Understanding Pupillometry in Neuroscience Critical Care Patients:

A Look at Clinician Usage, Understanding, and Perspective

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NURS 703: Doctor of Nursing Practice Project

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May 16th, 2025

Abstract

Monitoring pupil function is a key component of neurological assessment in patients with brain injuries, offering early indicators of neurologic deterioration (Bower et al., 2021; Kerr et al., 2016). However, manual pupillary assessments have shown low reliability when compared to automated pupillometry (Olson et al., 2016). Pupillometry provides objective, precise measurements that improve accuracy (Philips et al., 2018). At the improvement project site, the current state of pupillometry use and clinician understanding remained unclear. This project performed a historical chart review on patients admitted to the neuroscience intensive care unit with documented pupillometry use, followed by a clinician survey informed by chart findings. These interventions were used to inform next steps and future education needs. Findings showed no consistent indications for pupillometry use. Utilization was highest amongst patients with hemorrhagic strokes, though practice varied. Survey results demonstrated that clinicians perceived pupillometry as a valuable tool, however providers often felt that the data was not regularly utilized in their clinical decision making. The absence of a standardized guideline or protocol contributes to variability in pupillometry use and limited understanding of its clinical significance. Additionally, pupillometry appeared to be utilized in response to clinical deterioration rather than as a part of routine monitoring. These results suggest a potential education gap around device usage and results interpretation. Formal education and standardized guidelines, particularly for patients with hemorrhagic stroke, may improve device utilization and support more proactive neurological monitoring.

Introduction

Problem Description

Monitoring pupil function is a regular and important part of assessing neurological status of patients with brain injuries (Kerr et al., 2016). Primary components of the pupillary assessment include pupil size, pupil shape, difference in size (known as anisocoria), and their reactivity to light (Kerr et al., 2016). In neurocritical care settings, pupil assessments can give insight to impending neurologic deterioration, including that from elevated intracranial pressure (Bower et al., 2021). In high-grade subarachnoid hemorrhage patients, impaired pupil reactivity to light was considered an indicator of poor neurologic outcome (Kobata et al., 2023). Absence of pupil reactivity is also a key assessment in the diagnosis of brain death (Lenga et al., 2023).

Manual pupillary assessments done by the clinician can be unreliable (Bower et al., 2021). Many factors, such as room lighting and the way the light is shone, impact the ability to properly and consistently assess for pupillary changes on manual exam (Kerr et al., 2016). In a study that examined interrater reliability between individual practitioners and between practitioners and pupillometry, it was found that reliability was only moderate; practitioner assessment of fixed pupils was also only correct 33% of the time when compared to pupillometry (Olson et al., 2016). Additionally, a double-blind study found that traditional pupillary assessments were inaccurate when compared to pupillometry for detecting anisocoria (Couret et al., 2016).

Significance of the Problem

Pupil assessments provide invaluable data that give insight to a variety of clinical and neurologic outcomes (Bower et al., 2021; Kobata et al., 2023; Lenga et al., 2023). Given the significance of pupil changes on a patient's neurologic status and the inconsistencies that exist in

manual pupillary assessment, providers need to identify the utility in trending pupil changes through gathering objective data in guiding their treatment and interventions. Pupillometry is a tool shown to provide increased precision and reliability of pupillary assessment (Philips et al., 2018). Although pupillometry can be used to detect subtle, early pupillary changes, identify increased intracranial pressure or impending herniation, and be a tool used for neurologic prognostication such as in brain death testing, there are currently no guidelines for the routine use of this tool (Philips et al., 2018).

Local Problem

At a large West Coast academic medical center, pupillometry is an available tool not routinely used. A job aid exists with instructions for use and suggestions for clinical utilization, but no policy or procedure currently exists. Other than in-services performed by pupillometry device representatives, no formal training was done on the use and utilization of pupillometry among nursing and provider staff.

Rationale

Pupillometry is a clinical tool that offers precision and invaluable data that can indicate and detect a variety of pathologic processes (Philips et al., 2018). At the quality improvement project site, pupillometry was not routinely used and it was unclear if providers and nursing staff understood the full implications that pupillometry use could have in practice.

This project was guided by the Institute of Healthcare Improvement (IHI) Model for Improvement (MFI). The IHI MFI focuses on implementing change in the healthcare setting through a systematic approach. It aims to identify what is trying to be accomplished, how improvement will be recognized, and what interventions will bring about improvement (Institute for Healthcare Improvement [IHI], n.d). The Plan-Do-Study-Act cycle provided a structured and

repetitive model which guided improvement efforts that are purposeful and evidence-based (Institute for Healthcare Improvement [IHI], n.d). The IHI MFI is a validated tool with a user-friendly structure that can be used to create change in healthcare which will guide the successful implementation of this project.

