EFFECTS OF PATIENT POSITIONING ON CENTRAL VENOUS PRESSURE MEASUREMENTS AN EXPERIMENTAL STUDY

BY

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CHAPTER I

INTRODUCTION

Patients admitted to intensive care units are either in a state of acute physiological instability or in danger of becoming unstable. On admission and throughout the stay in the intensive care unit, the patient is assessed by both medical and nursing personnel to develop medical and nursing diagnoses upon which further assessment and treatment will be based. Part of this assessment regimen may include physiological monitoring. The value of physiological monitoring depends on the ability of the personnel to use the instrument when indicated, to properly perform the procedure incorporating the instrument, to accurately interpret the findings, and to disturb the patient as little as possible. It should be obvious that use of instrumentation should impose minimal or, hopefully, no further insult on an already traumatized organism.

Statement of Problem

Measurement of the central venous pressure (CVP) is instituted in the treatment program of patients to aid in assessment of the

hemodynamic state of the patient before, during, and after therapy. Bower (1973) and Debrunner and Buhler (1960) state that the CVP measurement has become an integral part in the treatment of the critically ill patient. The measurement is taken by means of a patent catheter whose proximal tip is positioned within the thoracic venous system or in the right atrial chamber of the heart and connected distally to a manometer graduated in centimeters of water (Hardaway, 1973). Studies have shown that a column of low specific gravity fluid in a manometer, when connected by fluid-filled patent tubing to an indwelling catheter, will accurately reflect the pressure exerted on the proximal end of the system which, in this instance, is the pressure in a centrally located vein (Wilson, Grow, Demon, Prevedel, and Owens, 1962).

The CVP measurement is taken as often as every 15 minutes until the patient's condition is considered stable (Hurst, Weems, Wilson, and Wood, 1971). Then measurements are taken at one to four hour intervals (Plumer, 1970). Measurements must be accurate to be meaningful (Johnson, 1970) and most investigators state that, if at all possible, the patient should be placed in the supine position to insure accuracy. There is no mention of how long the patient must be in the supine position before the venous system adjusts to the change in position, if it indeed needs to adjust. Other investigators state that the patient can, if necessary, have CVP measurements done in

some form of the semi-sitting position. They further state that the position must be the same for each measurement since the value of the reading is in serial measurements, not isolated values (Gowen, 1973; James, and Myers, 1973; Johnson, 1970; Plumer, 1970; Longerbeam, Vannix, Wagner, and Jorgenson, 1965; Rubin, and Gongiovi, 1970). The key question is how personnel can ascertain that the elevation of the head of the bed or the patient's position in the bed has not changed between readings, if indeed position actually affects the reading obtained.

Since many patients in intensive care units are most comfortable in some degree of sitting position, to obtain CVP readings in the recommended supine position necessitates changes in the patient's position for each reading. Because CVP readings may need to be taken as frequently as every 15 minutes, this frequent position changing creates a vicious circle: the more unstable the patient, the more rest his body needs yet the more often CVP measurement is indicated and the greater the number of interruptions to rest.

Edelstein (1972) provides a good review of the literature on the relationship between interrupted circadian sleep cycles and psycho-physiological changes in the subjects studied. She cites Stephan (1965) as saying that "immobility, painful monotony, aberrant schedules all might conspire to be stressors of an already tenuous physiological adaptation" in some patient care units. Long (1969)

further adds that patients in hospitals frequently have difficulty meeting a basic physiological need, i.e. sleep, at a time when it is most needed. Studies have shown that withdrawal, depression, and apathy have occurred when sleep deprivation is present in normal subjects, i.e., those without physiologically unstable states due to other causes (Long, 1969). Confusion, hallucinations, and increased sensitivity to pain are also cited as side effects of sleep deprivation (Long, 1969). Despite the agreement in the literature that care should be planned so the patient has blocks of uninterrupted sleep (Long, 1969) to reduce environmental stress (Kornfeld, 1969) there has been little mention of the best method of obtaining the CVP readings accurately, with minimal patient disturbances.

Definitions

Central Venous System

The central venous system refers to the major veins within the chest cavity which serve as conduits for blood entering the heart.

Central Venous Pressure

The blood pressure within the central veins of the thorax and right atrium is called the central venous pressure.

Zero Reference Point

The zero reference point refers to an arbitrary point, marked on the lateral aspect of the patient's chest, which is used as a base-line for all central venous pressure measurements. Anatomically, the zero reference point corresponds with the level of the right atrium. With the subject supine, the zero reference point (ZRP) is determined by finding the point at which the vertical line from the fourth intercostal space, adjacent to the sternum, drawn to the skin of the back, intersects a horizontal line, drawn midway between the anterior and posterior surface.

Operational Definitions

Central Venous Pressure Measurement

The central venous pressure measurement is a measurement of the pressure existing in the central veins of the thorax and right atrium using external tools directly connected via patent tubes to a catheter located in the central veins or right atrium. Catheter placement is confirmed by anterior-posterior x-ray view of the chest.

Three-way Stopcock Positions

Position #1 - the lever on the stopcock is turned to allow fluid

flow between the infusion bottle and the manometer column.

Position #2 - the lever on the stopcock is turned to allow fluid flow between the manometer and the thoracic venous system.

Position #3 - the lever on the stopcock is turned to allow fluid flow between the infusion bottle and thoracic venous system.

Patency of Infusion Lines

Infusion line patency is determined by observation of the column of fluid in the manometer with the stopcock in position #2. The fluid column should readily adjust to the thoracic venous pressure and fluctuate with the subject's respirations. When necessary, the infusion line is flushed with normal saline to establish patency.

Termination of Fluid Column Descent in Manometer

The actual CVP reading is that point, measured in centimeters of water, at the nadir of the fluid level within the manometer regardless of the patient's respiratory phase.

Review of the Literature

The review of the literature on central venous pressures is discussed in six sections:

1. History
2. Physiology
3. Importance and use

4. Interpretation of data
5. Zero reference point
6. Patient positioning

Establishing the sectional frame of reference for the literature review should be of value to the reader in identifying the significance of CVP measurements in intensive care units. The delineation also points out the data nurses should have concerning CVP measurements and the paucity of current research regarding the implications of the CVP measurement and the nursing consequences resulting from insufficient data from research.

History

In 1965 Longerbeam et al. published a lengthy and detailed review of the early literature on CVP's. They found that little clinical importance was attached to the measurement of CVP prior to the 1950's. It was not until 1962 that measurement of the CVP was popularized by Wilson in the United States. Since that time however, the use of CVP measurements has greatly increased (James, and Myers, 1973). This increase is probably related to advanced instrumentation and a concommitant increase in cardiac surgery (Longerbeam et al., 1965).

The increased acceptance of CVP measurement as an assessment tool has broad implications for the nursing profession since nurses are currently primarily responsible for obtaining the

measurement, making immediate interpretation of data, and correlating the data with therapy. For these reasons it is essential that the nurse understand the basic physiology of factors that determine the CVP.

Physiology

Filtration of fluid from the circulation at the capillary level is affected by the pressure difference between capillary lumen and interstitial fluid (hydrostatic pressure difference) and oncotic pressure. Total filtration increases with an increase in hydrostatic pressure difference across the wall and decreases with an increased plasma osmotic pressure. As total filtration increases, blood volume decreases, thereby influencing effective circulating blood volume (Folkow, and Neil, 1971).

The venous system is innervated by the sympathetic nervous system. Stimulation of the sympathetic nerves will result in venoconstriction (Folkow, and Neil, 1971). Veins are also equipped with strategically located, one-way valves to prevent backflow of blood and promote forward flow to the heart with the assistance of the blood pressure gradient from left to right heart, muscle activity, the reduction in intrathoracic pressure with inspiration, and the pulling forces of the right heart.

Inspiration promotes venous return by increasing the intrathoracic negative pressure. The increase in negative pressure results in a pressure gradient between the extrathoracic and the intrathoracic veins with the pressure in the latter the lower of the two. This pressure gradient produces a waterfall phenomena with increased blood flow down the gradient into the central venous system (Vander, Sherman, and Luciano, 1970). The right heart also produces a suction effect by the downward pull exerted during systole (Folkow, and Neil, 1971).

