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Automated quantitative pupillometry for the prognostication of coma after cardiac arrest.

Suys T, Bouzat P, Marques-Vidal P, Sala N, Payen JF, Rossetti AO, Oddo M.

Abstract

BACKGROUND:
Sedation and therapeutic hypothermia (TH) delay neurological responses and might reduce the accuracy of clinical examination to predict outcome after cardiac arrest (CA). We examined the accuracy of quantitative pupillary light reactivity (PLR), using an automated infrared pupillometry, to predict outcome of post-CA coma in comparison to standard PLR, EEG, and somato-sensory evoked potentials (SSEP).

METHODS:
We prospectively studied over a 1-year period (June 2012-June 2013) 50 consecutive comatose CA patients treated with TH (33°C, 24 h). Quantitative PLR (expressed as the % of pupillary response to a calibrated light stimulus) and standard PLR were measured at day 1 (TH and sedation; on average 16 h after CA) and day 2 (normothermia, off sedation: on average 46 h after CA). Neurological outcome was assessed at 90 days with Cerebral Performance Categories (CPC), dichotomized as good (CPC 1-2) versus poor (CPC 3-5). Predictive performance was analyzed using area under the ROC curves (AUC).

RESULTS:
Patients with good outcome [n = 23 (46 %)] had higher quantitative PLR than those with poor outcome [n = 27; 16 (range 9-23) vs. 10 (1-30) % at day 1, and 20 (13-39) vs. 11 (1-55) % at day 2, both $p < 0.001$]. Best cut-off for outcome prediction of quantitative PLR was <13 %. The AUC to predict poor outcome was higher for quantitative than for standard PLR at both time points (day 1, 0.79 vs. 0.56, $p = 0.005$; day 2, 0.81 vs. 0.64, $p = 0.006$). Prognostic accuracy of quantitative PLR was comparable to that of EEG and SSEP (0.81 vs. 0.80 and 0.73, respectively, both $p > 0.20$).

CONCLUSION:
Quantitative PLR is more accurate than standard PLR in predicting outcome of post-anoxic coma, irrespective of temperature and sedation, and has comparable prognostic accuracy than EEG and SSEP.

https://www.ncbi.nlm.nih.gov/pubmed/24760270

Neurocrit Care. 2014 Oct;21(2):300-8. doi: 10.1007/s12028-014-9981-z.
PMID: 24760270 DOI: 10.1007/s12028-014-9981-z

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Portable infrared pupillometry: a review.

Larson MD, Behrends M.

Abstract

Portable infrared pupillometers provide an objective measure of pupil size and pupillary reflexes, which for most clinicians was previously only a visual impression. But despite the fact that pupillometry can uncover aspects of how the human pupil reacts to drugs and noxious stimulation, the use of pupillometry has not gained widespread use among anesthesiologists and critical care physicians. The present review is an introduction to the physiology of pupillary reflexes and the currently established clinical applications of infrared pupillometry, which will hopefully encourage physicians to use this diagnostic tool in their clinical practice. Portable infrared pupillometry was introduced in 1989. The technology involves flooding the eye with infrared light and then measuring the reflected image on an infrared sensor. Pupil size, along with variables of the pupillary light reflex and pupillary reflex dilation, is calculated by the instrument and displayed on a screen immediately after each time-stamped measurement. Use of these instruments has uncovered aspects of how the human pupil reacts to drugs and noxious stimulation. The primary clinical applications for portable pupillometry have been in the assessment of brainstem function. Portable pupillometry is useful in the management of pain because it allows for assessments of the effect of opioids and in the titration of combined regional-general anesthetics.

Comment in
Portable infrared pupillometry: ready for prime time? [Anesth Analg. 2015]

https://www.ncbi.nlm.nih.gov/pubmed/25988634

Anesth Analg. 2015 Jun;120(6):1242-53. doi: 10.1213/ANE.0000000000000314.
PMID: 25988634 DOI: 10.1213/ANE.0000000000000314

3

Reliability of standard pupillometry practice in neurocritical care: an observational, double-blinded study.

Couret D, Boumaza D, Grisotto C, Triglia T, Pellegrini L, Ocquidant P, Bruder NJ, Velly LJ.

