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Review Article

Potential Neuroendoscopic Complications: An Anesthesiologist's Perspective

Abstract

Endoscopic techniques are being used extensively used in the current times for the diagnosis and treatment of numerous intracranial pathologies. Although the morbidity associated with these procedures is lower as compared to other conventional surgical modalities, neuroendoscopic techniques have its own fair share of distinct complications such as bleeding, cerebrospinal fluid leakage, and subdural hematoma. However, certain specific complication fall within the purview of the attending anesthesiologist who should remain vigilant, anticipating these problems to occur and should be well equipped to deal with such contingencies. This review attempts to sensitize the anesthesiologists regarding the well-known as well as rare complications of intracranial neuroendoscopic procedures and to familiarize them with their diverse presentations, preventive strategies, and management protocols.

Keywords: *Anesthesia, arrhythmias, neuroendoscopy*

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Introduction

A remarkable advancement in neurosurgical techniques has been the evolution of endoscopic procedures. This technique was described initially in the year 1910 by Victor Darwin Lespinasse (An urologist) where the lateral ventricles were accessed using rigid cystoscope to fulgurate the choroid plexus as a measure to reduce cerebrospinal fluid (CSF) production in hydrocephalic children.[1] Initial limitations in the propagation of this technique included lack of appropriate equipment and higher mortality and morbidity. However, technological refinements over the past years resulting in improved optics and miniature instruments have aided the immense progress in the field of neuroendoscopy allowing its development as an independent treatment modality as well as an adjunct to microneurosurgery for various neurological disorders.[2,3] As of today, endoscopy is the choice of procedure for certain well-defined indications and is an essential element of operative neurosurgical techniques. In general, neuroendoscopy is used in procedures with preexisting or pathologically formed cavities in the central nervous system.[4] Commonly performed neuroendoscopic procedures include endoscopic third ventriculostomy (ETV), choroid plexus coagulation, biopsy or removal of intraventricular or periventricular tumors, drainage or excision of arachnoid or colloid cyst, and retrieving displaced shunts.[5] Neuroendoscopic procedures have also been used to evacuate intracerebral hematoma, septated chronic subdural hematoma, subacute or chronic brain abscess, and endocavitary syringostomy.[6]

Neuroendoscopic procedures definitely offer the advantages of minimal invasiveness (less tissue trauma, minimal brain retraction, or dissection), lower blood loss, and shorter surgical time. At the same time, certain complications are also associated with these procedures. Complications such as subdural hematoma, pneumocephalus, and subdural hygroma, injury to basilar artery, hypothalamus, and cranial nerves are essentially surgical in nature. However certain complications are also encountered often in the course of these procedures, the management of which lie exclusively within the domain of the anesthesiologists. The exact incidence of complications is, however, difficult to assess as all the complications may not be reported,[7,8] and there is a lack of consensus on what actually constitutes a complication.[7] In this review, we attempt

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to discuss those complications which are often encountered by anesthesiologists during neuroendoscopic surgeries.

Intraoperative Complications

Arrhythmias

These include the following rhythm disturbances.

Bradycardia and asystole

This complication is well recognized during procedures such as ETV,[9] and its occurrence should be anticipated intraoperatively. The volume of the multiparameter monitor should be turned up during the surgery for its early detection and vigilance should be exercised during manipulations inside the third ventricle. Presumed reasons for this occurrence includes

a. Raised pressures inside the third ventricle following inability of irrigating fluid to drain due to obstruction of the Foramen of Monro by the scope
b. Hypothalamic irritation caused by cold fluid or fluid varying in osmolality
c. Traction on the floor or walls of the third ventricle irritating the posterior hypothalamus (which regulates cardiac activity) or the third cranial nerve affecting the autonomic outflow.