The central venous pressure (CVP) is the right heart filling pressure. More importantly, the CVP measurement is a dynamic index of circulating blood volume as it relates to the status of the heart and vascular bed (Debrunner et al., 1969). The CVP is not a linear function of the blood volume except under carefully controlled, non-stressful conditions (Longerbeam et al., 1965). It is the pressure exerted by the blood upon return to the right side of the heart. The right heart filling pressure is determined by many factors including the volume of blood in the venous system and how fast that volume returns to the right side of the heart (Longerbeam et al., 1965).

Circulation of the existing blood volume depends on the pressure difference and the resistance to flow in the systemic vascular bed. When blood leaves the left heart, it is forcefully extruded into the systemic circulation. The flow, $\dot{Q}$, for a given pressure difference,

P, is primarily controlled in the arterioles where resistance, R, is regulated by vasoconstriction or vasodilation from local and/or reflex control ($\dot{Q} = \frac{\Delta P}{R}$). The initiating factor in local control is not fully understood. Reflex or neurogenic control is primarily from the sympathetic nervous system (Vander et al., 1970). A lowered mean pressure in the carotid sinus, from hemorrhage for example, will, via the sympathetic nervous system, cause selective vasoconstriction for the purpose of improving effective circulating blood volume to the vital organs (Vander et al., 1970).

The next determinant of effective circulating blood volume is the precapillary sphincters which are primarily under local control (Folkow, and Neil, 1971), where capillary perfusing area, A, is available to flow, $\dot{Q}$, and flow velocity, ν, will decrease. Fluid velocity at a given flow is inversely proportional to the cross sectional area ($\nu = \frac{\dot{Q}}{A}$).

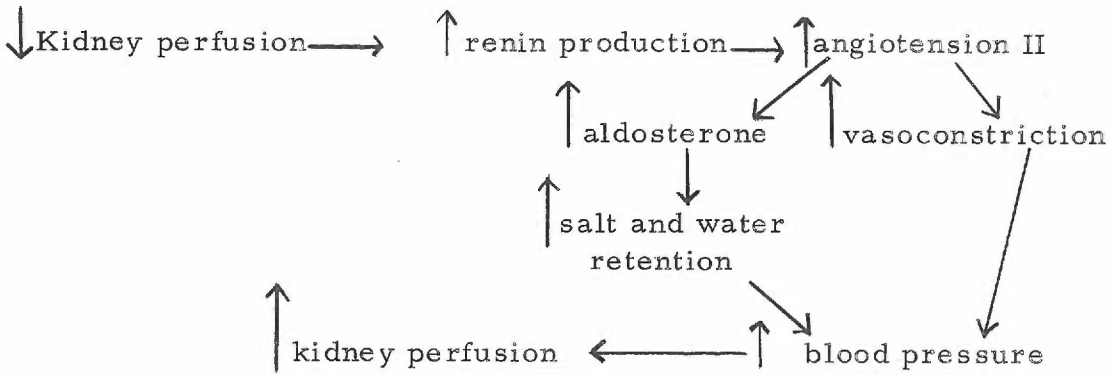
Importance to Medicine and Nursing

Indications for taking a CVP measurement are numerous. It is a commonly used procedure for evaluating the sufficiency of circulation in critically ill patients especially in the intensive care setting (Davison, and Cannon, 1974; Debrunner et al., 1969; Bower, 1973). Usefulness of the CVP measurement as a guide to choice of therapy has been established whenever there is difficulty in stabilizing the

circulatory dynamics as in shock (Williams, and McDonald, 1961; Wilson, 1965; Hurst, Weems, Wilson, and Wood, 1961). Circulatory status can be assessed and differential diagnoses more readily made with the aid of this procedure. Treatment programs can be instituted and followed more effectively than with other determinants of condition (Longerbeam et al., 1965).

Accurate determination of the circulatory defect is one of the paramount problems in the treatment of patients in shock (Wilson, 1965). Detection of shock and interruption of its progress through appropriate treatment is a major medical function. Wilson et al. (1962) stated that "no single aspect of patient care is more essential to survival than maintenance of optimal blood volume", a statement with which Johnson (1970) concurs. Implications for nursing are extensive since it is the nurse who is with the patient on a 24 hour basis and who implements and maintains the treatment programs prescribed by the physicians. It is the nurse who is in a position to first notice change in the patients' physiological status. Because of these responsibilities, the nurse needs to have more than a mere understanding that a change is taking place in a patient. In addition, she needs to accurately assess the extent of the change, understand the physiology of the change, and the implications of the change on the hemodynamic state of the patient.

Shock, a defect in adequate circulation to tissues (Hardaway, 1973; Royce, 1973), is either cardiogenic or hemogenic in origin and may occur within 30 seconds or as late as 24 hours or more after insult. Physiologic compensatory mechanisms are activated in response to the defective circulation. One of these mechanisms is the release of catecholamines from the adrenal cortex which acts to constrict the arterioles and venules leading to increased venous return (Royce, 1973). Royce further states that the catecholamine releasing mechanism becomes detrimental when shock is prolonged and is associated with an elevation in the serum hydrogen ion concentration from anaerobic metabolism (1973). Elevation of the serum hydrogen ion concentration causes vasodilation of the arterioles and constriction of venules, resulting in decreased perfusion. The decreased cardiac output emanating from diminution of venous return is reflected in the kidney by increased renin reproduction which enhances the production of angiotension II. Angiotension II increases the blood pressure, vasoconstriction and renal blood flow. Angiotension II also stimulates the adrenal cortex to release aldosterone. Aldosterone causes the kidney to increase its retention of salt and water. This action contributes to the elevation of blood pressure and maintenance of urinary output. The following is a schematic representation of the process.



Continuation of the shock state results in a decreasing ability of the activated mechanisms to maintain adequate cellular perfusion and circulation to the vital organs. If not halted death ensues (Hardaway, 1973; Royce, 1973).

If the imminence of shock is detected early enough and therapy instituted (Hardaway, 1973) the problem is often reversible. Since the nurse is often the one to detect and to report early signs of shock, her role is crucial in obtaining and/or instituting therapy.

Since treatment for shock is often prescribed on a sign rather than a diagnostic basis (Wilson, 1965), CVP measurement is a reasonably effective, dependable instrument to identify the types of shock from presenting circulatory findings. This determination is then used to select subsequent therapy for maintenance of adequate effective blood volume (Wilson et al., 1962). However, there are some writers who feel that the CVP reading alone tells too little, and needs to be used in conjunction with cardiac output observations such as the patient's general appearance, mucous membrane condition,

blood pressure, peripheral pulse, skin perfusion, urinary output, acid-base data, and arterial-venous oxygen difference (Hurst et al., 1971; Longerbeam et al., 1965; Royce, 1973; Wilson et al., 1962). Wilson et al., in 1962, emphasized that clinical inspection was inadequate to identify insidious circulatory deficits. The arterial pressure and pulse may remain stable until decompensation suddenly takes place at which time the body's compensatory mechanisms are no longer able to maintain effective circulating blood volume (Wilson et al., 1962; Royce, 1973). Hughs et al. (1959) maintain that urinary output is often adequate until after a fall in the CVP has occurred. This lag in urine reduction is partially attributed to the accumulated urine in the bladder and the continuance of urine formation.

Accurate measurement of the CVP can help distinguish between a shock state due to decreased cardiac output as a fluid problem versus one due to decreased cardiac output as a pump failure. Most shock has one or more of the following hemodynamic states: hypovolemia, cardiac insufficiency or defective vascular tone (Gowen, 1973; Wilson, 1965). Measurement of the CVP is useful in detecting obscure hypovolemia and in the differential diagnosis of pre-renal dehydration versus conditions such as acute tubular necrosis, pre-existing renal disease and post-renal obstruction (Longerbeam et al., 1965). Gowen in 1973 cited the value of the CVP measurement in one patient with a perforated appendix in a pre-operative state of shock

due to sequestration of fluid. Gowen states that "12 liters of fluid were given in a rapid but controlled manner into the 3 liter plasma space from which it diffused rapidly throughout the extracellular space including the third space" (p. 652). He was then able to operate successfully on the patient. Gowen also mentions other isolated cases where the CVP measurement was the basis for successful fluid therapy.

