

Implementation of a Pupillometer in a Trauma Admitting Unit

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Abstract

Problem: Traumatic Brain injuries (TBIs) are a significant cause of mortality in the United States. TBIs can cause rapid neurologic deterioration and require frequent neurologic exams with an accurate and consistent pupillary assessment. Manual pupillary exams are subjective, leading to inaccuracy and decreased pupillary assessment confidence among a trauma admitting unit staff.

Purpose: Implement the pupillometer, a device that objectively measures pupil size and reactivity, to measure the pupils of patients with TBIs in a trauma admitting unit of a major academic urban trauma center. **Methods:** Staff was trained on the use and documentation of the pupillometer.

Patients with moderate to severe TBI were assessed using the pupillometer within 1 hour of diagnosis and hourly after that until cleared by a neurosurgeon. Patients who were non-cooperative, had trauma to the eye, or had a history of pupillary dysfunction were excluded.

Results: Patient capture with the pupillometer was 30%, less than the goal of 80%. Of the 30%, 68% were assessed within 1 hour. Staff surveys did not show any statistically significant increase in staff confidence with pupillary assessments. **Conclusions:** Despite not reaching the desired patient capture, the project proved the pupillometer was feasible in the trauma admitting unit's busy environment. This project will help inform future implementations of the pupillometer.

Introduction

Traumatic brain injuries (TBIs) are a significant source of morbidity and mortality in the United States, with approximately 288,000 hospitalizations and 56,800 deaths per year (Centers for Disease Control and Prevention [CDC], 2019). TBIs can cause a rapid deterioration of neurologic function and affect all ages across the lifespan but disproportionately affect the elderly population, who are more susceptible to devastating injuries due to comorbidities and medications (CDC, 2017; Olson & Fishel, 2016). A pupillary assessment tests the function of cranial nerves II and III and is used as a rapid assessment for increased intracranial pressure signifying a worsening TBI and possible need for emergent intervention (McNett et al., 2018). An accurate and consistent pupillary exam is recommended by the Neurocritical Care Societies traumatic brain injury protocol (Zimmerman et al., 2019).

Traditionally, pupillary assessments in the trauma bay are performed manually with the most convenient light source available and are subjective, vary between providers, and often inaccurate (Olson & Fishel, 2016). A survey of nurses in the trauma bay found they feel their exams differ from other providers (48%), and the majority had less than high confidence (70%) in their exams. The trauma admitting unit staff were concerned that inconsistency, inaccuracy, and decreased confidence in pupillary exams degrades the quality of neurologic assessment and could lead to delayed recognition of declining neurologic function.

The purpose of this quality improvement project was to implement the use of a pupil measuring device called a pupillometer in a trauma admitting unit of a large academic hospital. The pupillometer is proven to increase accuracy and reliability, thereby improving pupillary exam quality and staff confidence.

Literature Review

This review will provide a synthesis of the evidence supporting the use of the pupillometer for pupillary exams. This review includes studies that detail the inaccuracy of manual pupillary assessments and studies that support the pupillometer's accuracy, reliability, and use. The quality of the evidence was determined using Fineout-Overholt et al. (2017) level of evidence rating system and Newhouse's (2006) quality of evidence rating system with a summary in tables one and two.

The inaccuracy of manual pupillary assessments was first established by Meeker et al. (2005), who found that the estimation of size had a high rate of error and was the basis for the majority of subsequent studies. In 2016, Olson et al. furthered Meeker et al.'s research by finding a high error rate in estimating pupil size and finding a high amount of disagreement among providers performing manual pupillary assessments. Additionally, Court et al. (2016) found manual pupillary assessments had high rates of error when estimating the pupils reflex to light and the presence of anisocoria. These studies' overall strength was found to be III-B, with consistent results lending strength to their findings. Together these studies confirmed the subjective, inaccurate, and inconsistent nature of manual pupillary assessments.

The pupillometer's accuracy comes from a level 1B systematic review performed by Phillips et al. in 2019. The study found the pupillometer produced precise measurements that could detect subtle changes in pupil size that the manual technique could not replicate. Additionally, these accurate results could be reproduced endlessly without bias from the user, making the pupillometer highly reliable (Phillips et al., 2019). The pupillometer's reliability was also validated by two level-III studies, Couret et al. (2016) and Zhao et al. (2016). Couret et al. (2016) performed a validation study of the pupillometer before their primary study and found high correlation levels between staff using the same handheld device. Zhao et al. (2016)

performed a similar validation study and found high correlations between separate handheld devices operated by different users. While Couret et al. (2016) had a quality level of B and Zhao et al. (2016) had a quality of C, the studies' consistent findings and their correlation with the level IB systematic review gives strength to these findings. This evidence confirms that the pupillometer is an accurate and reliable tool for pupillary assessment.

Theoretical Framework

Lewin's theory of change was developed from Kurt Lewin's field theory (Pratkanis & Turner, 2019). The theory describes how constancy exists in a state of quasi-equilibrium with forces that affect this equilibrium. The three components Lewin identifies to planned change are: unfreeze, change, and re-freeze. In order to unfreeze the equilibrium, an organization must identify the forces that are maintaining the current equilibrium. Once identified, these forces can be altered to allow for change. When change is complete, new forces can be applied to re-freeze the change and cause constancy again (Peterson & Bredow, 2017).

