ORIGINAL RESEARCH PAPER | Medical Science | Volume : 6 | Issue : 8 | August 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

A Study of Haemodynamic and Electrolyte Changes During Neuroendoscopic Procedures Under General Anaesthesia

KEYWORDS: Bradycardia, Hyperkalemia, Hypokalemia, Tachyarrhythmia, Third Ventriculostomy

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ABSTRACT *Endoscopic third ventriculostomy is a common neuroendoscopic procedure. Bradycardia, tachyarrhythmia, hyperkalemia or hypokalemia may occur during manoeuvring of endoscope, ventricular irrigation, or third ventriculostomy. A prospective, observational study was carried out in 35 patients undergoing neuroendoscopy to find correlation between these changes and anaesthesia technique. Base line preoperative vital parameters, serum electrolytes, details of anaesthesia technique, intravenous fluids, neuroendoscopy, pulse rate, blood pressure, and E.C.G. changes, irrigating fluid, and intraoperative and postoperative serum electrolyte levels were recorded and analysed using Paired students T test. A very highly significant fall in pulse rate was noted during insertion of neuroendoscope (96.29 ± 27.42, p=0.001), 3rd ventriculostomy (96.63 ± 27.079, p=0.000) and removal of scope (93.46 ± 27.91, p=0.000) more so with the use of Fentanyl as analgesic. Hence close communication between the neurosurgeon and the anaesthetist and judicious use of Fentanyl is recommended.*

INTRODUCTION

Neurosurgical endoscopy is being widely used for diagnostic and therapeutic indications. The technological advancements in optical and mechanical instrumentation, use of stereotactic or ultrasound-guided procedures have facilitated these less invasive procedures. Endoscopic third ventriculostomy (ETV) is one of the common neuroendoscopic procedures across all age groups[1,2,3,4]. It is being used as an alternative to ventriculo-peritoneal shunt due to lower morbidity and mortality[5,6]. Neuroendoscopic procedures are used for treatment of various pathologies like congenital hydrocephalus, post tuberculous meningitis, neurological cyst and tumour biopsy & excision.

Haemodynamic changes like bradycardia[7,8,9,10,11,12,13], tachyarrhythmia[14,15,16,17,18,19,20] and electrolyte changes like hyperkalemia[11] and sometimes even hypokalemia[9,21] are known with neuroendoscopic procedures. These changes have been observed at various stages of endoscopic third ventriculostomy such as during manoeuvering the endoscope within the third ventricle, during ventricular filling with irrigation to improve visibility, or while perforating the third ventricular floor, but it is not clear if the observed changes follow a predictable pattern.

We decided to study the incidence of haemodynamic changes i.e. changes in pulse rate and blood pressure, and electrolyte changes mainly sodium and potassium, in various neuroendoscopic procedures being conducted under general anaesthesia. We aimed to study whether these changes are affected by the anaesthesia technique and whether any changes are to be made in anaesthesia for neuroendoscopic procedures. We therefore conducted a prospective, observational study in patients undergoing neuroendoscopy in neurosurgery operation theatre.

MATERIALS AND METHODS

The study was carried out after approval of the Institutional Ethics Committee. All patients above age of 1 month undergoing neuroendoscopic procedures under general anaesthesia were included. Non consenting patients were excluded.

Sample size calculation: Based on a previous study conducted exclusively on paediatric neuroendoscopies[12] a sample size of 4 patients was required to detect significant bradycardia of around 50-60 beats per minute(bpm). However our institution included adult patients for ETV. In our pilot study we noted a fall in pulse rate of around 15 to 20 bpm. To detect a fall in pulse rate of 20 sample size of 35 was needed. Hence 35 cases undergoing neuroendoscopy over the time period of 2008-09 were included in this study.

The following data from the patient medical chart was entered in the proforma – base line preoperative vital parameters like pulse rate, systolic and diastolic blood pressure and values of serum sodium and potassium. The dose and nature of premedication given to the patients in the form of intravenous (IV) Glycopyrrolate or Atropine, Midazolam, Pentazocine or Fentanyl was noted. The method used for induction of anaesthesia – Intravenous Thiopentone Sodium or Propofol or inhalational induction with Sevoflurane was recorded. The neuromuscular blocking agent used and technique used for maintenance of anaesthesia was noted.

The quantity and composition of I.V. fluids used was documented. Time and duration of the neuroendoscopic procedure , vital parameters like pulse rate, systolic and diastolic blood pressure, and E.C.G. changes, if any, for each step of neuroendoscopic procedure like making the burr hole, introduction of scope, actual step of procedure and removal of scope were noted. Composition, quantity, duration of

Volume : 6 | Issue : 8 | August 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

irrigating fluid, and values of intraoperative and postoperative serum electrolytes were included in the proforma.

