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Original Investigation

Perioperative Complications of Intraventricular Neuroendoscopy: A 7-Year Experience

İntraventriküler Nöroendoskopinin Peroperatif Komplikasyonları: 7 yıllık Deneyim

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ABSTRACT

AIM: Despite being a minimally invasive procedure, serious perioperative complications are reported during neuroendoscopy, largely generated by its unique surgical maneuvers. We report here the complications of elective neuroendoscopic surgery for the treatment of hydrocephalus and other intraventricular pathology in 298 patients over a 7-year period at our institute.

MATERIAL and METHODS: The complication rate was determined by recording intraoperative hemodynamic variables, core temperature, bleeding episodes, time to arouse from anesthesia, serum electrolytes and neurological deterioration in the immediate postoperative period.

RESULTS: Intraoperative complications included hemodynamic alterations in the form of tachycardia (57 patients, 20.1%), bradycardia (35 patients, 12.4%) and hypertension. Bleeding episodes were major in 4 patients (1.4%) and minor in 32 patients (11.3%). Hypothermia occurred in 12 patients (4.2 %), delayed awakening in 3 patients (1.1%) and electrolyte imbalance in 3 patients (1.1%). Postoperatively, 2 patients each had convulsions, anisocoria and evidence of 3rd cranial nerve injury. Mortality from observed complications was 1.1% (3 patients).

CONCLUSION: Complications during neuroendoscopy may adversely affect its perioperative outcome. Anticipation of these complications in relation to the different surgical maneuvers, their prompt detection by close perioperative monitoring and coordinated efforts of the anesthetist and surgeon in treating them can help minimise the risks associated with neuroendoscopic procedures.

KEYWORDS: Neuroendoscopy, Endoscopic third ventriculostomy, Minimally invasive neurosurgery, Intraventricular endoscopic neurosurgery

ÖZ

AMAÇ: Minimal invazif bir işlem olmasına rağmen, nöroendoskopi sırasında ciddi peroperatif komplikasyonlar bildirilmiştir. Bunlar büyük oranda nöroendoskopinin kendine has cerrahi manevralarından kaynaklanmaktadır. Biz burada Enstitümüzde 7 yıllık bir süre içinde 298 hastada hidrosefali ve diğer intraventriküler patolojilerin tedavisinde kullanılan elektif nöroendoskopik cerrahinin komplikasyonlarını bildiriyoruz.

YÖNTEM ve GEREÇ: Komplikasyon oranı intraoperatif hemodinamik değişkenlerin, vücut ısısının, kanamaların, anesteziden uyanma zamanının, serum elektrolitlerinin, ve erken postoperatif dönemde nörolojik kötüleşmenin kaydedilmesiyle belirlenmiştir.

BULGULAR: İntraoperatif komplikasyonlarda hemodinamik değişiklikler taşikardi (57 hasta, %20.1), bradikardi (35 hasta, %12.4) ve hipertansyondu. Kanama 4 hastada majör (%1.4) ve 32 hastada minördü (%11.3). Hipotermi 12 hastada (%4.2), gecikmiş uyanma 3 hastada (%1.1) ve elektrolit dengesizliği 3 hastada (%1.1) rapor

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edildi. Postoperatif 2 hastada konvüzyon, anizokori ve üçüncü kranyal sinir yaralanma bulguları gelişti. Gözlenen komplikasyonlardan mortalite %1.1 (3 hasta) idi.

SONUÇ: Nöroendoskopi esnasındaki komplikasyonlar peroperatif sonuçlarını olumsuz yönde etkileyebilir. Bu komplikasyonların değişik cerrahi manevralarla ilşkili olarak öngörülmesi, yakın peroperatif monitörizasyonla zamanında farkedilmesi ve anestezist ve cerrahın işbirliğiyle tedavi edilmesi nöroendoskopik işlemlerle ilgili risklerin minimale indirilmesinde yararlı olacaktır.