In most cases, the CVP measurement is not only used as a diagnostic aid but also as a means of assessing the value of the treatment instituted following observation of circulatory insufficiency. Central venous pressure measurement provides a means of evaluating the state of circulation and is also found useful in ascertaining volume of needed fluid replacement and regulation of infusion speed (Gowen, 1973; Hurst et al., 1971). Gowen (1973) found the CVP an inexpensive and useful instrument for monitoring heart function in relation to blood volume in 1500 patients. Insertion of the CVP intracatheter is rapid and, in experienced hands, the complication rate is low (Gowen, 1973). Studies by James and Myers (1973) of more than 3000 patients determined that the complication rate of CVP line placement is comparable to that of modern day appendectomies. This descriptive study included both failure to puncture veins and occluded catheters in the findings, both complications carrying significant weight in the statistics. It is unusual to include these two variables in a statistical

analysis of the complications due to CVP line placement as these variables are found with placement of any type of intravenous infusion.

Many prominent investigators stress the importance of the CVP measurement in medicine. The increasing use of this instrument and the increasing reliance of the physician on the data obtained through CVP measurements only adds to the importance of knowledgeable nursing practice in intensive care settings when no physician is present to interpret the data or acknowledge the importance of the findings. The nurse is responsible for knowing what the data can and cannot tell her about her patient's circulatory status.

Interpretation of Data

For the nurse observing and recording serial CVP readings, a change in reading should alert her to impeding complications. She should be cognizant of all the possible causes of the change for she may be the one to initiate therapy before a physician can be called to the bedside (Betson et al., 1969).

A low CVP reading can indicate either an effective pump with reduced venous return (Wilson et al., 1962) or an ineffective pump unable to maintain homeostasis. To differentiate between the two potentialities, a trial of volume expanders can be given consisting of five percent of the patient's normal volume of blood in a 5-10 minute period. An elevation in the CVP greater than three to five centimeters

of water above the pre-infusion level indicates cardiac insufficiency and a need for treatment to inhance cardiac output. No change in the CVP reading indicates hypovolemia and the need for further fluid therapy (Hurst, 1971; Wilson et al., 1962; Wilson 1965). Furthermore, a lack of response to this fluid challenge may indicate hemorrhage and need for surgical intervention. Gowen (1973) likens the CVP to a speedometer in the regulation of fluid therapy indicating the time to increase, decrease or maintain the rate of infusion. Over-infusion or under-infusion can precipitate shock states in the patient.

Elevated readings of the CVP, in addition to indicating possible pump failure, may also be a harbinger of excess intravascular volume. When this is determined, the patient is managed on inotropic drugs, fluid restriction, diuretics, or vasodilators (Betson, and Ude, 1969; Wilson et al., 1962).

Some investigators cite difficulties with the reliability of the CVP readings for treatment purposes. For example, Rubin and Bongiovi (1970) cite false readings in the treatment of five burn patients. In their study, involving only patients whose CVP reading was misleading, they described how one type of treatment was indicated by the CVP measurement when in actuality another treatment was indicated by other criteria. Wilson (1965) mentions that with the CVP reading below 10 centimeters of water, which is normally considered satisfactory, some patients have developed pulmonary

edema due to left ventricular failure. Readings of zero to five centimeters of water have been observed in patients with increased capillary membrane permeability secondary to sepsis, who actually were in pulmonary edema. Brisman, Parks, and Benson (1967) also found that the CVP reading was misleading in 45 percent of the 20 patients studied due to failure to recognize the Starling curve impact on filling pressures. There are times when elevated CVP's are necessary to maintain adequate cardiac output. Delaurentis, Hayes, Matsumoto and Wolferth (1973) state that only 50 percent of the CVP readings correlated with the pulmonary wedge pressure measurements done on 32 consecutive patients. They felt that the pulmonary wedge pressure measurement was a better indicator of left heart function than CVP readings. Brisman et al., (1967) concurs with this opinion.

Despite these findings the CVP continues to be useful in evaluating right heart failure and blood volume.

Zero Reference Point

Once the physician determines that a CVP is indicated in the management of the patient, the indwelling CVP catheter is inserted. After this has been accomplished the nurse assumes responsibility for the remainder of the procedure required for CVP measurement. Since the measuring apparatus is an external device, some external point of reference corresponding to the level of the patient's right

atrium must be established so that the manometer base can be leveled for readings. This point, termed the "zero reference point" (ZRP), must be consistent for each reading. The nurse normally determines the location of this point. Winsor and Burch (1945) recognizing the lack of consistency in establishing such an external point, undertook a study to find a reference level for any patient, regardless of body build or position in bed. In the 99 patients investigated, it was found that "the reference level or heart level for the measurement of venous pressure is an axis which runs transversely through the thorax at the point of junction of a plane passing cross-sectionally through the fourth intercostal space adjacent to the sternum with a frontal plane passing midway between the posterior surface of the body and the base of the ziphoid process of the sternum" (p. 169). This reference point was used for the peripheral venous pressure determinations from the median basilic vein. Patients were studied in the 0, 25, 35, 45, 55, and 90 degrees of elevation. It was found that the readings were essentially the same with "Position of the vein under study in the same horizontal plane as the transverse axis of reference". Readings were counter-checked by placing the hand in the supine position reference level and then, with elevation of the trunk, corresponding changes in pressure equal to a column of water extending from the hand to the new position of the trunk were obtained. Winsor and Burch further state that a horizontal plane passing through the

reference point can be used for recording peripheral venous pressures with the patient in any position.

Since the study by Winsor and Burch in 1945, measurement of the CVP has replaced measurement of the peripheral venous pressure because peripheral veins are too easily affected locally by vasoconstriction, external compression or blockage (Burton, 1972). Burton further adds that venous valvular action can also give false readings.

Gowen (1973) finds no uniformity regarding the extracorporeal reference point in his review of the literature. Some investigators favor the mid-axillary level with the patient supine for all readings (Johnson, 1970; Wilson et al., 1962; Wilson, 1965; Plumer, 1970) while others add that it should also correspond to the plane of the fourth costochondral junction (Hurst, 1971; Longerbeam et al., 1965; Notaras, 1971). Still others indicate that the zero reference line could be the midpoint of the anterior-posterior diameter (Wilson et al., 1963), 10 centimeters anterior to the skin on the back (Longerbeam et al., 1965), or five centimeters below the manubriosternal joint (Lee, 1972). Most agree that consistency in measuring from the same reference point for all serial readings is the most significant factor (Davison, 1974).

The demand for consistency in determination of the extracorporeal reference point places responsibility on the nurse, particularly if the patient's condition changes so that he cannot tolerate

repositioning and the vertical as well as the horizontal axis is needed to insure accuracy of measurement. It is conceivable that a point where the axes cross should be determined for all readings, as close to the level of the right atrium as possible. Only the one study by Winsor et al., (1945) makes any reference to a vertical axis; however, some investigators do mention that when the patient cannot tolerate the supine position a variation of the sitting position may be used.

Patient Positioning

The primary value of the central venous pressure determinations arises from obtaining multiple values which indicate a trend rather than from isolated values (Gowen, 1973; James et al., 1973; Johnson, 1970; Plumer, 1970; Longerbeam et al., 1965; Rubin, 1970). In order to obtain accurate measurements from one time to the next, CVP readings should be done with the patient in the supine position (Johnson, 1970; Plumer, 1970; Royce, 1973; Wilson, 1965) because of the horizontal orientation of the arteries and veins to the heart (Betson et al., 1969; Burton, 1972). If that is impossible, the CVP reading should be done with the patient in the same position for each reading (Betson et al., 1969; James et al., 1972; Johnson, 1970). How the nurse can be certain that the patient is in the same degree of elevation from one reading to another is not clear.