El-Dawlatly *et al*. encountered bradycardia as the most common arrhythmia in their study on patients undergoing ETV.[10] Similar findings were reported in pediatric patients with an incidence of bradycardia being 41%.[9] Anandh *et al*. also found a significant drop in the heart rate during the process of fenestration of the floor of third ventricle.[11] Near fatal cardiac arrest requiring epinephrine, atropine, and electrical cardioversion for normalization has been also documented previously. Distortion of hypothalamus by the stream of irrigating water or by the raised intraventricular pressures was implicated in the genesis of this phenomenon.[12] Bradycardia in association with hypertension (Classical Cushing's reflex) which is considered to be the traditional indicator of raised intracranial pressure (ICP) has, however, been reported as an infrequent occurrence.

Bradycardia should thus be anticipated during such procedures. Suggested measures to prevent bradycardia include the following:

a. Ensuring that the outflow channel of the neuroendoscope remains open and does not gets blocked by blood or debris
b. Keeping the volume of cardiac monitor sufficiently high and noise level in the theatre low to appreciate any change in the heart rate
c. Placing an invasive arterial line is the ideal means to monitor beat to beat variability in the heart rate and therefore is essential in such procedures
d. Use of saline as an irrigating fluid can produce hypertension and bradycardia mimicking raised ICP[13] due to the disparity in its ionic composition with that of CSF. Ringers Lactate at body temperature is the preferred irrigating due to its similarity with CSF
e. Measurement of ICP by placing an intraventricular catheter or by measuring the intraendoscopic pressures to recognize any deleterious rise in ICP
f. Forceful or rapid irrigation should be avoided. Judicious use of irrigation at the speed of <10 ml/min is advocated.

Tachycardia

Few series, however, demonstrated that tachycardia was the predominant cardiovascular findings often associated with hypertension.[14,15] Tachycardia along with hypertension seems to have a good correlation with acutely raised ICP during ETV.[13,16] Investigations conducted by Kalmar *et al*.[16] revealed that all patients experienced tachycardia and hypertension thereby indicating that a combination of hypertension and tachycardia is a better and early indicator of impaired cerebral perfusion.

Others

These include supraventricular arrhythmias, nodal rhythm, bigeminy, and premature ventricular contractions which vary in their respective incidences in different studies.[17,18] These arrhythmias reflect the rise in intraventricular pressure and/or pressure over the hypothalamic nuclei. Rhythm changes may occur due to trauma to hypothalamus and vasculature too. The majority of the arrhythmias were transient in nature and abated on withdrawal of endoscope or reduction in the intraventricular pressures. Few of the patients, however, needed treatment with lignocaine or atropine for normalization of the rhythm.

Another specific rhythm disturbance worth mentioning in this context is the trigeminocardiac reflex which consists of bradycardia, arterial hypotension, apnea, and gastric hypomotility following stimulation of the trigeminal nerve or its branches anywhere along its central or peripheral course. This reflex is a major cause of bradyarrhythmia in these patients because the port of entrance of endoscope (nasal cavity) is in the territory of fifth cranial nerve (trigeminal nerve) and manipulations can thus incite this reflex during endonasal procedures. The occurrence of this reflex has been reported and elaborately studied in pituitary surgeries[19] and skull base surgeries.[20] Treatment of this reflex necessitates immediate cessation of the surgical stimulus which usually interrupts the eliciting mechanism. Rarely, anticholinergic medications such as atropine or glycopyrolate may be required to regain normal sinus rhythm.

Hypothermia

It is another common complication associated with neuroendoscopic procedures, especially in pediatric patients. Reasons for the development of hypothermia range from low temperatures of the operation theaters, inadequate warming measures, wetting of drapes by the irrigating fluid, and exchange of large volumes of irrigating fluid with CSF. Injury to the hypothalamus can also contribute to impaired thermoregulation.[21] Hypothermia can also occur if large volumes of perfusate kept at room temperature are used.[22] Because of excessive exchange of fluid, a cooling effect occurs both at local as well as systemic levels. Various strategies that can be used to avoid this complication include:

a. Use of warming mattresses or forced warm air blankets
b. Connecting a drainage line to the outflow channel of endoscope to avoid wetting the drapes
c. Use of prewarmed irrigation fluid (at 37°C)
d. Avoidance of hypothalamic injuries.