ANAHTAR SÖZCÜKLER: Nöroendoskopi, Endoskopik üçüncü ventrikülostomi, Minimal invazif nöroşirürji, İntraventriküler endoskopik nöroşirürji

INTRODUCTION

Endoscopic third ventriculostomy (ETV) is an established therapeutic alternative to conventional shunt surgery for patients with non-communicating hydrocephalus. Besides ETV, neuroendoscopy is also being used for the diagnosis and treatment of intraventricular pathology, like choroid plexus coagulation, biopsy or removal of intraventricular and periventricular tumors, drainage or excision of colloid and arachnoid cysts and retrieval of displaced shunts (23).

Despite the many advantages of neuroendoscopy which include, speed, simplicity, avoidance of implants and no brain retraction or dissection, a variety of perioperative complications are reported with its use, attributed mostly to its unique surgical technique leading to alterations in cerebral flow dynamics and injuries to vital brain areas; the incidence of complications is 5% to 30% and that of operative mortality is 0% to 1% (23). Serious hemodynamic variations, temperature alterations, electrolyte imbalance and delayed emergence after surgery are some of the complications that may adversely affect the anesthetic outcome (1). A thorough understanding of these complications in relation to the different maneuvers of endoscopy can help in their better management and substantially improve patient safety. We present here a prospective observational study undertaken at our institute with the aim of evaluating the various perioperative complications that can occur during intraventicular neuroendoscopy.

MATERIALS and METHODS

Consecutive patients undergoing elective neuroendoscopic surgery for the treatment of hydrocephalus and other intraventricular pathology performed by the same neurosurgeon between September 1999 and December 2006 were studied. Preanesthetic check up included a documentation of the patient's neurological status, presence of raised intracranial pressures (ICP) and prior shunt placements. Informed consent was obtained prior to the procedure. Anesthesia was induced with intravenous (IV) injections of thiopentone (4 mg/kg), atracurium (0.5 mg/kg), fentanyl (2 mcg/kg), and midazolam (1-2 mg); halothane induction was used in children. Patients were intubated and ventilated with an oxygen (O2) and nitrous-oxide (N2O) mixture (FiO2 0.4) to achieve end-tidal carbon-dioxide (EtCO2) values of 30-33 mmHg. Anesthesia was maintained with atracurium infusion (10mcg/kg/min), 0.5% isoflurane and fentanyl boluses. Electrocardiogram, pulse oximetry, EtCO2, nasopharyngeal temperature, invasive arterial blood pressure and arterial blood gases (ABG) were monitored. Intraoperative fluid requirements were met with Ringer's Lactate (RL) solution in adults and isotonic pediatric solution in children. Forced-air blankets and pre-warmed infusions were used to keep the patients warm. Anesthesia was reversed with IV neostigmine (0.05mg/kg) and IV glycopyrrolate (0.01mg/kg) and thereafter, the patients were closely monitored in the postoperative care unit for 4-5 hours.

For surgery, the patients were placed supine with head in a neutral position on a horseshoe head-rest. A rigid neuroendoscope (Karl Storz GmBH, Tottingen, Germany) with a 6 mm sheath and 1.8 mm telescope was introduced into the lateral ventricles through a standard burr hole. Continuous irrigation with pre-warmed RL fluid was started at slow speed (5-10 ml/min) and was increased if required. Whenever the third ventricle (TV) cavity got overfilled, fluid was let out through the sheath. The endoscope was advanced through the Foramen of Monroe (FOM) into the TV cavity where most of the surgeries were done. For ETV, the TV floor was identified as a bluish transparent membrane behind which the mammillary bodies and

basilar artery pulsations were visible. Perforation of the TV floor was done in the midline between the infundibular recess and the mammillary bodies with a bipolar cautery. The opening was dilated to 5-6 mm with a 3F Fogarty balloon catheter. Adequacy of ventriculostomy was judged by oscillations of cerebrospinal fluid (CSF) flow through the fenestration. On completion, the neuroendoscope was withdrawn and operative site closed in layers. The procedure was continuously displayed on a video screen. The total volume of irrigation fluid used and the color of the outflow fluid were noted.