DNP Project Aim

This project aimed to:

1. Perform a historical chart review from January 2024 through June 2024 for patients admitted to the neuroscience intensive care unit (ICU) who had automated pupillometry documented to gather the current state of pupillometry utilization, including indications for pupillometry use and what the admitting diagnosis was for patients evaluated by pupillometry.
2. Using the data collected from the historical chart review, create and distribute a survey to evaluate the current knowledge of clinical staff regarding the benefit of pupillometry, the significance of objective data collected by pupillometry, and its indication for interventions and patient outcomes. These survey results will direct future education needs.

Methods

Interventions

- Performed a historical chart review from January 2024 to June 2024 for all patients admitted to the neuroscience ICU who had pupillometry performed. The purpose of this was to understand the current state of pupillometry usage.
    - Data collected: indication for pupillometry use, admitting diagnosis of patient, and frequency of pupillometry assessment per patient.

- Created a survey using Qualtrics to evaluate the current knowledge of clinical staff regarding the benefit of pupillometry, the significance of objective data collected by pupillometry, and its indication for interventions and patient outcomes.
- Distributed the survey to neuroscience ICU providers, neuroscience ICU nurses, and neurosurgery providers.
- Synthesized the data gathered through the chart review and survey

Measures

The outcome measure for this project was the completion of the historical chart review and sending of survey, the synthesis of data gathered, and recommendations for next steps. Process measures included survey participation from multiple disciplines including neuroscience ICU nurses, neuroscience ICU providers, and neurosurgery providers. Since there was a retrospective chart review this project did not have any meaningful downstream impacts in which balancing measures could be considered, however, balancing measures should be considered as a part of future education or practice interventions.

Analysis

Historical data was gathered through identification of patients within the determined time frame who had pupillometry data documented in Epic Flowsheets. A chart review was done to identify frequency of pupillometry use, indications for use, and the patients' admitting diagnosis. Data from historical chart review findings was de-identified and saved on a OneDrive document which was on a shared Microsoft Office platform requiring a password and dual authentication for protection. Surveys were performed using Qualtrics; survey results were saved within the platform.

Ethical Considerations

This project was reviewed by the IRB and determined as not human research. Any protected health information (PHI) accessed for chart review was not distributed or disclosed. All PHI data was kept confidential and was de-identified for dissemination of findings. Survey results were anonymous and only required participants to disclose whether they were nursing or provider staff. There were no conflicts of interest that required disclosure for this project. There were no other ethical considerations.

Results

During the data collection period from January 2024 to June 2024, a total of 645 patients were admitted to the neuroscience ICU. Of these patients, 89 received automated pupillometry during their neuroscience ICU admission, with 1,295 individual pupillometry entries documented.

The State of Pupillometry- Patient Population and Indication for Use

The most common diagnosis among patients undergoing pupillometry was hemorrhagic stroke (38.2%, n = 34), followed by ischemic stroke (20.2%, n= 18). Approximately 14.6% (n = 13) of patients had other non-neurological diagnoses (see appendix A). Detailed diagnostic categories are provided in Appendix A, figure A1.

Of the 1,295 pupillometry entries, 1,011 lacked a documented indication. Trends included use in response to a pupillary change or within 4 hours of admission. The only explicitly documented indication for pupillometry was a written provider order. Two patients had standing orders specified under a neurological checks order, accounting for 284 entries. No other patients had documented orders for pupillometry during their admission in the neuroscience ICU (see Appendix B).

To further assess usage, data was collected on pupillometry performed within 4 and 24 hours of admission (see Appendix C), nursing communication to the provider team regarding pupillometry, and provider documentation in clinical notes. Notably, 71 of 89 patients who received pupillometry had pupillometry performed within 24 hours of admission.

Neuroscience ICU Clinician Survey

A survey, informed by the retrospective chart review, received 48 completed responses. Four incomplete surveys were excluded from the results. The survey was distributed to 141 individuals, including 94 registered nurses, 25 neuroscience ICU providers, and 22 neurosurgery providers. Of the respondents, 81.3% were registered nurses and 18.7% were providers. Among providers, 8.3% were neuroscience ICU attending providers, 4.2% were neuroscience ICU advanced practice providers, and 6.3% were neurosurgery providers.

Both nurses and providers strongly agreed that they understood how to use the pupillometer, determine appropriate application, and interpret results. Respondents also generally agreed that pupillometry is a nursing driven process and considered it a useful tool that should be regularly used. However, over half of provider respondents indicated they do not regularly review pupillometry data when evaluating patients' charts.