Venous air embolism

Although the incidence of venous air embolism (VAE) is low during neuroendoscopy, it is still known to occur.[23] Even though the incidences of VAE is highest during sitting or semi-sitting positions, supine positioning does not excludes the probability of its occurrence. It is a potentially fatal complication which might occur during the process of craniotomy or while the endoscope is being removed. VAE occurs when atmospheric air is entrapped in the open venous system with negative pressures inside or when the surrounding pressures are higher than venous pressures driving in the air. Endoscopic manipulations can lead to shearing of blood vessels, and atmospheric air can be driven during forceful irrigation. Creation of the burr hole or the endoscopic sheath is additional sources of causing VAE. The volume of the air embolus is likely to increase if nitrous oxide is being used. Stone *et al*.[24] had reported VAE in seated, sedated, and spontaneously breathing patients soon after the creation of burr hole and opening of duramater which was detected by drop in $EtCO_2$ and oxygenation. An abrupt fall in $EtCO_2$ along with the development of cardiovascular disturbances (hypertension, tachycardia, and ventricular bigeminy) is possible indicators which should alert the anesthesiologists of an impending catastrophic event.

VAE is a feared complication, especially during endoscopic strip craniectomies performed in pediatric patients. Tobias *et al*. reported an incidence of 8% in patients undergoing endoscopic strip craniectomies while using a precordial Doppler as a monitoring tool.[25]

Postoperative complications

Quite, a few of the complications are encountered during the postoperative period following neuroendoscopic procedures.

1. Delayed awakening: Although a conscious neurologically intact patient is desirable following neurosurgical procedures, delayed emergence has been reported to occur in 15% of the patients undergoing neuroendoscopic surgeries. The various reasons implicated in the development of this complication includes alteration in the CSF composition with the irrigation fluid, surgical injuries to brain structures, and sustained high pressures inside the endoscope.[17] Singh *et al*.[14] reported 7.6% of their patients experiencing delayed arousal. Ganjoo *et al*.[15] also documented 1.1% of their patients experiencing the same complication which they attributed to hypothermia. Neuroendoscopic procedures often end abruptly, and therefore, titration of muscle relaxants and narcotics/sedatives becomes challenging as their residual effects may persists postoperatively. Delayed arousal may manifest as inadequate respiratory efforts or inability to follow simple commands. Hence, the use of long-acting benzodiazepines or agents causing prolonged postoperative sedation should be avoided and shorter acting drugs such as propofol, fentanyl, or atracurium should be preferred. Postoperative pain in these patients is relatively less; hence, the use of narcotic analgesics should be judicious. Since intraoperative hypothermia may also contribute to delayed awakening in patients, it should thus be prevented
2. Electrolyte abnormalities: Various electrolytic imbalances can be sequelae to neuroendoscopic surgeries. Hypothalamic disorders can lead to syndrome of inappropriate antidiuretic hormone secretion or diabetes insipidus which alters the electrolyte balance. Different investigations have reported hyperkalemia,[11] hypokalemia,[26] hypernatremia[27] and hyponatremia[21,28] as the electrolytic abnormalities in their findings. Anandh *et al*.'s study utilized Ringer Lactate as the irrigating fluid in their subjects and reported hyperkalemia in 20 patients who additionally experienced significant intraoperative bradycardia.[11] They, therefore, proposed the distortion of posterior hypothalamus as the reason of postoperative hyperkalemia. Conversely, El-Dawlatly, who found hypokalemia in their study group had used normal saline as the irrigating fluid which might explain the lower serum potassium levels.[26] Postoperative electrolyte imbalance generally has a low clinical significance.[10] Exceptionally, although the development of permanent diabetes insipidus following ETV has been reported[29]
3. Seizures: Postoperative seizures can occur in certain patients undergoing minimally invasive neurosurgical procedures.[15,28] The genesis of seizure activity can be a result of pneumocephalus, intraventricular hemorrhage, or electrolyte disturbances. Data regarding the development of postoperative seizures following neuroendoscopic procedures is, however, relatively rare.[30] Seizures can occur in basically any procedure where cortical incisions have been made. A collection of bone dust over the cortex is also known to precipitate convulsions. Thus, the size of cortical incision should be limited, and bone dust should not be allowed to settle after opening of the dura