The following data was collected:

1. Intraoperative hemodynamic variables like heart rate (HR), rhythm and mean arterial pressure (MAP): Baseline values were obtained just before insertion of the endoscope in the anesthetized patient and any change in these values in relation to the various surgical maneuvers was recorded thereafter. Bradycardia or tachycardia was defined as decreases or increases respectively in HR of ?20% from baseline values. Hypotension or hypertension was defined as similar changes in MAP of ?20% from baseline values. Hemodynamic variations were to be treated initially by retraction of the associated surgical maneuver, and if persistent, drug treatment was to be given.
2. Intraoperative nasopharyngeal temperature: Hypothermia and hyperthermia were defined as decreases and increases respectively in temperatures outside the acceptable range of 350C to 380C.
3. Serum electrolytes: Sodium and potassium were monitored up to the first postoperative day. Hyponatremia and hypernatremia were defined as decreases and increases respectively in serum sodium values outside the normal range of 130 to 145meq/l. Hypokalemia and hyperkalemia were defined as similar changes in serum potassium values outside 3.5 to 5meq/l.
4. Intraoperative bleeding episodes: Major bleeding was defined as that which significantly obscured endoscopic visibility and did not clear despite increased irrigation and cauterization.
5. Time taken to arouse from anesthesia: Awakening was considered delayed if the patient's consciousness did not revert to preoperative levels within 40-45 minutes of reversing anesthesia.
6. Postoperative problems: Neurological deterioration, convulsions, anisocoria, nystagmus, fever and hemiplegia manifesting in the immediate postoperative period were noted.

RESULTS

Table I depicts the demographic profile of the total 298 patients studied. Preoperative evaluation revealed 8 patients with altered sensorium, 2 patients with hemiplegia, 2 patients with 6th and 7th cranial nerve palsy, 5 patients with convulsive disorder and 7 patients having undergone prior shunt surgery.

Surgery was abandoned in 15 patients (5%) due to either an unfavorable anatomy or when a major bleed obscured visibility; ventriculo-peritoneal shunt surgery was performed in the same sitting in 12 of these patients. The duration of surgery ranged between 10 minutes and 2 hours and the volume of irrigating fluid consumed was between 50 ml and 1500 ml.

Table II lists the perioperative complications seen in the remaining 283 patients. Intraoperative tachycardia occurred in 57 patients (20.1%), and was accompanied by hypertension (HT) in 26 patients, it . Bradycardia was observed in 35 patients (12.4%), out of which only 2 patients had accompanying HT. On being alerted, the surgeons halted surgery and performed maneuvers like letting out the irrigating fluid, deflating the balloon or withdrawal of the endoscope, which resulted in prompt normalization of observed hemodynamic changes. In 2 patients there was a delay in the surgeon's response and the tachycardia was followed by bradycardia that also got corrected with egress of fluid. HT was seen in 28 patients (9.9%) associated either with bradycardia or tachycardia but not in isolation. Two patients had hypotension during the procedure. All hemodynamic changes were transient, no drug treatment was required, and there was no postoperative morbidity related to these changes. No patient had intraoperative cardiac arrest.

Major bleeding was encountered in 4 out of 298 patients (1.4%) due to injury to basilar artery branches and large ependymal veins; the procedure was abandoned in 3 patients. Surgery could be completed in the remaining patient but he developed a transient

episode of intraoperative venous air embolism (VAE), suspected by an abrupt fall in EtCO2 values to 20 mmHg and development of ventricular bigeminy. Postoperatively, all 4 patients underwent external ventricular drainage and elective ventilation. One patient recovered and subsequently underwent shunt surgery while the remaining 3 patients died within a week. Minor bleeding was observed in 32 patients (11.3 %).

Intraoperative hypothermia in 12 patients (4.2%) was seen only during the earlier years. Three patients (1.1%) had a delayed awakening from anesthesia, 2 of which also had hypothermia. In the immediate postoperative period, 3 patients (1.1%) had electrolyte imbalance (hyperkalemia 1, hypernatremia 2). Two patients each had convulsions, anisocoria and evidence of 3rd nerve injury. Mortality related to the observed perioperative complications was 1.1% (3 patients).