Free-text responses highlighted that nurses find pupillometry particularly helpful when there is concern for acute neurological deterioration, though less so in stable patients. A commonly cited limitation was the limited availability of devices- only two pupillometers are shared hospital-wide. Providers appreciated the precision of the data but often noted it did not influence their clinical management decisions.

Discussion

Summary

Between January and June 2024, 645 patients were admitted in the neuroscience ICU; of these, 89 had documented pupillometry. Most patients receiving pupillometry had an admitting diagnosis of either hemorrhagic or ischemic stroke. While clinicians acknowledged its utility for obtaining objective neurological data, no standardized criteria or formal indications for use were identified.

Interpretation

Pupillometry is frequently used among stroke patients in the neuroscience ICU, and is a process primarily driven by nursing staff in response to neurological changes. Although providers recognize its potential value, many do not incorporate pupillometry data into their clinical decision-making. The lack of a standardized guideline or protocol contributes to variability in pupillometry use and the absence of clear indications for use. It also limits understanding whether there is clinical significance to pupillometry.

Device usage trends suggest that nursing staff primarily rely on pupillometry when they are concerned about changes in neurologic exams or to confirm change in pupil size or reactivity. This practice, however, is not applied among all patients consistently. In most cases, pupillometry is used when clinical deterioration is suspected, rather than as a part of routine monitoring or for data trending. This, along with providers indicating they do not regularly use pupillometry data in clinical management, suggests a potential education gap around device usage and results interpretation.

Limitations

Several limitations should be noted:

- The chart review did not differentiate by type of ICU admission (e.g., surgical admission, rapid response admission from the wards, lateral transfer from another ICU, admission from the emergency department, or admission outside hospital admission). This limited analysis of subgroups of patient populations.
- The project only focused on patients who had pupillometry performed in the neuroscience ICU. It did not account for any pupillometry data from other units if the patient was transferred.
- Voluntary response bias may have influenced the results of the survey, as those with stronger opinions may have been more likely to respond. Additionally, the majority of respondents were nursing staff, thus responses greatly reflected the nursing perspective.
- Since the initiation of this project, a standardized protocol has been developed for traumatic brain injury patients, which includes the routine use of pupillometry. Additionally, formal recommendations for the use of pupillometry in brain death testing has also been created.

Conclusion and Recommendations

Pupillometry is a tool that has the potential to detect early pupillary changes, identify impending neurological deterioration, and aid in neurological prognostication; however, there is a lack of guidelines for its use (Philips et al., 2018). In the neuroscience ICU, stroke patients are the most frequent recipients, and clinicians generally agree on the value of the tool in providing objective and accurate data. This project outlines and establishes the current state of pupillometry

practice in the neuroscience ICU and provides a foundation for future opportunities on pupillometry education and standardization.

Based on the current state of pupillometry use, formal training should be developed. The inconsistency in pupillometry use indicates that training should focus on key indications for use, interpretation of data, and clinical relevance for intervention. For providers to better understand the utility of pupillometry in their patients and to better understand its clinical significance, considerations should be made in establishing a protocol amongst hemorrhagic stroke patients. Initiating a protocol amongst those patients receiving pupillometry can help establish pupillometry utility, and facilitate standardization of application, allowing for better evaluation of clinical impact.

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Appendix A

Admitting Diagnosis of Patients Receiving Pupillometry

Figure A1

Admitting Diagnosis of Patients who Received Pupillometry in the Neuroscience ICU