Abstract

BACKGROUND:
In critical care units, pupil examination is an important clinical parameter for patient monitoring. Current practice is to use a penlight to observe the pupillary light reflex. The result seems to be a subjective measurement, with low precision and reproducibility. Several quantitative pupillometer devices are now available, although their use is primarily restricted to the research setting. To assess whether adoption of these technologies would benefit the clinic, we compared automated quantitative pupillometry with the standard clinical pupillary examination currently used for brain-injured patients.

METHODS:
In order to determine inter-observer agreement of the device, we performed repetitive measurements in 200 healthy volunteers ranging in age from 21 to 58 years, providing a total of 400 paired (alternative right eye, left eye) measurements under a wide variety of ambient light condition with NeuroLight Algiscan pupillometer. During another period, we conducted a prospective, observational, double-blinded study in two neurocritical care units. Patients admitted to these units after an acute brain injury were included. Initially, nursing staff measured pupil size, anisocoria and pupillary light reflex. A blinded physician subsequently performed measurement using an automated pupillometer.

RESULTS:
In 200 healthy volunteers, intra-class correlation coefficient for maximum resting pupil size was 0.95 (IC: 0.93-0.97) and for minimum pupil size after light stimulation 0.87 (0.83-0.89). We found only 3-pupil asymmetry (≥ 1 mm) in these volunteers (1.5% of the population) with a clear pupil asymmetry during clinical inspection. The mean pupil light reactivity was 40 ± 7%. In 59 patients, 406 pupillary measurements were prospectively performed. Concordance between measurements for pupil size collected using the pupillometer, versus subjective assessment, was poor (Spearmen's rho = 0.75, IC: 0.70-0.79; P < 0.001). Nursing staff failed to diagnose half of the cases (15/30) of anisocoria detected using the pupillometer device. A global rate of discordance of 18% (72/406) was found between the two techniques when assessing the pupillary light reflex. For measurements with small pupils (diameters <2 mm) the error rate was 39% (24/61).

CONCLUSION:
Standard practice in pupillary monitoring yields inaccurate data. Automated quantitative pupillometry is a more reliable method with which to collect pupillary measurements at the bedside.

KEYWORDS:
Anisocoria; Neurocritical Care; Neurological examination; Pupillary light reflex; Pupillary reactivity; Pupillary size; Pupillometer

https://www.ncbi.nlm.nih.gov/pubmed/27072310

Crit Care. 2016 Mar 13;20:99. doi: 10.1186/s13054-016-1239-z.
PMID: 27072310 PMCID: PMC4828754 DOI: 10.1186/s13054-016-1239-z

4

Quantitative pupillometry and transcranial Doppler measurements in patients treated with hypothermia after cardiac arrest.

Heimburger D, Durand M, Gaide-Chevronnay L, Dessertaine G, Moury PH, Bouzat P, Albaladejo P, Payen JF.

Abstract

BACKGROUND:
Predicting outcome after cardiac arrest (CA) is particularly difficult when therapeutic hypothermia (TH) is used. We investigated the performance of quantitative pupillometry and transcranial Doppler (TCD) in this context.

METHODS:
This prospective observational study included 82 post-CA patients. Quantitative assessment of pupillary light reflex (PLR) and TCD measurements of the two middle cerebral arteries were performed at admission (day 1) and after 24h (day 2) during TH (33-35°C) and sedation. Neurological outcome was assessed at 3 months using cerebral performance category (CPC) scores; patients were classified as having good (CPC 1-2) or poor (CPC 3-5) outcome. Prognostic performance was analyzed using area under the receiver operating characteristic curve (AUC-ROC).

RESULTS:
Patients with good outcome (n=27) had higher PLR amplitude than patients with poor outcome (n=55) both at day 1, 13% (10-18) (median, 25th-75th percentile) vs. 8% (2-11) (P<0.001), and at day 2, 17% (13-20) vs. 8% (5-13) (P<0.001), respectively. The AUC-ROC curves at days 1 and 2 were 0.76 (95% confidence interval [CI] 0.65-0.86) and 0.82 (95% CI 0.73-0.92), respectively. The best cut-off values of PLR amplitude to predict a 3-month poor outcome were <9% and <11%, respectively. A PLR amplitude of <7% at day 2 predicted a 3-month poor outcome with a specificity of 100% (95% CI 86-100) and a sensitivity of 42% (95% CI 28-58). No differences in TCD measurements were found between the two patient groups.

