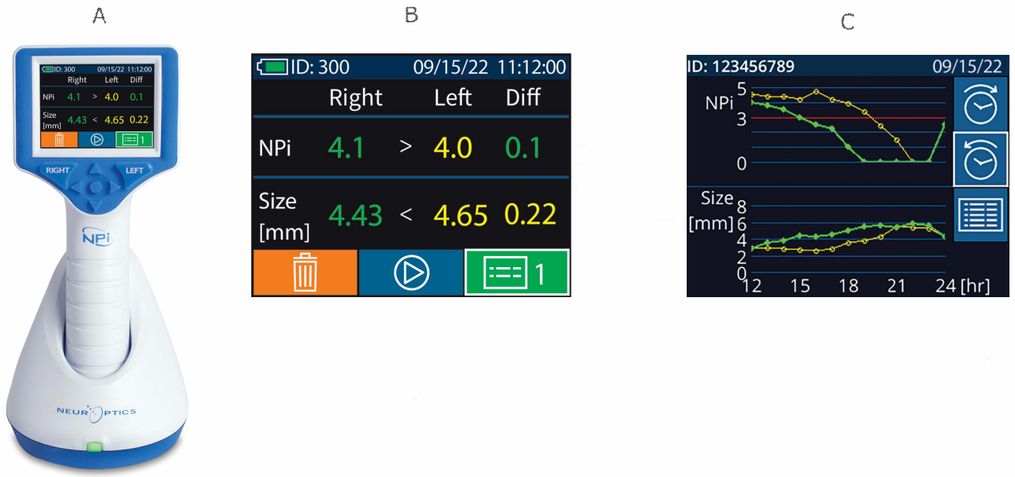
Figure 7-19. Pupillometer



A, Handheld optical scanner (pupillometer). **B,** Pupillary measurements (size and reactivity) displayed on the pupillometer. **C,** Graphic trend of pupillary measurements over a 12-hour period. Copyright NeurOptics, Inc. Irvine, CA. Reproduced with permission.

3. 0: Nonreactive, immeasurable, or atypical response

B. Reportable findings include pupil size difference between right and left of more than 1.00 mm (different from baseline), an NPi less than 3.0, declining NPi, or difference between right and left NPi of 0.7 or more.

Indications

Baseline (on admission) and routine assessment for any patient (adult or pediatric) with primary neurological injury or the potential for neurologic sequelae related to other diagnoses

A. Primary neurologic diagnoses: TBI, subarachnoid hemorrhage, intracerebral hemorrhage, ischemic or hemorrhagic stroke, postoperative craniotomy, multisystem trauma, seizure or status epilepticus, patients with intracranial monitoring (e.g., ICP, oxygen, CBF)

B. Potential for secondary neurological injury: post–cardiac arrest care, targeted temperature management, postoperative and postprocedure cardiac care, ECMO, intra-aortic balloon pump, substance abuse and withdrawal, diabetic ketoacidosis, pancreatitis, hepatic failure or transplant, sepsis, pulmonary compromise (pulmonary embolism, acute respiratory distress syndrome), deep vein thrombosis

C. Patients with conditions making neurologic or pupillary assessment difficult: sedated or pharmacologically paralyzed, dark irises, abnormally small pupils, abnormally large pupils, any manual pupil exam with questionable results

Limitations

A. The pupillometer can measure pupils between 1.00 mm and 10.00 mm in diameter. Pupils outside of this range will not be detected or measured.

B. The pupillometer minimum measurement threshold for detecting a change in pupil size is 0.03 mm (30 microns). In the event a change in pupil size is less than 0.03 mm (30 microns), the pupillometer will not be able to measure the change, and it will display an NPi of 0.

Management Considerations

A. Understand the effects of medications and neurological and metabolic disease processes on pupillary size and reactivity.

B. Educate the patient and family about use of the device.

C. Interpret values in the context of patient diagnosis, treatments, and neurological exam.

D. Record measurement results according to hospital protocol.

E. Report abnormal findings and trends indicating diminished pupillary response to provider.

Brain–Computer Interface

Brain–computer interface (BCI) is a computer-based artificial intelligence system that involves hardware and software enabling the patient to communicate and interact with their surroundings without using normal neuromuscular output pathways (**Figure 7-20**). The

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OBJECTIVES

1. Understand different technologies used to monitor ICP.
2. Identify the types of surgical drains used in neurosurgery.
3. Discuss the use of external CSF drains.
4. Describe the methods used, locations of placement, and indications for CSF shunts.
5. Discuss the methods used for assessing brain oxygenation.
6. Discuss the methods used for assessing brain perfusion and CBF.
7. Identify the indications for use of transcranial Doppler monitoring.
8. Discuss the monitoring of intracranial metabolites with cerebral microdialysis.
9. Discuss the indications and use of electroencephalography (EEG) and signal-processed EEG technologies such as the bispectral index.
10. Differentiate methods used for monitoring neuromuscular blockade.
11. Discuss the use and considerations for implantable stimulators and implantable infusion pumps.
12. Describe automated pupillary assessment.
13. Explore adaptive technologies such as brain–computer interfaces and functional electrical stimulation.