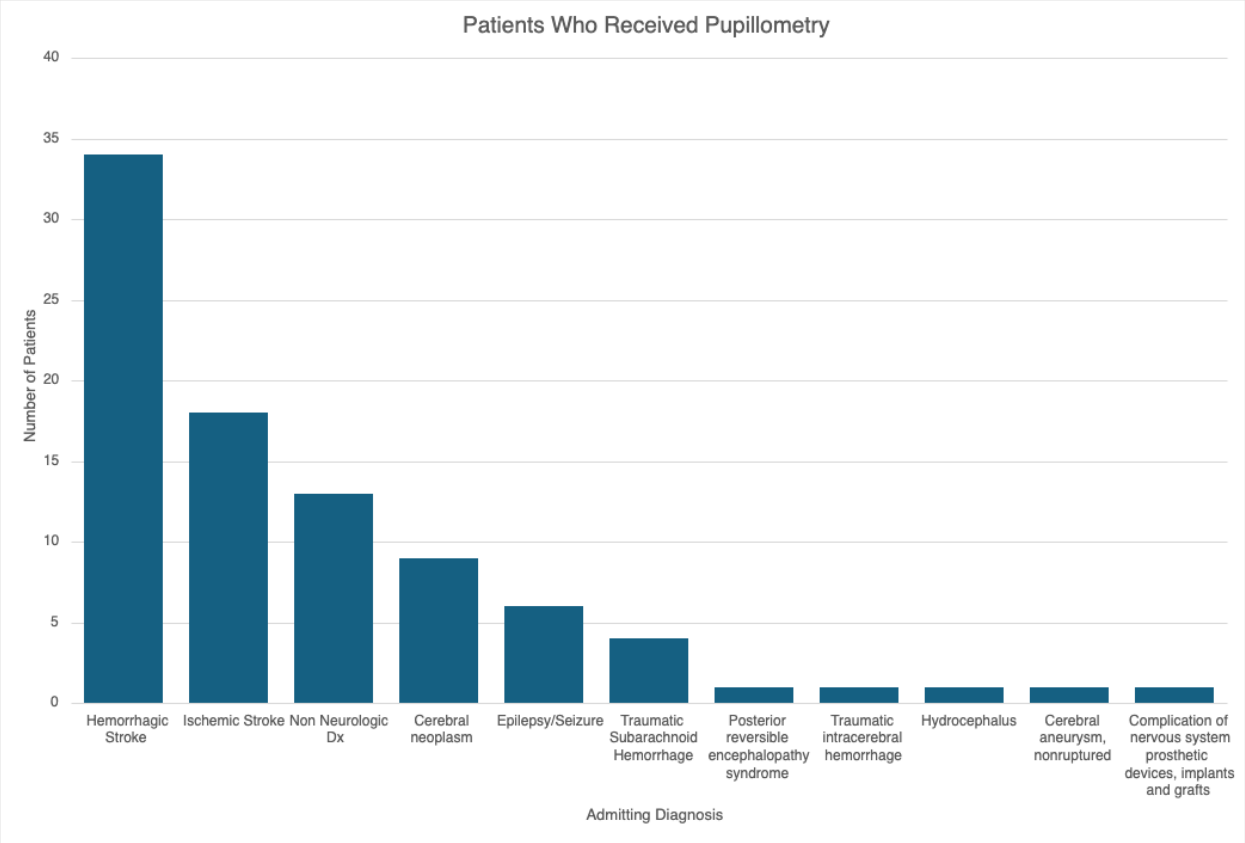


Table A2

Non-neurologic Diagnosis of Patients who Received Pupillometry

Non-Neurologic Diagnosis that Received Pupillometry (n = 13)
Acute lymphoblastic leukemia, in relapse
Acute myeloblastic leukemia, in remission
Cardiac arrest, cause unspecified
COVID-19
Hypo-osmolality and hyponatremia
Miliary tuberculosis, unspecified
Multiple fractures of ribs, right side, initial encounter for closed fracture
Obstruction of bile duct
Organ-limited amyloidosis
Other nondisplaced fracture of sixth cervical vertebra, initial encounter for closed fracture
Poisoning by other opioids, accidental (unintentional), initial encounter
Sepsis, unspecified organism
ST elevation (STEMI) myocardial infarction involving other coronary artery of anterior wall

Note: This figure demonstrates 13 individual admitting diagnosis from 13 individual patients who received pupillometry during their admission