In this project, the resisting forces identified were a lack of a better option when assessing the pupil. Simply introducing the pupillometer was enough to unfreeze the status quo as curiosity and a desire for a better assessment led nurses to use the pupillometer. Once unfrozen, several techniques were used to reinforce and re-freeze the use of the pupillometer as the new status quo. These strategies included accountability, practice champions, reinforcement, and re-education.

Methods

This quality improvement (QI) project took place in the trauma admitting unit of a level I trauma center in a major urban academic medical center. The target population was patients diagnosed with a moderate to severe traumatic brain injury. For this project, the definition of

moderate to severe TBI was simplified to any patient with an intracranial bleed seen on computed tomography scan after an appropriate mechanism for head trauma. Exclusion criteria included patients unable to tolerate assessment with the pupillometer, patients with traumatic eye injury preventing assessment of the affected eye, or a history of a medical condition causing pupillary dysfunction. Once identified, the patient's pupils were measured by the nurse within 1 hour of diagnosis and then hourly after that as part of the nurse's hourly neurologic assessment (appendix A). These assessments continued until deemed no longer necessary by the neurosurgeon.

The pupillometer was implemented over several weeks utilizing several educational techniques. The nursing staff was introduced to the pupillometer by PowerPoint presentation (Appendix B) at a staff meeting held virtually over Zoom. Next, an educational bulletin board was constructed in the unit's break room (appendix C). Finally, one-on-one hands-on training was conducted with each nurse during the pre-shift huddle. This allowed for a return demonstration of the proper use of the pupillometer device. After an unexpected month-long delay in obtaining the pupillometer device, additional educational materials accompanied the pupillometer after it was implemented on the unit (Appendix D).

Outcomes of the project were measured in several different ways. First, nursing staff confidence in their pupillary assessments was measured using a Likert-style survey before and after implementing the pupillometer. This survey was completed anonymously with an easy-to-access online platform (Appendix E). Staff confidence was assessed since nursing staff's perception of the device was key in achieving sustainability. If the staff had more confidence in their exam, then they would be more likely to use the device.

Next, chart reviews were conducted to track nursing staff compliance with documentation. This measurement was used to reflect the nursing staff using the device for their pupillary assessments (Appendix F). These measurements were plotted using run charts to look for trends and inform the investigator if changes were needed to the project.

Finally, overall patient capture was calculated from the chart audits to see if all patients meeting inclusion criteria were being assessed with the pupillometer. This was important as increased capture directly correlates with increased quality of care. This is assumed since the pupillometer is proven to be more accurate and consistent, allowing for a more detailed neurologic exam as recommended by the Neurocritical Care Societies' guidelines on TBI care (Zimmermann et al., 2019). Since it is impossible to isolate the pupillometer's effects on patient outcomes, increased quality of care was used as a secondary outcome measurement.

Results

A total of 104 moderate to severe TBI's were seen during the project's time frame. Results of the chart audit reveal 30% of eligible patients were assessed with the pupillometer. Of the patients assessed with the pupillometer, 68% were assessed in the first hour with an average hourly documentation of 22%. The run chart (appendix G) was very revealing as it showed an initial slow start after a 7-week delay in implementation. This delay was due to the manufacturer stopping trials of its device when the COVID pandemic started. Instead of having multiple devices as initially planned, the project had one device seven weeks after the nursing staff was trained and educated. Once identified, reminder emails, in-person follow up, re-education, and re-training was implemented with increasing usage. However, patient capture never reached the goal of 80%. One of the biggest barriers staff reported was remembering to use the device. This is likely due to the delay in implementation, among other things discussed further in the

discussion. The low documentation seen was caused by the device being used for several hours before prematurely being stopped before neurosurgery cleared the patient from hourly neurologic checks. Charting requirements were reduced from 7 measurements per eye to 2 measurements per with improvement seen with this change and reinforcement. The promising result was the 68% of patients assessed with the pupillometer being assessed with 1 hour of identifying the TBI. This suggests the pupillometer is feasible in a busy trauma bay, and requiring its use within the first hour was not too much of a burden for staff to accomplish.

A total of 56 surveys were completed, 27 pre-implementation and 29 post-implementations. Survey results were analyzed using Chi-square and Fisher exact test. No significant difference was seen in pre-implementation confidence (89%) and post-implementation confidence (75%, $p=0.2992$). however, the survey was limited since patient capture was low and not all of the nursing staff who took the survey used the pupillometer. Subjectively comments from the nursing staff were positive. They reported how easy the device was to use, finding it very useful for when the patient had small or large pupils, and asking for the device once the project was complete.

Discussion

QI projects often face unanticipated and unpredictable challenges that must be adapted to in order to be successful. For this project, the COVID-19 pandemic was a challenge that changed every aspect of this project from education to implementation, to the dissemination of results. One of the significant barriers the pandemic caused was the unexpected delay in implementation that contributed to the project's slow start and low patient capture. Staff reported a hard time remembering to use the device, and the delay between training and when the device was finally implemented on the unit likely contributed to this.