Primary neurological conditions or secondary insults often place patients at risk of neurological dysfunction. Determining the effects of injury on neurological function and applying optimal treatment strategies pose significant challenges for providers and nurses. Although nursing assessment remains a cornerstone of care, technologies used to monitor and treat the nerves, brain, and spinal cord continue to evolve and play an important role in patient evaluation, management, and rehabilitation. This chapter explores a variety of invasive and noninvasive technologies used in the assessment and care of patients with neurological disorders.

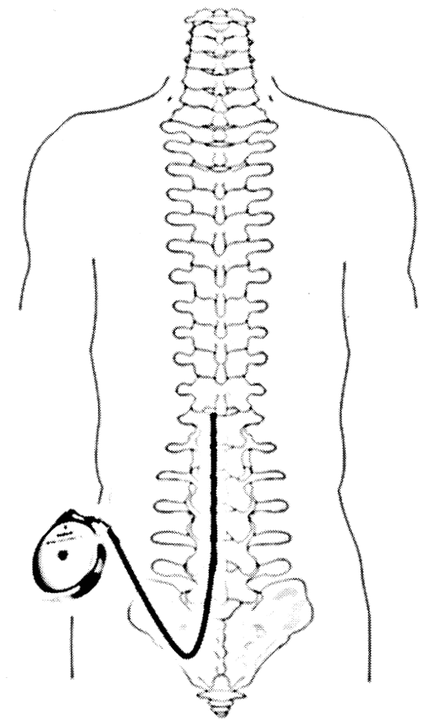
Intracranial Pressure Monitoring

Guillaume and Janny first described indwelling cerebral monitoring devices in the form of ventricular puncture in 1951. These devices became routine after Lundberg's 1961 publication that described their accuracy in reading normal and abnormal ICP waves. Since then, ICP monitoring has become widely accepted in the acute care setting. Despite its widespread use, controversy exists regarding proof of improved patient outcomes with ICP monitoring and ICP targeted therapy.

Indications

ICP monitoring is indicated for patients with TBI, intracerebral hemorrhage, subarachnoid hemorrhage

Figure 7-18. Implantable spinal pump



hyperactive reflexes and excessive muscle tone. Drug dosages range from 90 to 510 mcg for spasticity and from 200 to 2,000 mcg/day for dystonia. The pump is programmable for medication administration and dosage adjustment. In children with cerebral palsy, effectiveness is assessed via the Gross Motor Function Classification System. Advantages include direct effect on spinal nerves and less medication side effects.

Indications

Implantable pumps can be part of the treatment regimen for spasticity resulting from TBI, SCI, and multiple sclerosis; dystonia that accompanies TBI and cerebral palsy; and pain control (see Chapter 24, "Pain and Headaches").

Complications

The following complications can occur with implantable pumps: spinal headache, fluid collection around pump, CSF leak, wound dehiscence, spinal hygroma, or infection.

Nursing Responsibilities

A. Perform postoperative management care.
B. Adjust medication infusion accordingly.
C. Educate the patient and family about the pump.
D. Monitor incisions for signs and symptoms of wound infection.
E. Monitor neurological condition and notify provider of any changes.

Automated Pupillometry

Pupillary examination is a critical component of neurological assessment. Abnormalities of pupillary response or pupil asymmetry are often associated with neurologic deterioration and correlate with poor neurological outcome. Often performed with a flashlight or penlight, manual pupillary assessment is subject to many limitations and sources of inaccuracy, including inconsistent light sources and techniques, darkly colored irises, and small pupils. Manual pupil examination is characterized by high inter-examiner variability and lack of reliability when assessing pupil size, equality, and reactivity. Use of an automated device removes subjectivity from the measurement of pupil size and reactivity and provides a way to trend pupil data in an accurate, objective, and quantifiable way, independent of examiner. Recent literature describes the clinical use of pupillometry in a variety of diagnoses and its prognostic value for patients with cardiac arrest, targeted temperature management, extracorporeal membrane oxygenation (ECMO), TBI, and SAH.

Description (Figure 7-19)

A. The automated pupillometer is a noninvasive, battery-operated, handheld device that uses an LED light source, infrared camera, high-precision optics, and data processor to measure and trend pupil size and reactivity.
B. A disposable piece, called the SmartGuard, is programmed with a unique patient identifier and houses a memory chip that allows collection and storage of all pupil data related to a specific patient. SmartGuard programming can be done manually or via barcode scanner.
C. An optional SmartGuard reader allows upload of data to common file formats and most major electronic medical record systems via middleware integration platforms.

Measurements

A. Measurements include resting and constricted pupil size, percentage of change in pupil size, constriction velocity, latency, and dilation velocity. The internal processor uses these data to calculate an algorithm-based reactivity index, called the neurological pupil index (NPi). Scalar values of NPi range from 0 to 4.9 and indicate the following:
   1. 3.0–4.9: Normal/brisk response
   2. Less than 3.0: Abnormal/sluggish response