Chow (1974) cites a study by Driver from the University of Texas School of Nursing in which the point of the vertical axis crossing the horizontal axis on the lateral chest was determined in 10 patients. Driver then examined the effects of positioning the patients in the 0, 15, and 30 degree upper trunk elevation and found no significant variation between the readings. Jeros (1972) studied the effects of the right lateral and left lateral positioning of the patient on the CVP as they relate to the readings obtained in the supine position. Choosing a population of 10 post-operative patients, Jeros recorded readings in each of the three positions at 15, 30, and 45 minutes post-positioning in addition to the initial reading. The mean supine reading was 11.54 centimeters of water, the mean change in left lateral position was 5.35 centimeters below the supine mean. The mean right lateral reading varied from the supine readings by a drop of 3.65 centimeters of water.

Hughs, et al. (1959) conducted a study to determine the value in right atrial monitoring in 25 consecutive thoracotomy patients. They recorded pressures with the patient in any position using a level to obtain the correct baseline for the base of the manometer. Twenty-three of the 25 patients, with replacement of known losses, had recordings consistently within the normal range and no change was noted in the blood pressure, hemoglobin concentration, pulse rate, urinary output, hematocrit or blood volume. In one patient the

hemoglobin concentration, blood pressure and hematocrit decreased while the pulse rate increased. All these signs are consistent with hypovolemia but an elevation in the CVP reading pointed to pump failure as the primary malfunction. The reduced hemoglobin concentration and hematocrit can be explained on the basis of hypervolemia diluting red blood cell concentration. Inotropic drugs were administered and the clinical findings returned to normal.

It is of interest that the few studies reported in the literature do show that the patient can be repositioned without losing the clinical diagnostic value of the serial CVP readings. The one exception was the study by Jeros (1972).

Physiologists have shown that gravity affects the circulatory system by temporarily decreasing venous return in proportion to the degree of uprightness the body assumes (Burton, 1972; Ganong, 1969). The peripheral venous pressure will rise 0.77 millimeters of mercury for each centimeter the vein is positioned below the right atrium and a 0.77 millimeters of mercury drop for each centimeter the vein is positioned above the right atrium. Thus, during quiet standing, venous pressure at the ankle is 85-90 millimeters of mercury with consequent pooling of blood in the legs, decreased venous return and cardiac output (Ganong, 1969). The effect of pooling in the circulatory system usually lasts about 5 minutes until the veins become full then venous return reaches normal again (Burton, 1972).

All the studies reviewed used an apparatus such as a tilt table to change body elevation. However, only the upper trunk is usually elevated in intensive care units. Thus the effects of pooling may be reduced in the clinical situation do to maintenance of lower extremity position closer to the level of the right atrium.

Purpose of this Study

This study was undertaken to determine whether or not accuracy in CVP measurement was dependent on the patient being in the supine position for all readings or whether serial readings taken with the patient in other positions could be just as accurate, using a consistent, well marked zero reference point. It was also desirable to know if the patient must be in the same position for all readings and whether differing lengths of time in a position would affect measurements.

If the patient must be in the same position, not necessarily supine, or if he was able to tolerate supination, then the horizontal and vertical axis for the ZRP must be accurately determined. The exact degree of patient trunk elevation must also be determined and maintained. A ZRP gauge was designed for accurage determination of the ZRP and the degree of upper trunk elevation. The ZRP gauge was used in this study.

Hypotheses

1. There would be no difference between the central venous pressure readings taken while the patient's trunk was at 0, 30, or 45 degrees of elevation.
2. There would be no difference in the central venous pressure readings taken in a specified position and readings taken at 5 and 15 minutes after being placed in that position.

CHAPTER II

METHODOLOGY

Design

The research design is a field experiment on a convenience sample of 17 subjects, randomly assigned to group A or group B. In order to assure random assignment of subjects, 10 pieces of paper with group A written on them, and 10 pieces of paper with group B written on them were placed in an envelope. After the subject was selected and agreed to participate in the experiment, one piece of paper was drawn from the envelope and the subject assigned to the group listed on the paper.

Group A subjects had their CVP's measured in the 0, 30, 45, and 0 degrees of elevation of the upper trunk, in that order. The standard hospital bed was used throughout the study period for each patient. CVP readings were taken at the time of positioning, then 5 and 15 minutes after positioning. This series was performed three times on each subject with rest periods between each series.

Group B subjects had their CVP's measured in the 0, 45, 30, and 0 degrees of elevation of the upper trunk, in that order. CVP

readings were then taken at the time of positioning, then 5 and 15 minutes later. This series was performed three times on each subject with rest periods between each series.

This design is termed intrasubject replication by Sidman (1960), and involves direct replication by repeated observations on the same subject. Intersubject replication (Sidman, 1960), direct replication of the intrasubject observations within each group, is also a part of the design.

The incorporation of measurements over a time continuum, with application of treatment occurring in the middle of the continuum, is one of the quasi-experimental designs, and a modification of Campbell and Stanley (1963) "time series" design.

The decision to have two groups was based on the desire to ascertain whether there was any difference between CVP readings as the patient was positioned in the ascending order of evaluation as in group A, and those in the positioning of the subject in the descending order of elevation as in group B.

Subjects

A total of 17 adult, male patients at the Veterans Administration Hospital, Portland, Oregon, served as the study population. The mean age for the study population was 63.9 years with a range of 41 to 84 years.

The original design called for 20 subjects but it was decided to terminate the study after 15 subjects on the basis that the difference in obtained readings did not appear to be significant. Three additional subjects were obtained prior to start of the study to test the instrument designed for the study. During the pre-test the instrument was found to be adequate in design and therefore there was no change in the method used or the instruments incorporated in the study. Two of the three pre-test subjects were included in the study results. One patient of the pretest group had questionable patency of the CVP line and therefore the results of his series of tests was not included in the final statistical analysis.

The sample was chosen from a population of patients with central venous pressure lines in position. Intrathoracic position of the venous pressure intracatheter was confirmed by an anterior-posterior chest x-ray. Each line was sutured in place at the time of insertion. The investigator measured the distance between the skin and the catheter sheath. This distance was watched for change indicating an unexpected shift in catheter position in the thoracic vein.

Permission to conduct the study at the Veterans Administration Hospital was co-ordinated through the Associate Chief of Nursing Service for Education. The study was referred to the Veterans Administration research committee from the nursing education department. The research committee sent the study to the Veterans

Administration Subcommittee on Human Studies. The latter approved the request to conduct the study. In addition to the general approval, the primary physician of each subject was consulted for permission to include his patient in the study. Following approval of the physician a written consent was obtained from each patient using a standard Veterans Administration form (see Appendix A).

In order to reduce the chance of biasing the CVP readings, no subject receiving vasopressor drugs at the time of the study or within four hours of onset of the study was included. In addition, intravenous fluid was infused at a rate not to exceed 125cc (cubic centimeters) per hour.

Patients with a lower extremity amputation above the knee were also excluded from the study for amputation could alter the magnitude of the effects on the CVP by venous pooling of blood in the extremities. Patients deemed by this investigator to be hemodynamically unstable and therefore unable to provide measurements over a time continuum that were specifically related to the physiological effects of positioning of the patient were excluded from the study, i.e., cardiogenic shock, concurrent renal peritoneal dialysis or hemodialysis or gastrointestinal bleeding. No subjects were artificially ventilated at the time of CVP measurement.

Type of illness was not a determining factor for inclusion in the study.

Instruments

McGaw In-line Venous Pressure Monitor

This instrument, commercially prepared and currently used as standard equipment in many hospitals, consists of a 13-inch, plastic tube with a centimeter scale marked on the side. The base of the manometer is permanently bonded to the middle outlet of a three-way stopcock, referred to as the manometer stopcock. An airfilter on top of the manometer prevents pressure build-up within the tube.