Another barrier caused by the pandemic was staff fatigue and burnout to practice change. Throughout the pandemic, every aspect of nursing care was in fluctuation, causing almost daily change to the way nurses functioned. This constant change in practice caused the nurse to become burned out and fatigued, leading to a noticeable resistance to the device's training and education. This also contributed to nurses having difficulty remembering to use the device as they were simultaneously attempting to keep up with the other practice changes of the day, such as a new COVID testing policy or a change to donning and doffing procedures. Frequent reminders, using the charge nurses as practice champions, and positive reinforcement helped counteract this fatigue.

This study was limited by the short implementation time and low patient capture. This limitation led to a limited staff survey that was likely biased since not all responders had used the device. Despite those limitations and despite not reaching the desired outcomes, the project was successful because it proved the pupillometer was feasible in the busy and chaotic environment of the trauma bay. This is significant if the inpatient floors also utilize the pupillometer device. With all units using the device, accurate pupillary measurements can be trended from diagnosis in the trauma bay into the ICU or intermediate care unit once they become admitted. Healthcare providers no longer need to question whether the difference in their results is due to a subjective error. Minor changes will be more easily identifiable, allowing for better quality care of TBI patients throughout the hospital. This study also greatly informs future implementation projects of the pupillometer.

Conclusions

Implemented during an unprecedented time, this project faced many barriers. While the desired outcomes were not reached, this project successfully demonstrated that the pupillometer

is a feasible and reliable tool in the trauma admitting unit's fast-paced and chaotic environment. This will be vital in bringing objectivity to the pupillary assessment allowing for the trending of pupil size and reactivity between different providers or different inpatient units as the patient progresses through care. This will allow for a quality of care not achievable with manual pupillary assessments.

While this project was limited in timeframe, it will inform future implementations of the pupillometer, allowing them to anticipate and overcome known barriers. Suggestions for future implementations include delaying the pupillometer's use until a TBI is diagnosed, having multiple devices on the unit, decreasing documentation requirements to two items per eye, and building the documentation into the unit's specific flowsheet. These changes, along with audits and reinforcement, will ensure sustainability for future projects.

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Zimmermann, L. L., Tran, D. S., Lovett, M. E., & Mangat, H. S. (2019). Emergency neurological life support traumatic brain injury protocol version 4.0. *Neurocritical Care Society*, 1-33. <https://enls.neurocriticalcare.org/protocols>.

Table 1.
Evidence Review Table

Citation: Courlet, D., Boumaza, D., Grisotto, C., Triglia, T., Pellegrini, L., Ocquidant, P., ... Velly, L. J. (2016). reliability of standard pupillometry practice in neurocritical care: an observational, double-blinded study. Critical Care, 20(99). https://doi.org/10.1186/s13054-016-1239-z					Level: III
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
<p>Validation study: Determine the inter-observer agreement of the Neurolight algiscan pupillometer.</p> <p>Main study: "The objective of this ... study was to compare the efficacy of standard versus automated pupillary measurements for pupil size evaluation, anisocoria detection, and PLR in brain-injured patients."</p>	<p>Validation study: Quasi-experimental double-blinded study</p> <p>Main study: Observational prospective, double-blinded study</p>	<p>Sampling technique: Purposeful (both studies)</p> <p>Eligible:</p> <p>Validation study: healthy volunteers.</p> <p>Main study: "Patients 18 years old admitted to the NCCU within 48 hours of an acute brain injury (head trauma, subarachnoid hemorrhage, stroke, neurosurgical complications after surgery, medical intracranial hypertension)"</p> <p>Excluded:</p> <p>Validation study: history of intracranial or ophthalmological disease.</p> <p>Main study: Patients with direct eye injury, irreversible signs of coma, medical history of cataract, iris surgery, blindness, or third intracranial nerve damage</p> <p>Accepted:</p> <p>Validation study: 200 volunteers</p> <p>Main study: 59 patients</p> <p>Power analysis: None stated (both studies)</p>	<p>Validation Study: Healthy volunteers had their pupils measured by an attending physician and then by a resident physician with a small rest between measurements to allow for stabilization of pupil size.</p> <p>Main study: Two sets of measurements were performed. The first by the primary RN caring for the patient with a penlight and pupil size chart. The second by a trained physician with the pupillometer.</p> <p>Intervention fidelity: Both tests were performed within 5 minutes of each other with a resting "stabilization period" in between. Each assessor was blinded to the others results.</p>	<p>Validation Study: Data was collected on the maximum pupil size obtained prior to exposure to light and the minimum pupil size obtained after exposure to light.</p> <p>Main Study: Data was collected on pupil size in mm, anisocoria as absent or present (present if ≥ 1mm difference), and PLR as absent or present (present if $>15\%$ change in size).</p> <p>Data Collection: Categorical values were compared with a chi-square test or fisher's exact test. continuous values were assessed with t-test if normally distributed and Mann-Whitney U test if not. intraclass correlation of the validation study was assessed using the Wilcoxon signed-rank test. other correlations were assessed with Spearman's Rho test.</p>	<p>Validation Study: Minimal difference in size measurement between providers. Overall correlation between pupil size measurement was very high at 0.95(95% CI: 0.93-0.97)</p> <p>Main Study: There was poor correlation between standard and automated pupil size measurements for pupil between 2-4mm. The manual assessment missed 50% of anisocoria and falsely detected 16 episodes of anisocoria. there was a high error rate of 18% in determining the PLR.</p>

