University of Cincinnati Medical Center
Clinical Practice Guidelines for Pupillometry

GENERAL INFORMATION

Document Title: Clinical Practice Guidelines for Pupillometry

Purpose: Describe standardized clinical practice for quantitative monitoring of pupillary exam in patients with acute brain injuries.

Objective:

1. Describe pupillometry equipment and procedures for its clinical use.
2. Define expected normal and abnormal value thresholds.

Target Population: Patients with acute brain injuries admitted to the Neuroscience Intensive Care Unit (NSICU) or being cared for by the Neurocritical Care (NCC) service.

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CONTENT OF DOCUMENT

Patients with acute brain injury undergo frequent neurological exams, including clinical examination of the pupillary responses to light. The size and reactivity of pupils on clinical exam demonstrate only moderate inter-rater reliability (Olson 2016). In selected patients, objective and quantitative pupillary assessments may be important to detect early changes in pupillary responses and standardize this important clinical measurement. These guidelines were developed to inform providers about the local standards of care for pupillometry.

RELATED PROTOCOLS

Advanced Neuromonitoring Protocol
Guidelines for the Management of Severe Traumatic Brain Injury

I. Rationale
   a. Patients with mass lesions from trauma, stroke, or tumors may experience elevations in intracranial pressure that may precipitate brain herniation, a potentially fatal progression of these acute brain injuries.
   b. Pupillary size and reactivity changes occur early during central herniation (i.e. herniation of the supratentorial compartment under the tentorium cerebelli)
   c. Serial measurements of the pupil may allow for early detection of increased intracranial pressure or central herniation and thus earlier intervention.
   d. Automated pupillometry provides accurate, reproducible, and quantitative measurements of pupillary size and reactivity using a graded scaled called the Neurological Pupil Index (NPi), which grades pupillary parameters from 0 (nonreactive) to 5 (briskly reactive) (Chen 2011).
      i. Pupillometry is a validated measure of pupillary size and reactivity (Meeker 2005).
      ii. Changes in NPi may precede peak intracranial pressure by up to 16 hours (Chen 2011).
      iii. NPi correlates with Glasgow Coma Scale score in comatose patients following traumatic brain injury (Park 2015).
   e. Automated pupillometry may also be useful in selected patients with dark irises, miotic pupils (e.g. those receiving opiates) in whom pupillary responses may be difficult to evaluate manually.

II. Procedure for Pupillometry at the University of Cincinnati
   a. Patient Selection
      i. Patients in whom Advanced Neuromonitoring is recommended (Levels I-III) should undergo pupillometry q1h as standard-of-care (See Advanced Neuromonitoring Protocol).
      ii. Patients in whom Advanced Neuromonitoring is not recommended or in whom the Attending Physician has chosen to observe with standard ICU monitoring:

1. With mass lesion of any cause at high risk for uncal or central herniation
    a. Focal lesions, e.g. hemispheric stroke or tumor
    b. Global lesions, e.g. hypoxic-ischemic encephalopathy
2. Post-operatively following decompressive craniotomy or craniectomy

iii. Patients in whom RN assessments are complicated by difficult visualization or questions about the nature of the pupillary size or reactivity (RN discretion)

b. Frequency
    i. MD should place an order in EPIC for Pupillometry.
    ii. By default, pupillometry should be performed at the frequency of manual pupillary assessments and replaces the manual pupillary assessments in the documentation flowsheets. In general, this will be q1h.
    iii. Pupillary assessment frequency may be modified by MD.
c. Beginning the Assessment
    i. Pupillometry devices are located in the vicinity of every two-room block within the NSICU.
    ii. Patient-specific SmartGuards (single-use only) should be located within the Clean Utility in the NSICU.
        1. Obtain a new SmartGuard for each new patient.
        2. Keep SmartGuards in the patient's room and place a patient medical record sticker on the plastic SmartGuard to avoid using the SmartGuard on any other patient.
        3. SmartGuards are usable for hourly measurements up to a maximum of 5 days, at which point a new SmartGuard is required.
    iii. Lift the pupilometer from its Charging Cradle and 'snap' the SmartGuard into place:
        1. For new patients, select "Manual ID" and enter the patient's medical record number – this step only needs to be performed once.
        2. For established patients, verify the patient's medical record number by select "Accept".
d. Performing the Assessment
    i. Select eye (right or left) to be scanned and position the pupillometer over this eye. The SmartGuard should be positioned with the foam pad at the patient's cheekbone below the eye.
    ii. Press and hold the corresponding RIGHT or LEFT button until the pupil is centered on the screen and the display shows a green circle around the pupil.
    iii. Once the green circle appears, release the button and hold the pupillometer in place for approximately 3 seconds until the data is displayed on the screen.
    iv. Once the measurement is complete, a message will appear on the bottom of the screen. At this point the device can be removed from the eye area.
        1. If the screen reads "Rescan", there was an issue with the reading; repeat the measurement for the appropriate eye.
        2. In case of a non-responsive pupil, the device will prompt the user to repeat the measurement for confirmation before reporting the results on the touchscreen.
    v. Repeat the same procedure for the patient's other eye to complete the bilateral pupil exam.