A three-inch rubber sleeve connects another outlet of the three-way stopcock to a 44 inch plastic extension tube. At the other end of the extension tube is a pliable "flash chamber" and needle adaptor. The needle adaptor connects to the patient's indwelling CVP line.

The third outlet of the three-way stopcock receives the adaptor from the infusion line.

Venoset® Microdrip®

This instrument, a commercially prepared and currently used article from Abbott Company is the means by which fluid from the intravenous bottle is relayed to the patient's indwelling infusion catheter. The infusion bottle is connected to the third outlet of the three-way stopcock by means of a 70 inch flexible tubing. A piercing

pin and metal microdrip tube connect the infusion bottle to the drip chamber which serves as the reservoir for fluid descending into the tubing. A needle adaptor on the other end of the tubing facilitates attachment to the in-line venous pressure monitor. A screw clamp on the tubing itself permits adjustment of fluid flow rate.

ZRP Gauge

The ZRP gauge was specially designed for this study (see Figure 1). It is a wooden apparatus with three water-bubble levels and a protractor mounted on it.

A dowling, 12 inches long and one-half inch in diameter forms the back section of the gauge. This section is marked off in centimeters along its dorsal length. A four inch piece of one-quarter inch plywood, one inch wide is glued to the base of the dowling at a 90 degree angle; angle verified by a carpenters square.

Another piece of wood, one-inch wide and eight inches long forms the upper arm of the gauge. It has a one-half inch diameter hole drilled approximately one-half inch from the end designated the backend of the upper arm. A narrow fissure traverses the center of the superior-inferior dimension longitudinally from the back end to beyond the hole. A wingnut screw extends through the lateral dimension midway between the hole and the back end.

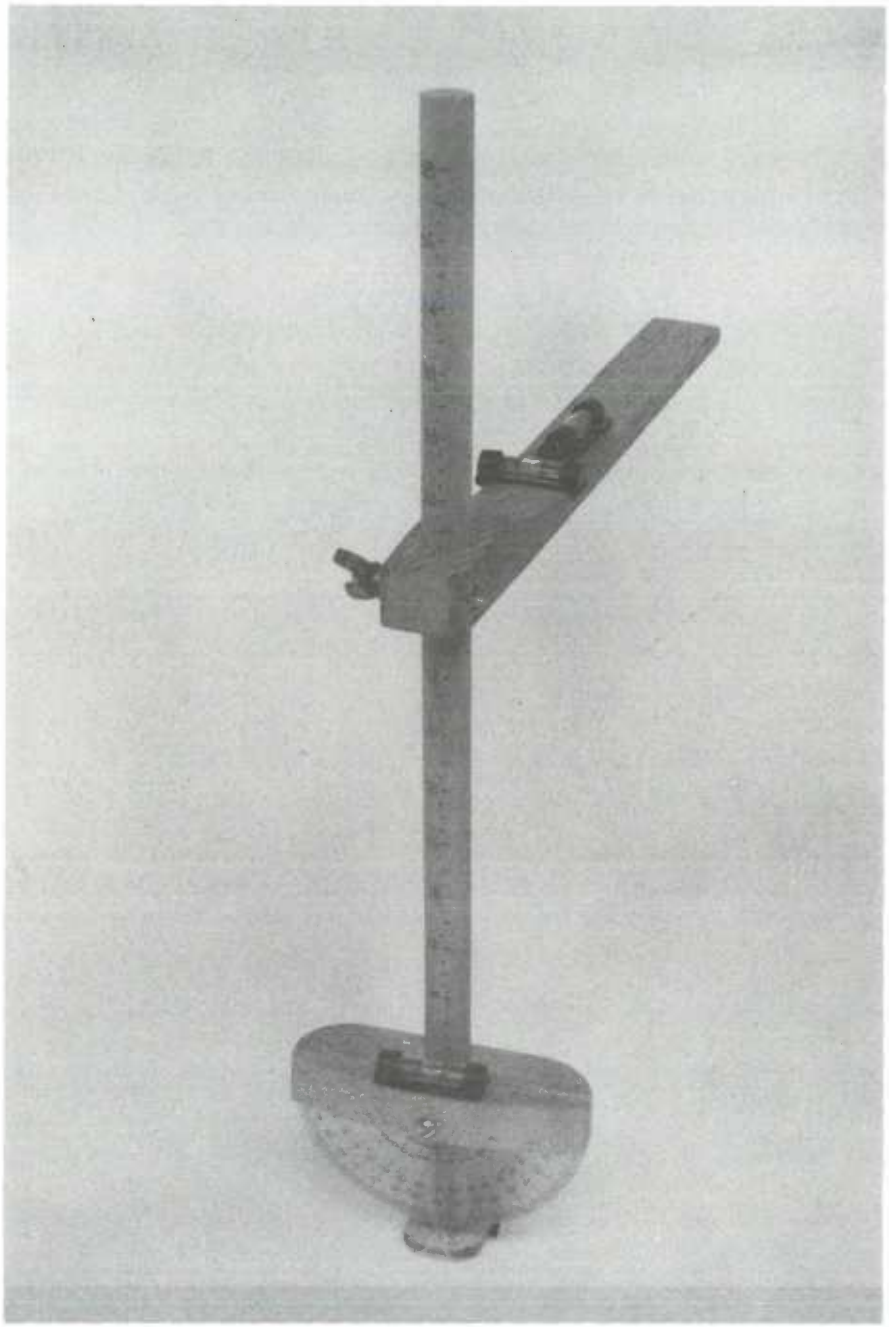


Figure 1. ZRP Gauge

The upper arm fits over the back section extending at a 90 degree angle to it; this angle verified by a carpenters square. This arm moves freely up and down the back section. The wingnut screw, when tightened, secures the arm in the selected position on the back section.

On the lower third of the back section a protractor is mounted on a four inch piece of wood, vertical to the back section. Another four inch length of wood is glued to the face of the protractor. On the superior surface of this piece of wood is mounted another level. A screw through both pieces of wood and the back stabilized the protractor and permits the protractor to be positioned from zero to 90 degrees, in reference to the back position of the gauge.

Procedure

The investigator conducted all phases of the experiment to assure continuity in all aspects of the procedure.

The indwelling CVP catheter was connected to a McGaw® in-line venous pressure manomitor (see page 24). An intravenous infusion bottle was attached to the third outlet of the three-way stopcock on the CVP manometer. The intravenous fluid was infused into the subject at a rate no faster than 125cc per hour but sufficient to maintain a patent channel between the manometer and the thoracic venous system.

The patient was placed in the supine, 0 degrees position. The ZRP was then determined by using the ZRP gauge. The upper arm of the gauge was placed on the chest, parallel to a vertical line extending from the fourth intercostal space adjacent to the sternum to the patients back. The back section of the ZRP gauge paralleled the vertical line as it traversed the lateral chest area. The vertical and horizontal line of the ZRP gauge was verified by the levels on the upper arm of the gauge. The bubbles on both levels were within the center lines.

The lower arm of the ZRP gauge was placed horizontally to the back, against the skin, to stabilize the gauge and to assist in chest thickness measurements. The midway point between the position of the lower and upper arms was calculated by halving the total lateral thoracic span, utilizing the centimeter scale on the back portion of the gauge. A mark was placed on the subject's chest at the junction of the vertical and horizontal lines. This mark was designated the ZRP for all subsequent readings of the CVP.

Placement of the ZRP gauge was necessary prior to change in tilt of the patients upper trunk but generally was not left in place during measurements. The gauge tended to move as the patient was tilted upward so the upper arm was taped to the patients chest to assure that angulation measurement was consistent and accurate.

Actual measurement of the CVP was done in the following manner. The base of the manometer stopcock was placed on the ZRP with

the manometer upright and perpendicular to the floor. The CVP manometer was then filled with fluid to the 30 centimeter mark on the manometer with solution from the infusion bottle by manipulation of the stopcock to position #1 (see Operational Definitions, p. 5). The stopcock was then turned to position #2. Patency of the fluid line was ascertained. The CVP reading was then taken by noting the fluid level in the manometer at the maximal descent of the meniscus. The fluid level was recorded in centimeters of water according to the scale on the manometer.