Citation: Phillips, S. S., Mueller, C. M., Nogueira, R. G., & Khalifa, Y. M. (2019). A Systematic Review Assessing the Current State of Automated Pupillometry in the Neuro ICU. <i>Neurocritical Care</i> , 31(1), 142–161. https://doi.org/10.1007/s12028-018-0645-2					Level: I
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
"We aim to assess the specific outcomes associated with the use of automated quantitative pupillometry in neuromonitoring of critically ill patients with neurological impairment ... examine specific outcomes associated with the use of automated pupillometers ... and assess potential limitations to wider adoption of the automated pupillometry technology."	Systematic Review	<p><u>Sampling Technique:</u> Following PRISMA guidelines a literature search was performed using PubMed, MEDLINE, and EMBASE with the search terms "pupillometry" along with a combination of several other critical care terms.</p> <p><u>Eligible:</u> Original studies with human subjects reporting on specific outcomes associated with pupillometry that were in English and had 15 or more subjects</p> <p><u>Excluded:</u> Case reports and case series.</p> <p><u>Accepted:</u> 30 records (22 articles and 8 abstracts) were included out of the 135 records originally identified.</p>	All studies were reviewed by two reviewers with data extraction preformed independently. Quality was assessed using the GRADE approach.	<p><u>Primary outcomes:</u> 1) Precision, reliability, and reproducibility as compared to manual assessment. 2) Ability to detect subtle changes in pupillary exam, detect changes that indicate a rise in ICP, and detect level of analgesia. 3) Ability to serve as a prognostic indicator and severity indicator</p> <p><u>Secondary outcomes:</u> 1) Impact on clinical outcomes. 2) Influence of cost, environmental factors, and presence of medical comorbidities on use of pupillometer.</p>	<p><u>Primary:</u> 1) Pupillometer greatly increased precision, reliability, and reproducibility of pupillary exams. 2) Pupillometry is able to detect subtle changes in pupillary exam, can detect changes indicating a rise in ICP, and can show level of deep versus light sedation with correlation through the PLR. 3) Pupillometer can be used as a tool for prognostic and severity indicator for post-cardiac arrest and SAH patients as PLR is associated with 90-day mortality and severity of injury.</p> <p><u>Secondary:</u> 1) Lack of high-quality research regarding impact on clinical outcomes. more research is needed. 2) initial cost can be a barrier. Ambient light can affect results. Standardized lighting should be established. Comorbidities of the eye and sporadic movement can affect results.</p>

Citation: Olson, D., Stutzman, S., Saju, C., Wilson, M., Zhao, W., & Aiyagari, V. (2016). Interrater Reliability of Pupillary Assessments. <i>Neurocritical Care</i> , 24(2), 251–257. https://doi.org/10.1007/s12028-015-0182-1					Level: III
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
"This study fills an important gap by examining the interrater reliability of subjective pupillary assessments in a diverse group of practitioners, and the comparison between subjective and objective pupillary assessments."	Quasi-experimental observational prospective, double-blinded study	<p><u>Sampling technique:</u> Convenient: whoever was available at the time of consent.</p> <p><u>Eligible:</u> Patients with neurological or neurosurgical diagnosis with orders for serial pupil exams. MDs and RNs who routinely perform pupil assessment in the neuroscience department.</p> <p><u>Excluded:</u> None stated</p> <p><u>Accepted:</u> 127 patients with 1166 observations</p> <p><u>Power analysis:</u> 1163 observations</p>	<p><u>Intervention:</u> Manual pupil exams (size, shape, and reactivity) were performed by two practitioners separately using a light source they would normally use when assessing pupils.</p> <p><u>Control:</u> Pupillary measurements (size, shape and reactivity) were taken by the researcher using a pupillometer in research mode (no data displayed on the screen).</p> <p><u>Treatment fidelity:</u> Ambient lighting was kept the same for all three exams. All exams were done separate but within 5 minutes of each other. Practitioners were blinded to each other's results and everyone was blinded to the results of the pupillometer.</p>	<p><u>Dependent variable:</u> Agreement between providers was defined as difference in pupil size <1mm between measurements and dichotomized as ≤ 3mm and >3mm, having the same shape and having the same reactivity.</p> <p><u>Measures:</u> Agreement between providers was measured using Cohen's Kappa coefficient with 0-0.2 as slight, 0.21-0.4 as fair, 0.61-0.8 as substantial, and 0.81-1 as perfect agreement. agreement between manual exam and pupillometer exam was measured with Bland-Altman plots with regression lines to look for bias.</p>	<p><u>Size and shape:</u> There was moderate ($k=0.54$) agreement between providers on size with only fair agreement between providers and device. There was moderate agreement between providers on anisocoria and shape ($k=0.6$ & $k=0.62$)</p> <p><u>Reactivity:</u> Overall there was moderate ($K=0.64$) agreement between providers on reactivity and moderate to fair agreement between provider and device ($k=0.52$ & $K=0.4$). when isolated for nonreactive, provider agreement was fair. When compared with the device assessment of nonreactive, providers over-assessed nonreactivity by 16.4%.</p> <p>Providers had only fair to moderate agreement in their manual assessments of pupils and over-assessed pupil nonreactivity.</p>

