Abdominal Subjects* | | | |
| Normal or Mild Impairment | 5 | 5 | 5 |
| Moderate Impairment | 2 | 2 | 2 |
| Severe Impairment | 1 | 1 | 1 |
| Very Severe Impairment | 1 | 1 | 1 |
| | 9 | 9 | 9 |

*Note*. One subject who ambulated in the postoperative period had missing FEV1 data.

Table I-21

Ten Subjects Repositioned After Surgery for Sample and Separated by Sequence According to FEV1 in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| TOTAL SAMPLE | | | |
| Normal or Mild Impairment | 0 | 0 | 2 |
| Moderate Impairment | 2 | 4 | 1 |
| Severe Impairment | 2 | 1 | 3 |
| Very Severe Impairment | 6 | 5 | 4 |
| | 10 | 10 | 10 |
| SEQUENCE | | | |
| Sequence 1 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 0 | 2 | 1 |
| Severe Impairment | 1 | 0 | 0 |
| Very Severe Impairment | 4 | 3 | 3 |
| | 5 | 5 | 5 |
| Sequence 2 Subjects | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 1 | 1 | 2 |
| Severe Impairment | 2 | 2 | 2 |
| Very Severe Impairment | 2 | 2 | 1 |
| | 5 | 5 | 5 |

Table I-22

Ten Subjects Repositioned After Surgery Separated by Incisional Type According to FEV1 in Three Positions

| | Position | | |
|---|---|---|---|
| | Flat | 45 | 90 |
| **Upper Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 2 | 2 | 1 |
| Severe Impairment | 0 | 0 | 0 |
| Very Severe Impairment | 2 | 2 | 2 |
| | 4 | 4 | 4 |
| **Combination Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 0 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 1 | 1 | 2 |
| Very Severe Impairment | 3 | 2 | 2 |
| | 4 | 4 | 4 |
| **Lower Abdominal Subjects** | | | |
| Normal or Mild Impairment | 0 | 0 | 1 |
| Moderate Impairment | 0 | 1 | 0 |
| Severe Impairment | 1 | 0 | 1 |
| Very Severe Impairment | 1 | 1 | 0 |
| | 2 | 2 | 2 |

# APPENDIX J

# THESIS ABSTRACT

AN ABSTRACT OF THE THESIS OF

Carolyn A. Bawden

For the Master of Nursing

Title: THE INFLUENCE OF BODY POSITIONS UPON PULMONARY FUNCTION TESTS IN POSTOPERATIVE PATIENTS

Approved [signature]

Naomi Ballard, R.N., M.A., M.S., C.N.R.N.,

Associate Professor, Thesis Advisor

Pulmonary complications of the postoperative patient remain a serious problem even as medical science has moved forward. Nursing interventions that increase the ventilatory abiltiy of these patients should help to decrease the occurrences of pulmonary complications. The purpose of the present study was to evaluate the intervention of positioning in improving ventilatory function as measusred by tidal volume, respiratory rate, minute ventilation, FVC, and FEV1 in postoperative patients in the three positions of head of bed flat, head of bed elevated to 45 degrees, and head of bed elevated to 90 degrees.

A convenience sample of thirty-four adult patients undergoing a surgical procedure that involved an upper abdominal incision, a lower abdominal incision, or a combination of the two types of incisions were included in the study. Subjects were tested the morning after the

procedure in the three positions to determine the pulmonary function measures in each of the positions.

A one way analysis of variance with repeated measures between positioning and the pulmonary function tests produced a significant F score for the measures of tidal volume, minute ventilation, FVC, and FEV1 with the total move from flat to 90 degrees. The second repeated measures analysis of variance between each incisional type and the changes in the pulmonary function tests with the three positional changes was significant for FVC, and the FEV1 in the upper abdominal incisional group, FEV1 in the lower abdominal incisional group, and minute ventilation for the combination incisional group. Planned comparison t-test and Tukey tests were done for the two ANOVAs to determine which of the positional changes flat to 45 degrees, 45 to 90 degrees, or flat to 90 degrees produced the significant values. Control variables of age, weight, concurrent disease entities, smoking history, perioperative factors, and the use of respiratory interventions in the postoperative period were summarized into frequency distributions and used to further interpret the ANOVA results.

The results indicate that positioning of the head of the bed from flat to 45 to 90 degrees did improve the pulmonary function measures studied for the sample and for some measures for each of the incisional types.