Appendix B

Indications for Pupillometry Use

Figure B1

Indications for Pupillometry Use Amongst Individual Documentations

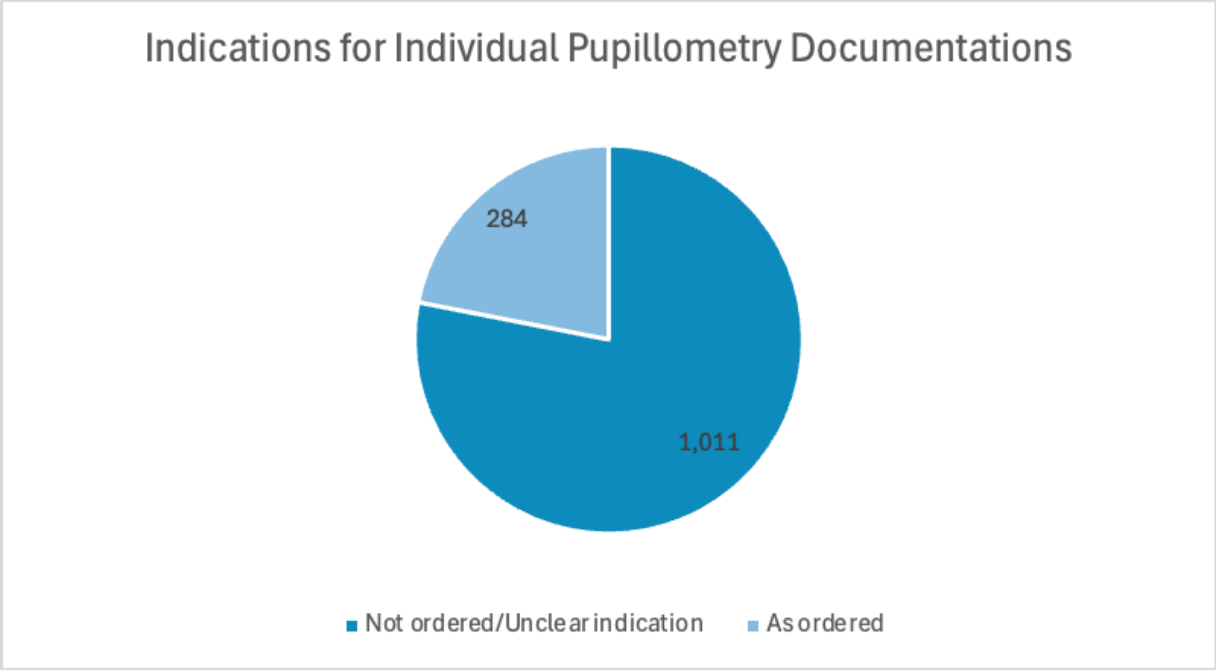
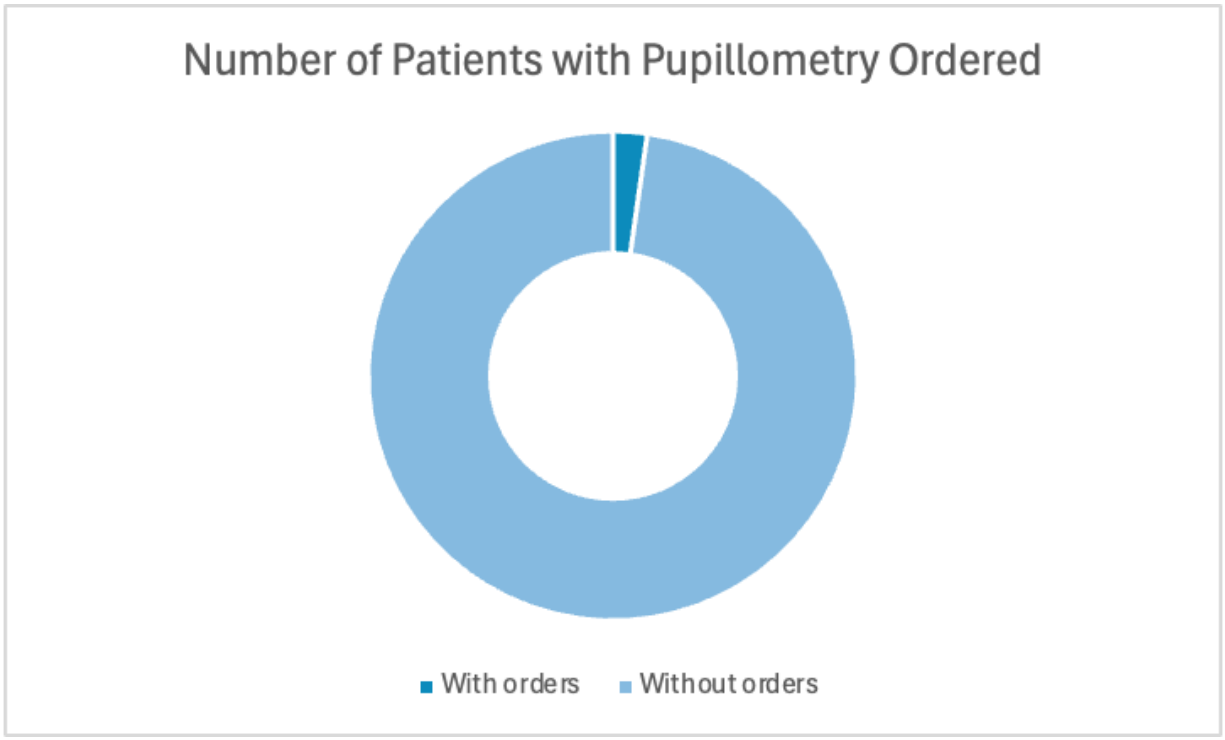


Figure B2

Patients who had Pupillometry Ordered Amongst Patients that Received Pupillometry



Appendix C

Timeframes for Patients Receiving Pupillometry

Patients who Received Pupillometry within 24 hours of Admission