Table I: Demographic data of patients.

	No. of patients	
Sex	Male	182
	Female	116
Age	< 2 years	126
	2 - 5 years	84
	5-18 years	59
	> 18 years	29
Diagnosis	Aqueductal stenosis	90
	Tubercular meningitis	77
	Neonatal hydrocephalus	33
	Postinfective hydrocephalus	28
	Normal pressure hydrocephalus	13
	Shunt infected meningitis	9
	Dandy Walker syndrome	4
	Tumors with hydrocephalus	44
	• Colloid cysts	23
	• Neurocystecercosis	6
	• Pineal tumors	4
	• Intraventricular tumors	4
	• Thalmic mass	2
	• Ependymal cyst	2
	• Arachnoid cyst	2
	• Choroidal cyst	1

DISCUSSION

ETV is the commonest neuroendoscopic procedure with a reported success rate of 60% to 90% (23). Intraventicular tumors, colloid cysts and arachnoid cysts are also accessed easily via the endoscope and can be safely removed or biopsied, and ETV can be performed at the same sitting wherever indicated (1) (Table I).

The anesthetic management of patients undergoing neuroendoscopy (23,1) begins with a thorough preoperative evaluation, keeping in mind that hydrocephalic patients may present with altered sensorium, dehydration, electrolyte imbalance, convulsions, other congenital anomalies and prior shunt placements. Abnormalities should be maximally corrected before surgery and sedative premedication preferably avoided. Intraoperative management is directed towards providing optimal conditions for surgery and preventing technique-related complications. One must ensure strict patient immobility during endoscopy and yet have a reasonably awake patient at the end of anesthesia to facilitate early neurological assessment. The procedure may end abruptly and is also relatively painless, and hence, general anesthetic regimes incorporating easily titrable drugs like propofol, thiopentone, fentanyl, atracurium and inhalational agents are preferred over long acting drugs. Use of N2O during neuroendoscopy is questionable as it can diffuse into and expand ventricular air bubbles. We have discontinued its use after the episode of suspected VAE.

Serious intraoperative complications during neuroendoscopy can be generated by any of its surgical maneuvers such as endoscopic manipulations inside the TV cavity, continuous irrigation with electrolyte solution and perforation of the TV floor. Hemodynamic disturbances in the form of HR and blood pressure (BP) changes are the most frequently reported complications with an incidence of 28-32% (23). These responses may be due to acute rises in intracranial pressures (ICP) secondary to continuous use of high-speed irrigation or obstruction to the outflow of fluid leading to impairment of cerebral perfusion (21,3,15). Tachycardia and HT have been shown to correlate well with an acutely raised ICP during ETV (15, 25). Inadvertent stimulation or injury of the posterior hypothalamus (which modulates the

Table II: Perioperative complications during neuroendoscopy.

Intraoperative complications	
• Hemodynamic variations:	
Tachycardia	57 (20.1%)
Tachycardia and HT	26 (9.2%)
Bradycardia	35 (12.4%)
Bradycardia and HT	2 (0.71 %)
HT (with tachy/ brady)	28 (9.9 %)
• Bleeding episodes:	
Major bleeding	4 (1.4%)
Minor bleeding	32 (11.3%)
• Venous air embolism	1 (0.35%)
Immediate postoperative complications	
• Hypothermia	12 (4.2%)
• Delayed awakening	3 (1.1%)
• Electrolyte imbalance	3 (1.1%)
• Convulsions	2 (0.71 %)
• Anisocoria	2 (0.71%)
• 3rd nerve palsy	2 (0.71 %)
Mortality from perioperative complications:	3 (1.1%)