Citation: Zhao, W., Stutzman, S., Olson, D., Saju, C., Wilson, M., & Aiyagari, V. (2016). Inter-device reliability of the NPi-100 pupillometer. <i>Journal of Clinical Neuroscience</i> , 33, 79–82. https://doi.org/10.1016/j.jocn.2016.01.039					Level: III
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
"The Purpose of this prospective study is to explore the inter-rater reliability of different [same brand but different device] pupillometers when operated by different users."	Quasi-experimental observational prospective, blinded.	<p><u>Sampling technique:</u> Convenient sampling</p> <p><u>Eligible:</u> Patients on the Neurocritical, Acute stroke, and surgical ICU with a neurological or Neurosurgical diagnosis. Assessors were medical students, neuroscience RNs, NPs, resident MDs, Fellow MDs, and Attending MDs of the above ICUs.</p> <p><u>Excluded:</u> None stated</p> <p><u>Accepted:</u> 20 patients with 210 paired pupillometer measurements.</p> <p><u>Power analysis:</u> None performed</p>	<p><u>Intervention:</u> Staff who normally provided care for the patient performed assessment using pupillometer. A second measurement is performed by separate staff member with a separate pupillometer.</p> <p><u>Treatment fidelity:</u> All measurements are done within 5 minutes of each other. The pupillometer is set to research mode which does not display results blinding staff to results. all staff received a 5-minute education session on proper use of the pupillometer and demonstrate competency prior to the study.</p>	<p><u>Dependent variables:</u> Pupil size and NPI, a reflection of reactivity, were used to compared inter-rater reliability between devices. Pupil size was rounded to the nearest whole number and treated as a continuous variable. NPI was dichotomized to ≥ 3 and < 3 and treated as nominal data.</p> <p><u>Measures:</u> Mean pupil size and NPI was compared using an un-named statistical analysis to form a p-value. results were also assessed using Cohen's Kappa to assess for agreement.</p>	<p>No statistical difference was found between the mean values of device 1 and device 2. Agreement between size and reactivity was almost perfect ($k=0.91-0.97$)</p> <p>The pupillometer had high inter-rater reliability between devices and users.</p>

Citation: Meeker, M., Du, R., Bacchetti, P., Privitera, C., Larson, M., Holland, M., & Manley, G. (2005). Pupil examination: validity and clinical utility of an automated pupillometer. <i>Journal of Neuroscience Nursing</i> , 37(1), 34 – 40.					Level: III
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
"The Purpose of this study was to test the accuracy and reliability of an automated pupillometer compared with the standard manual examination as a preliminary step in assessing the usefulness of automated pupillometry in critical care setting."	Randomized observational prospective, blinded.	<p><u>Sampling technique:</u> Random convenient</p> <p><u>Eligible:</u> Intensive care unit patients. Assessors were neurosurgical attending, interns, and neuroscience RNs.</p> <p><u>Excluded:</u> Patients with history of ophthalmological disease.</p> <p><u>Accepted:</u> 20 patients 7 assessors</p> <p><u>Power analysis:</u> None performed</p>	<p><u>Control:</u> Pupil size was established with a static pupillometer validated to have a maximum error of 0.1mm prior to intervention.</p> <p><u>Intervention:</u> Assessors performed a manual assessment of size and reactivity followed by measurement with the dynamic pupillometer.</p> <p><u>Treatment fidelity:</u> All measurements were within 5 minutes of each other. ambient was controlled and made constant for all exams. assessors were blinded to manual, static, and dynamic pupillometer results. assessors were trained in the use of the pupillometer and show competence prior to use.</p>	<p><u>Dependent variable:</u> Size measurements were recorded in 0.5mm increments. Error was calculated by comparing measured pupil size to established size by the static pupillometer.</p> <p><u>Measures:</u> Error was calculated by calculating the divergence of the measurement from the established size. This error was then compared using Wilcoxon signed-rank test. Correlations were calculated using Spearman Rho test.</p>	<p><u>Size:</u> Median absolute error for the manual and pupillometer were 0.5mm and 0.23mm respectively. The median error for the manual exam was statistically ($p<0.0001$) greater than the pupillometer.</p> <p><u>Reactivity:</u> The disagreement among manual measurements was statistically ($p<0.0001$) greater than pupillometer.</p> <p>The pupillometer was better at measuring pupil size and reactivity then the manual exam.</p>

Notes: Pupillary light reflex (PLR), Neurocritical care unit (NCCU), Subarachnoid hemorrhage (SAH), Grading of recommendations, assessments, development, and evaluations (GRADE), Medical Doctors (MDs), Registered Nurse (RNs), Preferred reporting items for systemic reviews and meta-analyses (PRISMA), Intracranial pressure (ICP), Intensive care unit (ICU), Nurse Practitioner (NP). Evidence level based on: Fineout-Overholt, E., Cleary-Holdforth, J., Lake, P., Magers, T., & O'Mathuna, D. (2017). The Evidence-Based Competencies Related to Critical Appraisal, Evaluation, Synthesis, and Recommendations. In B. Melnyk, L. Gallagher-Ford, & E. Fineout-Overholt (Eds.), *Implementing the Evidence-Based Practice (EBP) Competencies in Healthcare: A Practical Guide for Improving Quality, Safety, and Outcome* (pp. 77–107). Indianapolis, IN.