Upon termination of the reading, the CVP line was flushed with fluid from the infusion bottle by turning the stopcock to position #3 and increasing the flow from the bottle for five seconds by adjusting the screw adaptor on the intravenous tubing. The infusion rate was then readjusted to the predetermined rate.

Central venous pressure readings were taken in the 0 degrees position at the time of positioning and then 5 and 15 minutes later.

Subjects in group A were raised to the 30 degree semi-sitting position by manipulation of the head of the bed. The position was verified by placing the ZRP gauge on the chest prior to elevation of the head of the bed, in the same position used for ascertaining the ZRP. The protractor was turned until the 30 degree mark on it was parallel with the back of the ZRP gauge, level with the nail indicating the center of the back of the gauge. The head of the subject's bed

was elevated until the bubble in the level on the top of the protractor, was positioned between the two center line on the level. This indicated that the patient's chest was positioned at the 30 degree angle at the point of the ZRP. Central venous pressure readings were then taken immediately as well as 5 and 15 minutes after positioning.

The head of the bed was then raised to the point at which the subject was in a 45 degree semi-sitting position. The position was verified by using the ZRP gauge as was done previously except that the protractor was turned to read 45 degrees instead of 30 degrees. Again CVP readings were taken at the time of positioning and 5 and 15 minutes after positioning.

The subject was then placed in the 0 degrees position by lowering the head of the bed to horizontal. CVP measurements were again taken as described previously.

Group B subjects differed from group A subjects only in the sequence of position changes. Group B subjects' position were adjusted from the 0 degree elevation directly to the 45 degree semi-sitting position. Following the CVP reading sequence in this position, they were lowered to the 30 and 0 degree positions respectfully, for the CVP measurements to be taken.

The series of position changes and CVP measurements were conducted on each of the subjects a total of three times with rest periods between series.

CHAPTER III

RESULTS

Pilot Study

Prior to actual start of the study it was necessary to test the ZRP gauge to assure accuracy and consistency in measurement. Three subjects were chosen according to the criteria established for the study (see p. 27). The pilot study was conducted in the same manner as the actual study. It was found that the gauge tended to tip toward the patients feet as the patient was elevated. To counteract this, the upper arm of the gauge was taped in place after the fourth intercostal spaces were marked with a pen. Frequent checks of the relationship of these marks to the upper arm were made during the maneuvering of the patient to verify that the gauge had remained in the proper position and that the degree of tilt was therefore accurate.

No further difficulties were encountered with the ZRP instrument so the actual study was undertaken.

Statistical Analysis

Analysis of the data first necessitated obtaining the mean of

each series of readings for each of the 17 patients (group A = 9 patients, group B = 8 patients). The means for all patients were then treated as raw data (see Appendix B) and subjected to a 17 x 3 x 4 analysis of variance with repeated measures on two factors, time and degree of elevation (tilt) (Table 1). Because "between subjects" variation was not relevant to this study, only a "within subjects" analysis of variance was done.

Table 1

Analysis of Variance Summary Table

	SS	df	MS	F
Total	4211	203		
between subjects	4010	16		
within subject	201	187		
time	1	2	.50	3.12
time x subject within groups	5	32	.16	
tilt	9	3	3.00	.87
tilt x subject within groups	166	48	3.46	
time x tilt	4	6	.67	3.94*
time x tilt x subject within groups	16	96	.17	

*F = 3.94; P > .05

There was no significant difference within the time variable or within the tilt variable. There was a statistically significant interaction ($F = 3.94 \alpha \leq .05$) between time and tilt but the significance was small. Further analysis of the significant interaction was

accomplished by testing the simple effects of tilt for each time interval (Table 2).

Table 2

Simple Effects of Tilt for Each Time Interval

	SS	df	MS	F
tilt (time 0)	10.57	3	3.52	2.79*
tilt (time 5)	1.63	3	.54	.43
tilt (time 15)	.19	3	.06	.05
E	182	144	1.26	

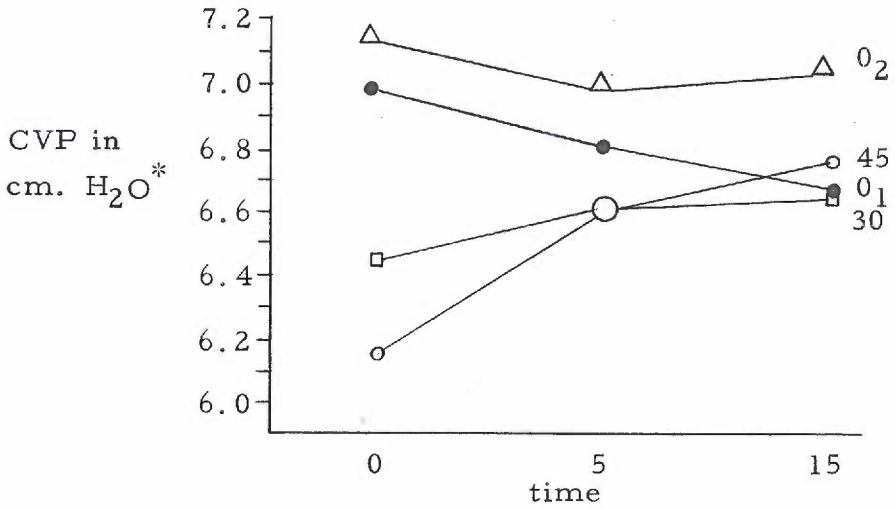
*F = 2.79; p > .05

In the study of the simple effects the only significant difference occurred between angle of tilt at time 0 (Graph 1).

The 17 patients were divided into their groups A (Graph 2) and B (Graph 3) consisting of nine and eight subjects respectively. A t test was run between 0_1° tilt and 45° tilt at time 0 for each group to test the effects of tilting the patient abruptly to 45° and tilting by stages to the 45° tilt. The t test for group A was insignificant ($t = .04\ \alpha \leq .05$) as was the t test for group B ($t = .31\ \alpha \leq .05$).