CONCLUSION:
PLR measurements might be informative in the prediction of outcome of post-CA patients even under sedation and hypothermia.

KEYWORDS:
Heart arrest; Hypothermia; Induced; Patient outcome assessment; Pupillary; Reflex; Transcranial Doppler sonography

https://www.ncbi.nlm.nih.gov/pubmed/26970030

Resuscitation. 2016 Jun;103:88-93. doi: 10.1016/j.resuscitation.2016.02.026. Epub 2016 Mar 9.
PMID: 26970030 DOI: 10.1016/j.resuscitation.2016.02.026

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Portable infrared pupillometry in critical care

Merlin D. Larson and Vineeta Singh

Abstract

Infrared pupillometry was introduced in 1962 but portable instruments that use this technology have only recently become available in the hospital setting. Questions surrounding the accuracy of these instruments have been addressed by documenting the inter-observer agreement on pupillary measurements and also by comparisons with standard pen-light examinations. The following commentary summarizes the development of these devices and provides a wider perspective on how the pupil and its reflexes might be used in providing care for patients with critical illness.

BACKGROUND:
Couret et al. [1] recently presented a large observational study comparing automated pupillometry with the standard subjective pupillometry in brain-injured patients. The study confirms previous reports [2, 3] of discordance between these two methods of examining pupillary size, anisocoria, and the pupillary light reflex (PLR). Importantly, the discovery of discrepancy in measurement in both directions as measured by bedside nurses highlights the lack of standardization of this essential examination. As such, there is potential for unnecessary interventions, delays in diagnosis, and adverse clinical outcomes.

When the technique of portable infrared pupillometry was introduced over 25 years ago [4], there was the concern that eye movements of the subject or hand movements of the examiner might introduce artifacts that would falsely mimic a PLR. Modern techniques of tracking the pupil have eliminated this concern. For example, movement of the pupillometer or the target while measuring fixed metal holes will result in scans that are flat because of algorithms embedded in the instrument that maintain a steady image of the aperture. Thus, the attending physician can be assured that changing trends of pupil size and PLR originate from the patient and not from subjective interpretations of the pen-light examination from different examiners, or from noise in the recording device. Confidence in the accuracy of sequential measurements may be a primary reason to use this new technology.

CONCLUSION:
Several authors have stated that therapy has been altered because of pupillary signs detected by portable infrared pupillometry, but whether these measurements improved the clinical outcome has never been evaluated. If there is value to patient outcome by learning about the pupil, then it seems logical to obtain accurate measurements, especially when sequential measurements might indicate an evolving pathologic process that would go undetected by other bedside examinations or with imaging studies. Proof of added value from the use of portable infrared pupillometry may be difficult to demonstrate. As an example, most clinicians recognize the value of the pulse oximeter, but it remains a technology that has never been shown to improve outcome [15]. In the end, the value of any precise measurement depends on the clinician's ability to interpret it. Physicians will eventually have to decide for themselves if precise pupillometry can improve the care of patients with critical illness.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4916536/

Crit Care. 2016; 20: 161.
Published online 2016 Jun 22. doi: 10.1186/s13054-016-1349-7

6

Correlations Between Hourly Pupillometer Readings and Intracranial Pressure Values.

McNett M, Moran C, Janki C, Gianakis A.

Abstract

INTRODUCTION:
Automated pupillometry is emerging as a mainstay in neurocritical care primarily because it overcomes limitations of manual pupillary examinations. Although several recent studies show improved assessment accuracy with a pupillometer, few investigate clinical use, specifically how well parameters correlate with multimodality monitoring and outcomes. The primary aim of this study was to examine correlations between serial pupillometer readings and intracranial pressure (ICP) values among neurocritically ill patients.

DESIGN:
Prospective cohort, repeated measures.