Table 2.
Synthesis Review Table

Evidence Based Practice Question: Does the use of pupillometers in trauma patients admitted to the Trauma Admitting Unit increase the accuracy and reliability of pupillary assessments as compared to manual pupillary assessments.			
Level of Evidence	# of Studies	Summary of findings	Overall Quality
I	1	Phillips et al. (2019) found the pupillometer increased precision, reliability and reproducibility of pupillary exams in the hospital setting. With this increase in accuracy the pupillometer was shown to be effective in detecting subtle pupillary changes indicative of increasing ICP and could be used as a prognostic and severity tool. However, there is still a lack of evidence regarding the impact on clinical outcomes and more research is needed on outcomes and limitations of the device.	B - While the systematic review had a large number of articles (30) and employed PRISMA and GRADE review techniques, the majority of the research was from level III studies with grade B or lower quality. No Grade A quality research or RCTs were available for review. Despite the reduced level and quality of the individual research, the large number of studies had consistent results lending power to the final conclusions.

<p>III</p>	<p>4</p>	<p>Meecker et al. (2005) originally established the high error rate of manual pupillary assessments and the increased accuracy of pupillometers. This study was used as the basis for the majority of subsequent studies.</p> <p>Court et al. (2016) and Olson et al. (2016) established the high disagreement between providers performing manual exams, the general inaccuracy of manual exams, and found increased accuracy with the use of the pupillometer.</p> <p>Court et al. (2016) and Zhao et al. (2016) both established the reliability of the pupillometer and its consistency between users.</p>	<p>B - Meecker et al. (2005) was the only study to randomize selection of their participants, and the study had a thorough explanation of statistical analysis that lent the study strength. However, they had a small sample size and were not able to control all variables limiting the quality of the overall study.</p> <p>B - Court et al. (2016) and Olson et al. (2016) had larger sample sizes with appropriate design and statistical analysis. However, the lack of randomization and the inability to control all aspects of the study lowering the strength of these studies.</p> <p>C - Zhao et al. (2016) lacked randomization, had a small sample size, and the explanation of statistical analysis was lacking important information all lowering the grade of this study.</p>
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Notes: Evidence grading based on Newhouse, R. (2006). Examining the source for evidence-based nursing practice. JONA. Volume 36, Number 7/8, pp 337-340

Appendix A
New Process Map

New Process

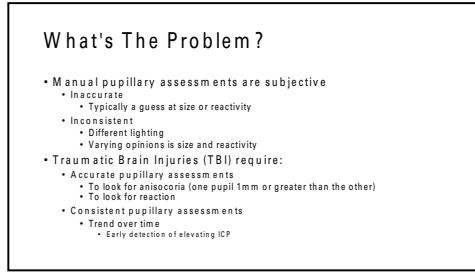


Appendix B
Staff Education Project

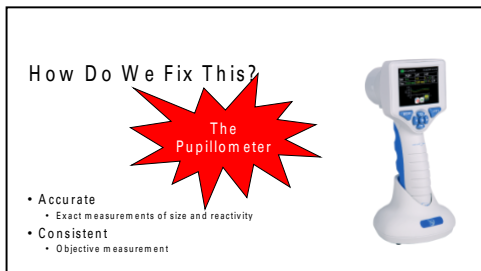
11/2/20



1



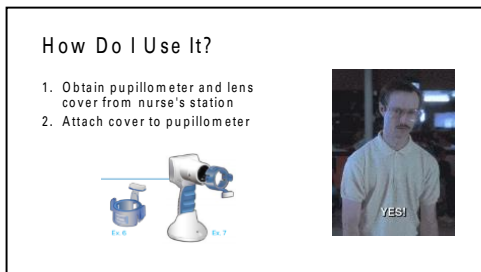
2



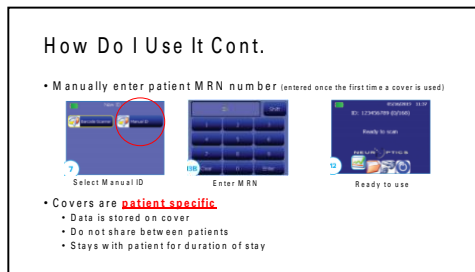
3



4



5



6

11/2/20

How Do I Use It Cont.
Measuring pupils:

- Ensure cover is on
- Ensure device is on
- Align device with eye

7

How Do I Use It Cont.
Measuring pupils:

- Hold corresponding button:
 - "RIGHT" button for right eye
 - "LEFT" button for left eye

8

How Do I Use It Cont.
Measuring pupils:

- A video of the eye will appear on the screen
- Align pupil with circle
- When circle turns green – release button
- Pupillometer will automatically measure pupil
- Repeat for other eye

9

What Do I Document?