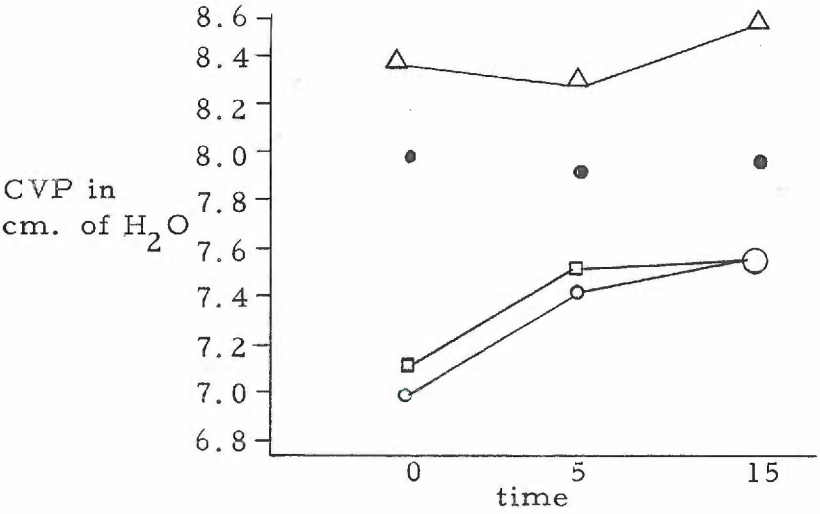
Graph 2

Simple effects of tilt for each time interval
for all patients using mean CVP



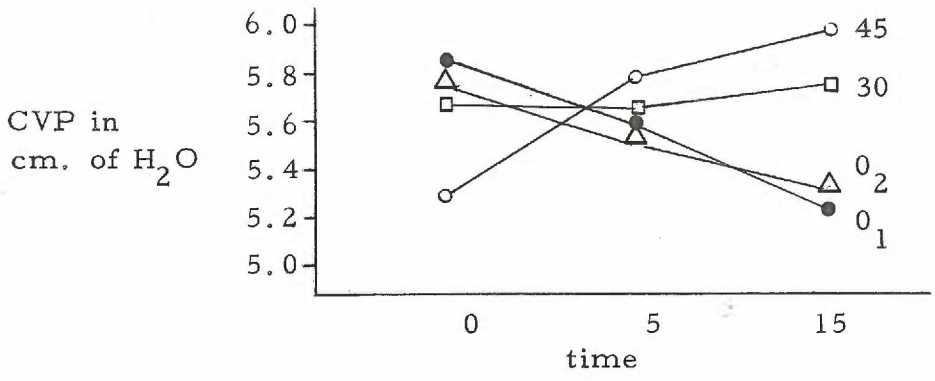
*centimeters of water

Mean CVP for group A patients at each level of time factor



Graph 3

Mean CVP for Group B Patients at Each Level of Time Factor



Results

The analysis of variance supported the first hypothesis. There was no significant difference ($F = .87$ $\alpha \geq .05$) between the CVP readings obtained while the patient's trunk was at the 0, 30 or 45 degrees of tilt. The second hypothesis, that of no difference in the CVP readings taken at the time of positioning, 5 and 15 minutes later, was also supported ($F = 3.12$ $\alpha \geq .05$).

There was a significant interaction ($F = 3.94$ $\alpha \geq .05$) between tilt and time. The analysis of simple effects between tilt at each time factor yielded significant differences only at time 0_1 position (see Graph 1, p. 40). The CVP came down over time when the patients were not subjected to tilt. However, when subjects were tilted, the

initial readings were reduced but increased over time to reach a level equivalent to that of the non-tilted values at the 5 and 15 minute readings.

The t test between the 0_1° and 45° tilt at time of positioning for group A shows that patients can be slowly raised from the former to the latter position without significant change in CVP readings.

The t test between the 0_1° and 45° tilt at time of positioning for group B shows that patients can tolerate an abrupt rise from the flat position to the 45° semi-sitting position without a significant drop in CVP reading.

Discussion

One must keep in mind that the central venous pressure can be altered by changes in intrathoracic pressures. Vander et al., (1970) described extraneous variables affecting the measured pressure. One such variable is the respiratory influence on the intrathoracic cavity pressure. The greater the inspiratory volume, the lower the CVP reading. Conversely, a decrease in inspiratory volume will yield a higher CVP reading. The researcher in this study observed that patients had variable depths of respirations, regardless of tilt. This variation should be taken into consideration when CVP readings are interpreted.

It is possible that the slight increase in the 0_2 tilt reading over the 0_1 tilt reading (noted in Graph 1) could be attributed to change in depth of respirations, that is, the subjects may have reduced the depth of respirations due to fatigue from the 45 minutes of data collection procedures. The difference in the readings taken in the 0 tilt positions, however, was not statistically significant.

The raw data for group A (see Appendix B) shows a mean difference within subjects of 3.1 cm of H_2O for all readings across time and tilt. The range of difference in CVP readings for the group A subjects was 1.8 to 4.8 cm of H_2O (the 4.8 cm of H_2O reading was obtained on a severely kyphotic patient).

The group B patients (see Appendix B) shows a mean difference within subjects for all readings of 3.0 cm of H_2O with a range of 2.5 to 5 cm of H_2O. One patient consistently showed a 5 cm of H_2O rise when elevated from 0_1 to the 45 degree tilt position. This unexpected increase could possibly be a result of a ZRP that did not correspond with the level of the right atrium in the vertical or horizontal axis for one of three reasons; investigator error in measurement, abnormal position of the right atrium, or a combination of these.

The differences in the CVP readings for each of the subjects would not indicate a change in the treatment of the patient. One possible exception to this statement exists. If the patient were being given a fluid challenge, a change of 3 or 4 cm of H_2O within a 15

minute period would indicate that the patient was not tolerating the fluid hemodynamically. The range of difference found with this study would support not moving the patient from one degree of elevation to another during a fluid challenge as the change in reading could be attributed to the move and not the fluid infusion.

Results indicate that the ZRP used in this study will facilitate reliable CVP readings over time. This study also shows that the serial CVP measurements are comparable if taken with the patient on his back, in any degree of tilt as long as the external reference point is properly ascertained and consistently used. The statements that patients should be in the supine position for CVP readings because of the horizontal orientation of the arteries and veins to the heart, by Betson et al., (1969) and Burton (1972) are not supported by the findings of this study.

The statistically significant finding in this study was the time x tilt interaction. Analysis of the simple effects for tilt at each level of time revealed that the significant interaction occurred between the angle of tilt at time 0. The greater the degree of tilt the lower the initial readings. Those readings taken at the 30 and 45 degree tilt positions tended to rise, matching those taken in the 0 degree of tilt position over time. The difference was not significant at the 5 and 15 minute intervals. Burton (1972) described this phenomena stating that the effects of venous pooling usually lasts about five minutes until

the veins become full then venous flow returns to normal. The study by Driver (1974), however, did not show this initial drop in pressure readings.

Results of this study contradict Betson's position (1969) that the patient should be flat for all CVP readings and, for those patients who were unable to be in the flat position, that the CVP readings should be taken in the same degree of elevation. The significant interaction between time and tilt points out the need to measure the CVP either immediately upon placing the patient in the desired position or after he has been placed in the position for at least five minutes. If the patient has been in a position for five minutes the CVP readings will be comparable.

The mean CVP readings for the group B patients shows that the readings dropped initially when they were abruptly tilted from 0_1 to 45 degrees of elevation. Interestingly, the CVP readings in the latter position, after 15 minutes, overshot the declining reading taken with the patient flat for 15 minutes. It is likely that this overshoot is a result of the compensatory mechanisms initiated when the pressure receptors in the carotid sinus sensed the drop in pressure immediately evident upon tilt. The difference was not statistically significant however.

The mean CVP graph for the group A patients shows a more consistent CVP reading over the time continuum for each tilt position

than did the group B patients. The reason for this is not clear. The CVP readings did change as the position was changed although not significantly so.

Conclusions and Recommendations

This study shows that, in the population studied, central venous pressure measurements are consistent from one reading to another if the ZRP is properly marked and if the patient has been in the position for a minimum of five minutes. The ZRP is that point where a vertical line from the fourth intercostal space, adjacent to the sternum, to the back, intersects a horizontal line, drawn midway between the anterior-posterior diameter.

The method of measurement of the ZRP used in this study was time consuming and awkward. A study to determine a precise yet easy method of ZRP determination is needed.

Since this study dealt only with the hemodynamically stable patient, further investigation of the unstable patient is essential.

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APPENDICES

APPENDIX A

Form approved.
Budget BureauNo. 76-R0138.

REQUEST FOR AND CONSENT TO RELEASE OF INFORMATION FROM CLAIMANT'S RECORDS

NOTE.—The execution of this form does not authorize the release of information other than that specifically enumerated herein.

TO	Veterans Administration,	NAME OF VETERAN (*Type or print*)	
		CLAIM NO. C-	SOCIAL SECURITY NO.

NAME AND ADDRESS OF ORGANIZATION, AGENCY, OR INDIVIDUAL TO WHOM INFORMATION IS TO BE RELEASED

VETERAN'S REQUEST

I hereby request and authorize the Veterans Administration to release the following information, from the records identified above, to the organization, agency, or individual named hereon:

INFORMATION REQUESTED (*Number each item requested and give the dates or approximate dates—period from and to—covered by each.*)

PURPOSES FOR WHICH THE INFORMATION IS TO BE USED

NOTE.—Additional items of information desired may be listed on the reverse hereof.

DATE	SIGNATURE AND ADDRESS OF CLAIMANT, OR FIDUCIARY, IF CLAIMANT IS INCOMPETENT

VA FORM NOV 1970 **07-3288** Existing stocks of VA Form 07-3288, Apr 1965, will be used.