SAMPLE:
The study sample was composed of adult patients with neurological injury who were admitted to intensive care unit, requiring hourly neurological assessment and pupillary checks within a level I trauma, urban, academic medical center.

PROCEDURES:
Hourly pupillometer readings and corresponding ICP values were consecutively recorded for 72 hours after intensive care unit admission.

RESULTS:
Serial assessments resulted in more than 2100 pupillometer readings from 76 subjects. Mean age of the study sample was 55.4 years, with a mean Glasgow Coma Scale score of 8.9. The mean pupillometer values for the enrolled subjects included left constriction velocity of 1.22, left neurological pupil index of 4.21, left pupil size of 2.69, right constriction velocity of 1.18, right neurological pupil index of 4.18, and right pupil size of 2.57. The mean ICP of the study sample was 12, with mean cerebral perfusion pressure of 77. Pupillometer values significantly correlated with ICP values in bivariate ($P < .001$, $r = 0.13-0.23$) and multivariate regression models ($F(6) = 17.63$, $P < .001$).

CONCLUSIONS:
Automated pupillometry in neurocritical care is a valuable adjunct to traditional invasive monitoring. Integration of routine pupillometer assessments not only improves accuracy of examinations but also correlates with ICP values.

https://www.ncbi.nlm.nih.gov/pubmed/28661946

J Neurosci Nurs. 2017 Aug;49(4):229-234. doi: 10.1097/JNN.0000000000000290.
PMID: 28661946 DOI: 10.1097/JNN.0000000000000290

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Consensus summary statement of the International Multidisciplinary Consensus Conference on Multimodality Monitoring in Neurocritical Care : a statement for healthcare professionals from the Neurocritical Care Society and the European Society of Intensive Care Medicine.

Le Roux P, Menon DK, Citerio G, Vespa P, Bader MK, Brophy GM, Diringer MN, Stocchetti N, Videtta W, Armonda R, Badjatia N, Böesel J, Chesnut R, Chou S, Claassen J, Czosnyka M, De Georgia M, Figaji A, Fugate J, Helbok R, Horowitz D, Hutchinson P, Kumar M, McNett M, Miller C, Naidech A, Oddo M, Olson D, O'Phelan K, Provencio JJ, Puppo C, Riker R, Robertson C, Schmidt M, Taccone F; Neurocritical Care Society; European Society of Intensive Care Medicine.

Abstract

Neurocritical care depends, in part, on careful patient monitoring but as yet there are little data on what processes are the most important to monitor, how these should be monitored, and whether monitoring these processes is cost-effective and impacts outcome. At the same time, bioinformatics is a rapidly emerging field in critical care but as yet there is little agreement or standardization on what information is important and how it should be displayed and analyzed. The Neurocritical Care Society in collaboration with the European Society of Intensive Care Medicine, the Society for Critical Care Medicine, and the Latin America Brain Injury Consortium organized an international, multidisciplinary consensus conference to begin to address these needs. International experts from neurosurgery, neurocritical care, neurology, critical care, neuroanesthesiology, nursing, pharmacy, and informatics were recruited on the basis of their research, publication record, and expertise. They undertook a systematic literature review to develop recommendations about specific topics on physiologic processes important to the care of patients with disorders that require neurocritical care. This review does not make recommendations about treatment, imaging, and intraoperative monitoring. A multidisciplinary jury, selected for their expertise in clinical investigation and development of practice guidelines, guided this process. The GRADE system was used to develop recommendations based on literature review, discussion, integrating the literature with the participants' collective experience, and critical review by an impartial jury. Emphasis was placed on the principle that recommendations should be based on both data quality and on trade-offs and translation into clinical practice. Strong consideration was given to providing pragmatic guidance and recommendations for bedside neuromonitoring, even in the absence of high quality data.

https://www.ncbi.nlm.nih.gov/pubmed/25138226

Intensive Care Med. 2014 Sep;40(9):1189-209. doi: 10.1007/s00134-014-3369-6. Epub 2014 Aug 20.
PMID: 25138226 DOI: 10.1007/s00134-014-3369-6

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Ref: CNL-EN-V1 - Revision: 06/2018