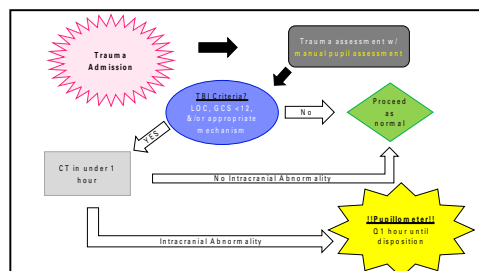
- TRU Head to Toe Assessment - Add Rows - Pupillometer
- Npi: Neurologic pupil index
- Pupil size
 - Max / Min
- % pupil change
- Constriction velocity
 - Millimeter/Second

10

When Do I Use It?

- With Moderate to Severe TBI's
- Inclusion Criteria:
 - Confirmed intracranial abnormality on CT scan
 - Intracranial bleed (SDH, SAH, EDH, IPH)
 - DAI
 - Pretty much anyone you consult Neurosurgery for (that is not a spine).
- Exclusion Criteria:
 - Anyone you cannot obtain a pupil exam on
 - Severe eye trauma inhibiting eye exam
 - Hx of eye condition with non-reactive pupil (severe Glaucoma, cataract, artificial eye)
 - Uncooperative

11




12

11/2/20

How Often Do I Use It?


1. Within 1 hour of confirming intracranial abnormality
2. Every hour as part of the hourly neurologic exam
 - Continue until patient is dispositioned
 - Sent to the floor
 - Discharged
 - No longer needs Q1 hour neuro checks

A meme featuring a woman in a blue jacket pointing upwards with the text "COOL BEANS!" overlaid.

13

When Do I Notify Neurosurgery

- Anisocoria: Unequal pupils
 - One pupil >1mm the other pupil
- Non-reactive
 - Npi 0-1
- RN judgement
 - Unexplained pupillary changes

A meme featuring a man in a red shirt talking on a phone with the text "Why are you not answering" overlaid.

14

Project Timeline

A project timeline diagram with three horizontal bars connected by downward arrows. The top bar is blue and labeled "Training: August 31st". The middle bar is purple and labeled "Start: Once Everyone is Trained". The bottom bar is pink and labeled "End: December 19th".