vi. When the bilateral pupil exam is complete, the measurement results will be displayed in green for the right eye and yellow for the left eye. The difference between right and left eye values will also be shown on Page 1 (**Figure 1**).
    1. If too much time has elapsed between the analysis of the right eye and left eye, then the values will not appear on the same screen.
vii. The bedside RN will document the NPi and Pupil Size for the left and right pupil on the Complex Vital Signs Flowsheet in Epic.

NPi®-200 Pupillometer: Results Page 1

Figure 1

e. Trending Assessments on the Pupillometer
    i. From the main screen of the pupillometer, use either the keypad or the touchscreen to select the Chart icon.
    ii. To trend additional parameters, go to the Settings menu, select Trending Var., and select the desired parameters to trend and display as a graph.
    iii. After additional parameters are selected, they may be viewed by clicking on the Chart icon and using the Left and Right arrow keys.
f. Watching the Playback on the Pupillometer
    i. From the Results screen, select the Video icon to view the video playback.
    ii. Only the last measurement can be replayed, and once the device has been turned off, the last video is not accessible.
g. Getting Back to the Main Menu
    i. Press the RIGHT or LEFT key and the main screen will appear.
    ii. You may use the arrow keys to navigate the icons on the screen and press the center key to select an icon, or use the touchscreen.
h. Completing the Assessment
    i. When done, remove the SmartGuard and leave it at the patient's bedside.
    ii. Place the pupillometer firmly in the charger. A lightning bolt will appear in the upper right screen, meaning the pupillometer is charging.
i. Discontinuing Pupillometry
    i. When a patient is discharged or the EPIC order for pupillometry has been discontinued, patient-specific data must be deleted from the SmartGuard prior to its disposal.
        1. To delete patient-specific data, go to the Settings menu, select Delete Rec.w/ID, and select the patient's MRN.
        2. Select Yes to confirm deletion of the patient's records.
    ii. After this data is wiped, the SmartGuard may be disposed of in the trash.

III. Interpretation of Pupillometry Data

a. The following are normal and threshold values (**Table**):

Table: Normal and Abnormal Pupillometry Values

Value	Definition	Normal	Abnormal
NPi (Neurological Pupil Index)	Numeric score derived from the size, constriction velocity, percentage change, and minimum diameter of the pupil.	≥3 (values closer to 5 are consider more "brisk" than those closer to 3)	• < 3 • Decrease of ≥0.7 or more in one or both eyes • Difference of ≥0.7 between sides
Size (Maximum Diameter)	Maximum pupil size prior to measurement	Equal between right and left	> 1 mm between sides
Size (Minimum Diameter)	Pupil diameter at peak constriction		

b. The following values should be immediately reported to Neurosurgery or Neurocritical Care:

i. Any *new* NPi value < 3 in either eye compared to prior reading
ii. Any *decrease* in NPi by ≥0.7 in either eye compared to prior reading
iii. Any *difference* in NPi of ≥0.7 between eyes compared to prior reading

c. Exceptions and Medication Effects

i. Patients in barbiturate coma may develop NPi=0 (loss of pupillary reactivity) as an effect of the medication.
    1. Pupillometry should be performed *once per shift* until NPi > 0, when assessments should return to ordered frequency
ii. In patients with global injury (e.g. hypoxic-ischemic encephalopathy), ultra-slow pupillary reactivity may be observed. An NPI=0 should not be used as a substitute for manual pupillary light responses observed using light stimulus duration of 5-10s (Kramer 2014).
iii. NPi may be affected by inhaled anesthetics; caution should be used in the OR or in the immediate post-operative period when interpreting NPi in patients receiving inhaled anesthetics (Shirozu 2016).
iv. Opiate infusions may decrease the pupillary size but exhibit a slight, non-threshold effect on NPi (<10% change) (Rollins 2014).

IV. References

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