GPO 043—16—70470-2 410-646

APPENDIX B

Raw Scores

Group A

	0 minutes				5 minutes				15 minutes			
Subject	$\bar{X}\ 0_1$*	$\bar{X}\ 0_2$	$\bar{X}\ 30$	$\bar{X}\ 45$	$\bar{X}\ 0_1$	$\bar{X}\ 0_2$	$\bar{X}\ 30$	$\bar{X}\ 45$	$\bar{X}\ 0_1$	$\bar{X}\ 0_2$	$\bar{X}\ 30$	$\bar{X}\ 45$
1	5.17	5.33	3.50	3.33	5.17	5.67	3.83	3.50	4.83	5.83	3.67	3.83
2	-.50	-.17	-3.50	-3.00	-.83	-.83	-2.50	-2.33	.33	-.50	-3.00	-2.83
3	8.83	9.33	9.00	8.33	8.83	9.17	8.67	9.33	8.67	9.17	8.83	9.17
4	6.00	6.50	8.17	5.17	8.83	6.50	5.67	6.50	5.67	6.33	5.67	6.83
5	13.67	13.00	12.33	11.67	13.33	12.83	12.33	12.00	12.67	12.83	12.50	12.17
6	5.33	5.33	5.83	6.33	6.17	5.17	5.83	6.17	5.33	5.17	5.67	6.00
7	6.17	6.83	5.00	5.83	5.50	6.67	5.50	5.83	6.17	7.50	5.33	5.67
8	17.50	18.00	16.00	14.83	17.17	18.83	16.17	15.33	17.00	19.30	16.33	16.50
9	9.67	11.33	10.50	10.33	10.00	10.50	11.83	9.67	11.00	11.50	12.17	9.83

* tilt

Raw Scores

Group B

	0 minutes				5 minutes				15 minutes			
Subject	$\bar{X}\ 0_1$*	$\bar{X}\ 0_2$	$\bar{X}\ 30$	$\bar{X}\ 45$	$\bar{X}\ 0_1$	$\bar{X}\ 0_2$	$\bar{X}\ 30$	$\bar{X}\ 45$	$\bar{X}\ 0_1$	$\bar{X}\ 0_2$	$\bar{X}\ 30$	$\bar{X}\ 45$
1	8.17	8.33	7.67	8.00	7.50	7.17	7.50	8.67	8.33	7.67	7.33	8.67
2	3.83	3.67	2.50	1.50	4.00	3.67	2.67	1.67	3.17	3.67	2.50	2.17
3	8.00	7.67	11.83	12.83	8.00	7.67	12.00	13.17	6.67	7.83	11.67	13.00
4	2.50	2.50	2.50	1.83	2.17	2.50	2.00	1.83	3.00	2.17	2.00	2.50
5	8.00	7.75	6.25	4.00	7.25	7.50	5.50	4.25	7.00	7.00	6.00	5.75
6	3.00	1.17	2.00	1.83	2.83	1.33	2.17	3.50	1.67	.33	2.17	2.33
7	10.17	10.17	10.50	10.80	9.50	10.00	10.50	11.33	9.50	10.17	11.50	11.83
8	3.33	4.50	2.17	1.33	3.50	4.17	2.67	1.83	2.50	3.67	3.00	1.67

* tilt

AN ABSTRACT OF THE FIELD STUDY OF

ARLENE B. STRONG

For the Master of Nursing

Date of Receiving this Degree: June 13, 1975

Title: Effects of Patient Positioning on Central Venous Pressure Measu[redacted]

Approved: _____
Marie Berger, Assistant Professor
Field Study Advisor

Measurement of the central venous pressure (CVP) may be instituted in the monitoring program of patients to aid in assessment of the hemodynamic state before, during, and after therapy. These data are obtained to test the hemodynamic state as often as every 15 minutes in the critically ill patient or when rapid fluid infusion is being given. The majority of the critically ill patients are most comfortable in some degree of the sitting position, yet to obtain the serial readings for comparison evaluation, most investigators state that the patient should be in the supine flat position to insure accuracy. If the patient cannot tolerate the horizontal position then the same degree of elevation of the patient is essential. The measurement of the CVP thus presents some major problems. One problem is that the patient is frequently disturbed by having the head of the bed rolled down. A second problem is that of determining consistent

degree of elevation in patients that are unable to tolerate the flat position. A third difficulty is that of determining the external reference point (ZRP) which accurately corresponds to the level of the right atrium. This point is the baseline to which the manometer is placed for all readings.

Accurate, serial CVP readings have been proven valuable in the treatment process of the acutely ill patient yet only one study could be found in the literature regarding CVP determinations with the patients in different degrees of upper trunk tilt (Chow, 1974). The results of that study showed that the difference in CVP readings for the variations in elevation of the patient were insignificant. The review of literature also indicated a variety of theories on the placement of the external reference point.

The study was undertaken to determine if the central venous pressure readings could be reliable when taken with the patient in different degrees of elevation and whether time in position would be a factor in the obtained data.

Seventeen male patients at the Veterans Administration Hospital served as the study population. They ranged in age from 41 to 84 with a mean age of 63.9. Criteria for inclusion in the study were:

1. CVP line in place and position confirmed by x-ray.
2. No vasopressor drugs at the time of the study or within four hours of onset of the study.

3. Intravenous fluid infusion no greater than 125cc per hour.

4. No above the knee amputation of lower extremities.

5. Hemodynamically stable.

The study design was a field experiment. Seventeen subjects were selected according to the five criteria above and were then randomly assigned to group A or group B. Group A subjects (N = 9) differed from group B subjects (N = 8) only in the sequence of upper trunk tilt. Group A subjects had their CVP's measured in the 0, 30, 45 and 0 degrees of elevation, in that order while group B subjects underwent elevation from 0, 45, 30, to 0 degrees of elevation. Measurements were taken with the subject on his back in each tilt position, at the time of positioning and 5 and 15 minutes after positioning. The series of readings for tilt and time were completed three times on each subject with rest periods between series.

The ZRP was that point at which a vertical line drawn from the fourth intercostal space at the sternum laterally to the skin of the back, intersects a horizontal line dividing the mid anterior-posterior diameter of the chest. Determination of that point was made by use of a ZRP gauge which was specifically designed for this study. The gauge was also equipped with a protractor-level apparatus to be used in determining the degree of tilt. A standard CVP manometer was used for the CVP readings. All patients were in a standard hospital bed for the study.

The obtained data were subjected to a 17 x 3 x 4 analysis of variance with repeated measures on two factors, time and degree of elevation (tilt). Because "between subjects" variation was not relevant to this study, only a "within subjects" analysis of variance was done. There was a statistically significant interaction ($F = 3.94$ $\alpha \leq .05$) between time and tilt. The differences for time or tilt individually was not significant ($F = 3.12$ $\alpha \leq .05$ and $F = .87$ $\alpha \leq .05$ respectively). An analysis of the simple effects of tilt for each time interval showed the only significant difference occurred between the angle of tilt at time 0.

A t test was run between 0°_{1} tilt and 45° tilt at time 0 for each group, to test the effects of tilting the patient abruptly to 45° and tilting by stages to the 45° tilt. The t test for group A (N = 9) ($t = .04$ $\alpha \leq .05$) and the t test for group B (N = 8) ($t = .31$ $\alpha \leq .05$) were not significant.

The raw data for group A subjects showed a mean difference (within subject) of 3.1 cm of H_2O for all readings across time and tilt with a range of 1.8 to 4.8 cm of H_2O. Group B subjects showed a mean difference (within subject) for all readings of 3.0 cm of H_2O with a range of 2.5 to 5 cm of H_2O.

Analysis of the simple effects of the means of all readings of tilt for each time interval showed that the greater the degree of tilt the lower the initial readings. Those readings taken at the 30 and

45 degree of tilt positions tended to rise, matching those taken in the 0 degree of tilt position over time. This study indicates that the hemodynamically stable patients can be in any degree of elevation for CVP readings but that they should be in the position for at least five minutes before the reading is taken to insure consistency and accuracy and the ZRP must be correct. The study showed that the ZRP used during the study will yield consistent readings, which are meaningful in serial measurements for differing degrees of tilt.