cardiac regulatory function of the brain stem via descending autonomic pathways) or of the 3rd cranial nerves, both of which lie in close proximity to the TV floor, can also produce significant hemodynamic responses (3). Bradycardia was reported in 43% and 41% of the patients in two separate studies during fenestration of the TV floor (5, 6) and in 26.8% of the patients during balloon inflation of a Fogarty catheter (3). Rapid CSF drainage while inserting the endoscope may lead to sudden brain shifts with hemodynamic alterations (1). Use of saline as an irrigant is also known to produce HT with reflex bradycardia which may be confused with raised ICP (25); RL is preferred as it does not cause HT and its ionic composition is close to that of CSF. Most often, the observed HR and BP changes are transient and respond to simple surgical maneuvers but failure to recognize them in time can lead to serious consequences. Two cases of cardiac arrest have been reported during ETV; one, due to a forceful and rapid irrigation causing hypothalamic distortion (the authors recommend judicious use of irrigation at a speed of ≤10 ml/min) (12) and the other during balloon inflation causing local pressures on the underlying hypothalamus (3). Prompt management of cardiovascular complications can be achieved by anticipation of the hemodynamic change specific to a surgical maneuver, necessitating close observation of surgery on the video monitor and, by early detection, requiring beat to beat monitoring of changes with an indwelling arterial catheter (15,25,9). Rises in ICP can be detected by directly measuring the ICP (19) or the intra-endoscopic pressures, though these may sometimes be unreliable (12,9). At our institute, we do not measure the ICP routinely and rely only on hemodynamic changes to alert the surgeons.

Minor hemorrhages are commonly encountered and are easy to control whereas major bleeding can result in serious postoperative neurological sequelae. Injury to the basilar artery or basilar perforating vessels remains the most dangerous complication of neuroendoscopy associated with a high morbidity and mortality, highlighting the importance of a correctly placed fenestration on the TV floor (23,21,22,16). Monitoring the colour and volume of the returning perfusate is useful for assessing the extent of bleeding (1). Hypothermia during neuroendoscopy is seen more often in small children, caused by large exchanges of irrigation fluid and ventricular CSF and by wetting of drapes with the returning perfusate (1). Hypothalamic injury may contribute to impaired temperature regulation manifesting after surgery (3). Routine use of pre-warmed irrigation fluid and forced-air blankets helped us to reduce the incidence of intraoperative hypothermia in our patients. Delayed awakening after neuroendoscopy has been reported in up to 15% of patients, attributed largely to high pressure levels inside the neuroendoscope (9); hypothermia appeared to be the most probable causative factor in our patients. Intraoperative air entrainment leading to pneumoventricle or pneumocephalus with serious postoperative sequel is reported (20); we also witnessed an episode of VAE.

Complications arising from a faulty surgical technique or an inadvertent injury to vital brain areas may manifest in the immediate postoperative period. Transient episodes of loss of consciousness, neurological deficits (incidence: 8-38%), confusion, memory loss and impaired cognitive function have been reported (23,3,11). Convulsions may occur due to pneumocephalus, intraventricular bleed or electrolyte imbalance (1,3,20). Transient hypothalamic

dysfunction may lead to syndrome of inappropriate secretion of antidiuretic hormone and diabetes insipidus with fluctuating serum electrolyte levels, mandating their close monitoring in the postoperative period (23,3,11). Hyperkalemia (2), hypokalemia (7), hypernatremia (21) and hyponatremia (3,24) have been variously reported. Meningeal irritation, headache and high fever can occur due to an inflammatory response to irrigating fluids (14, 18) or to spilled colloid cyst contents causing chemical ventriculitis (4). Transient ocular divergence and anisocoria can occur from inadvertent stretching of the midbrain and resultant palsy of 3rd and 6th cranial nerves during fenestration of the TV floor (21,3). Bilateral retinal hemorrhage due to steep rises in ICP is also reported (13). Respiratory arrest in 2 patients (8) and cardiorespiratory arrest in 1 patient due to acute subdural collection (17) is also reported, reinforcing the importance of close monitoring in the immediate postoperative period.

Improved perioperative outcome from neuroendoscopic procedures is largely dependent on an efficient handling of its related complications. This requires understanding the complications in relation to the different surgical steps, meticulous intraoperative monitoring, effective communication between the surgeon and the anesthetist and, close vigilance of the patient in the postoperative period.

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