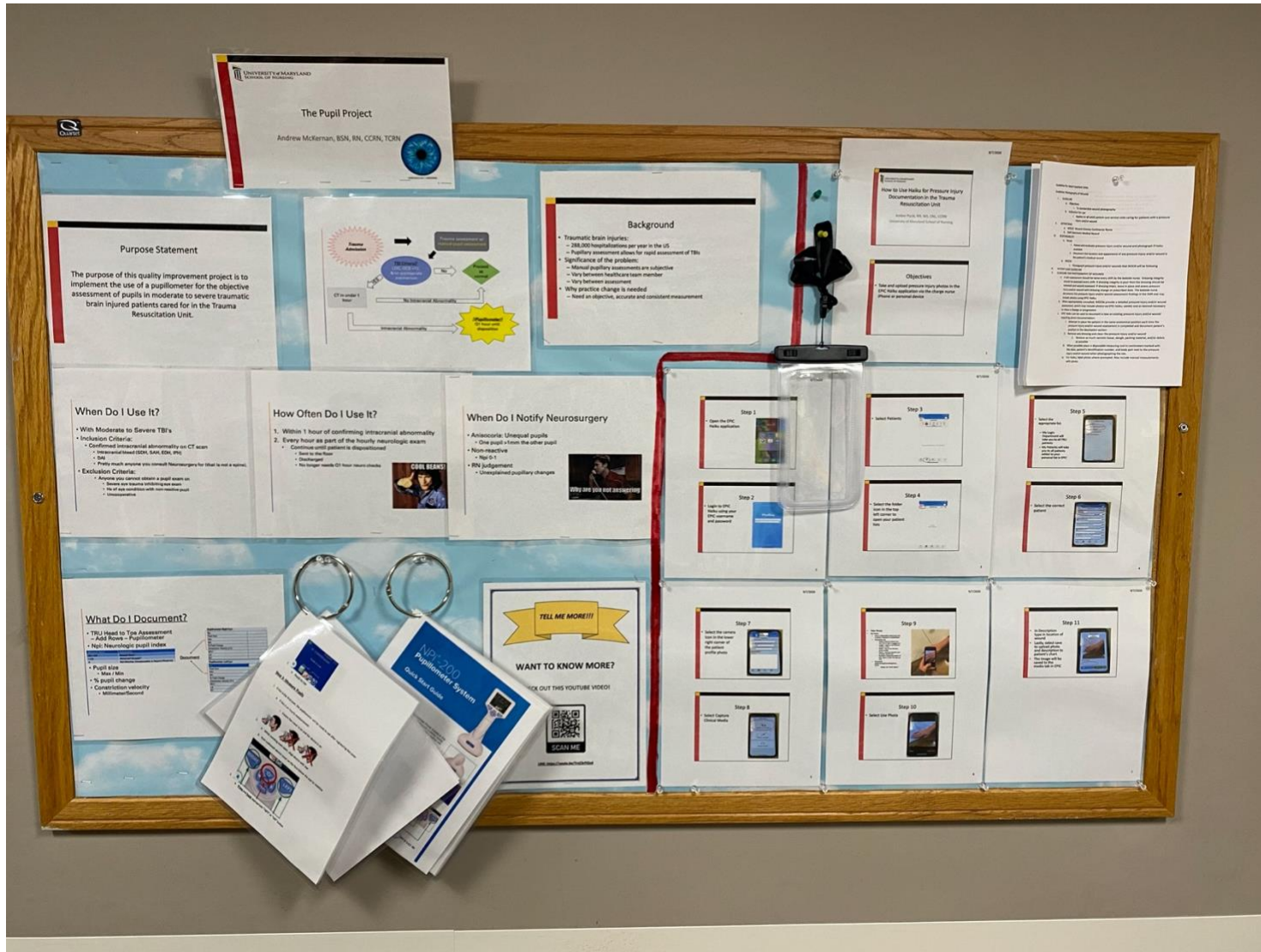
Training: August 31st

Start: Once Everyone is Trained

End: December 19th

15

Appendix C
Educational Bulletin Board



Appendix D
 Additional Educational Materials

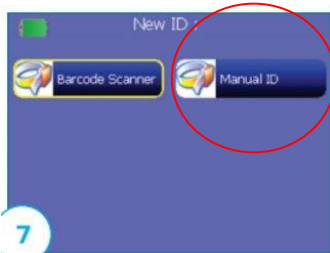
Step 1: Obtain pupillometer and cover

Located at the nurses' station. Please place a patient sticker on the form when obtaining a cover (Helps with chart reviews)

Step 2: Program Cover with Patient data



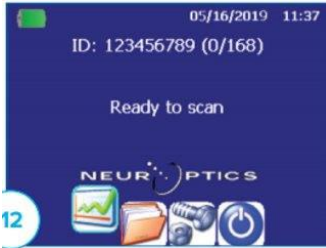
1.
 - a. Place cover over lens of pupillometer until it clicks
2. Screen will turn on
 - a. If not press power button



3.
 - a. Select manual entry



4.
 - a. Enter MRN



- 5.
 - a. Ready to Use

Step 3: Measure Pupils

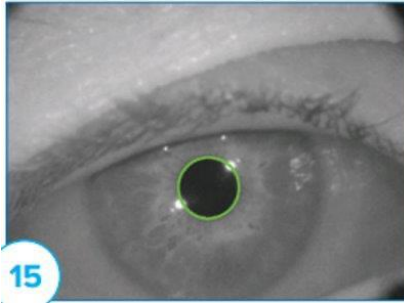
- 1. If this is the first scan, the pupillometer will be ready to use after registering the cover
 - a. If this is an hourly measurement:
 - i. Ensure the cover is on and the device is on



- 2.
 - a. While assisting eyes open, align device with eye
 - b. Rest cushioned device cover on the face below the eye to stabilize



- 3.
 - a. Press and hold appropriate "right" or "left" button



4.
 - a. With the video screen align pupil with circle
 - b. Once aligned **Release** the Button and the measurement will be taken automatically

Step 4: Interpret and Document



1.
 - a. Results will display automatically (screen 17) when measurements are taken
 - b. Select 1/2 to see extended results view (screen 18)
2. Look for and report:
 - a. One pupil ≥ 1 mm than the other
 - b. NPI less than 1

Appendix E

Staff Surveys

Pre-implementation Staff Survey					
Question #	Always/Extremely confident	Usually/Very Confident	Sometimes/Somewhat confident	Rarely/Not so confident	Never/Not at all confident
Q1: How often do you measure pupillary size with a pupil size chart?					
Q2: During the primary trauma assessment, how often do you feel like your pupillary assessment is rushed?					

<p>Q3: While performing a primary trauma assessment, how often does your assessment of pupillary size differ from others?</p>					
<p>Q4: While performing a primary trauma assessment, how often does your assessment of pupillary reactivity differ from others?</p>					
<p>Q5: How confident are you in your assessment of pupillary size and reactivity?</p>					

Q6: How confident are you in assessing anisocoria (a condition characterized by an unequal size of the eyes' pupils)?					
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Comments

Post-implementation Staff Survey

Question #	Always/Extremely confident	Usually / Very Confident	Sometimes/Somewhat confident	Rarely / Not so confident	Never / Not at all confident
Q1: How often do you use the pupillometer within 1 hour of admission of moderate to severe TBIs?					
Q2: How often do you use the pupillometer every hour for hourly neurologic assessments?					
Q3: How confident are you in assessing pupillary size and reactivity with the pupillometer?					
Q4: How confident are you in assessing anisocoria (a condition characterized by an unequal size of the eyes' pupils) with the pupillometer?					

Comments

Appendix G
Run chart