4. Respiratory disturbances: Close monitoring of patients who had undergone neuroendoscopic procedures in the immediate postoperative period is mandatory as reports exist regarding the development of sudden respiratory arrest. Infants have been known to suffer from respiratory arrests in the initial few hours of neuroendoscopy. Enya *et al*.[31] reported two cases of infants experiencing postprocedural respiratory arrest. The first case was a 4-month-old female undergoing endoscopic fenestration of septum pellucidum who developed two episodes of respiratory arrest 15 min after surgery. CT scan did not reveal any evidence of intracranial bleed. Another case mentioned was an 1-month-old male who had undergone ETV and developed respiratory arrest within 10 min of extubation. Hence, mandatory monitoring with apnea monitors was stressed in this subset of patients. Mohanty *et al*.[32] also described a case of cardiorespiratory arrest in the recovery room where a massive subdural collection had occurred following surgery. Singh *et al*.[14] in their series encountered a single patient who developed unexplained tachypnea. Temporary alterations in the biochemistry of CSF following irrigation are supposed to stimulate the respiratory centers located in the brain stem leading to abnormalities such as hyperventilation. One of their patients developed bilateral wheeze, and two of them developed stridor postoperatively
5. Pneumocephalus: Entrapment of air during surgery can obscure vision intraoperatively and can be a source of postoperative seizures. The development of pneumocephalus can result from excessive loss of CSF, improper site of burr hole, and due to use of nitrous oxide. Ensuring that the head in kept in midline and the burr hole is made in the superior-most point obviates the formation of pneumocephalus
6. Lower cranial nerve palsies: Cranial nerves such as VIII, IX, X, and XI are liable to be involved as a result of direct injury following surgery or due to postoperative edema. This leads to defective speech, swallowing, coughing, taste disturbances, sensory/autonomic dysfunctions, dysphagia, pharyngeal or neck pain and weakness of tongue muscles. These patients require alternate modes of feeding such as nasogastric tubes, endoscopic gastrostomy or feeding jejunostomy for preventing aspiration. Speech therapy may be required. Tracheostomy may be needed in select patients for airway protection
7. Other rare complications: These include
    a. Neurological deficits: Cranial nerves III (Oculomotor) and VI (Abducens) are liable to get inadvertently injured during blind perforation of the floor. Aggressive pushing or abnormal anatomy can also accentuate nerve damage during the procedures. Manifestations in the postoperative period include ocular divergence and anisocoria[21,27] Transient hemiplegia and memory loss may be other subtle expressions of neurological deterioration
    b. Infections: Continuous ventricular irrigation raises the potential of development of ventriculitis and meningitis. These manifest in the form of fever, headache, vomiting and raised ICP occurring within 2–7 days. The spilled contents of the colloid cysts can be a source of chemical ventriculitis.[33] Use of prophylactic antibiotics and disposable fibreoptic scopes can avoid the development of infections
    c. Neuropsychological and psychiatric manifestations: Impairment of cognitive functions have also been reported sporadically.[5,10,21] Benabarre *et al*.[34] had reported an extremely rare case of a 20-year old male patient developing organic personality disorder (impulsiveness, binge eating, hypersomnia, and memory impairment) following ETV which suggested frontal basal structural damage. The clinical hypothesis was subsequently confirmed through magnetic resonance imaging.

Even though neuroendoscopy offers the advantage of easier means of diagnosis and less aggressive form of treatment, there are certain associated complications which are often encountered. Hemmorhage, damage to the fornices or hypothalamus or loss of CSF are related to surgical instrumentation or techniques. However, certain complications are intrinsically related to the anesthetic techniques or require the anesthesiologist's intervention for their appropriate management. Therefore, a thorough knowledge and awareness of the intraoperative as well as the postoperative risks involved in every step of neuroendoscopic procedures is imperative to ensure a positive medical as well as neurological outcome. Meticulous preparation, close communication between the perioperative caregivers and vigilant monitoring in the intraoperative as well as the postoperative period is essential for obtaining the desired favorable outcome.

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Conflicts of interest

There are no conflicts of interest.

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