Data thus obtained was analyzed using software version SPSS 12.0 (SPSS Inc., 233 South Wacker Drive, 11th Floor, Chicago, IL 60606- 6412). For each parameter mean and standard deviation were calculated and statistically analyzed using Paired students T test to estimate the significance. The test was applied to compare the changes in pulse rate, blood pressure during various stages of the neuroendoscopy. Changes occurring in serum electrolytes were also compared. A 'p' value of <0.05 was considered significant, p value < 0.01 as highly significant, and P value < 0.001 as very highly significant.

OBSERVATIONS & RESULTS

A total of 35 cases that had undergone neuroendoscopy over the time period of 2008-09 were studied. Tuberculous meningitis was the most common diagnostic indication for ETV as seen in Table 1.

Table 1 DEMOGRAPHIC DATA

Parameter	Number
AGE GROUP Infant/ Paediatric/ Adult	2/14/19
SEX Male/Female	26/09
ASA CLASSIFICATION I/II/III	13/19/03
DIAGNOSIS	
Aqueductal stenosis	3
Tubercular meningitis	16
Hydrocephalus with tumours	6
Neonatal hydrocephalus	3
Post-infective hydrocephalus	1
Posttraumatic hydrocephalus	1
Obstructive hydrocephalus	5

A very highly significant fall in pulse rate was noted during insertion of neuroendoscope, 3rd ventriculostomy and removal of scope as seen in Table 2. Similarly blood pressure changes were observed but there was no significant change in blood pressure throughout the procedure in any case.

Table 2 HAEMODYNAMIC PARAMETERS

STAGES	MEAN± S.D PULSE RATE	P Value	MEAN± S.D SBP	P Value	MEAN± S.D DBP	P Value
Base line	104.69 ± 34.26		110.03 + 13.46		71.97 + 8.99	
Burr hole	102.74 ± 33.02	0.382	108.46 ± 13.06	0.29	73.43 ± 8.75	0.17
Scope in	96.29 ± 27.42	0.001*	107.94 ± 13.21	0.18	71.57 ± 7.69	0.75
ETV	96.63 ± 27.079	0.000*	108.03 ± 13.62	0.18	72.46 ± 8.77	0.61
Scope out	93.46 ± 27.91	0.000*	110.8 ± 14.37	0.59	73.31 ± 7.75	0.30

*** P value statistically very highly significant**

Ringer lactate was used as an irrigation fluid in 23 cases & NS in 7 cases and in 5 patients no irrigant was used. Duration of irrigation ranged from 10 min to 2hrs 45 min. There was a minimal change in serum electrolyte values both intraoperatively and postoperatively but the 'P' value was not significant. (Table 3) Neither the choice nor the duration of irrigating fluid affected the serum electrolyte values.

Table 3 SERUM ELECTROLYTES

STAGES	MEAN± S.D S. SODIUM	P Value	MEAN± S.D S. POTASSIUM	P Value
Base line	135.77 ± 4.54		3.983 ± 0.45	
Intraoperative	136.15 ± 3.12	0.310	4.006 ± 0.40	0.688
Postoperative	136.18 ± 3.24	0.222	4.038 ± 0.3500	0.318

*** P value statistically not significant**

The induction agents used were Thiopentone Sodium in 29 cases, Sevoflurane in 5 cases and Propofol in 1 case. The small sample size of cases with use of Sevoflurane or Propofol precluded statistical comparison. Atracurium was used for all patients. Propofol was used for maintenance in 30 cases and Sevoflurane in 5 cases. Since Sevoflurane was used for maintenance in just 5 cases, we did not perform a statistical comparison.

Table 4 FALL IN PULSE RATE- FENTANYL VS PENTAZOCINE

STAGES	MEAN± S.D PULSE RATE (Fentanyl Group)	P Value	MEAN± S.D PULSE RATE (Pentazocine Group)	P Value
Base line	114.40 ± 35.5		80.40 ± 12.53	
Burr hole	112.60 ± 33.74	0.511	78.10 ± 11.78	0.571
Scope in	105.40 ± 26.52	0.007*	73.50± 12.51	0.440
ETV	105.08 ± 27.37	0.004*	75.50± 8.85	0.718
Scope out	101.04 ± 29.47	0.001*	74.50± 8.24	0.162

***P value statistically very highly significant**

The analgesic used was Fentanyl in 25 cases and Pentazocine in 10 cases. As Fentanyl is known to cause bradycardia we decided to compare its use against Pentazocine. We found that the fall in pulse rate occurring during various stages, when Fentanyl was used as analgesic was statistically significant as compared to cases with Pentazocine (Table 4)

DISCUSSION

Neuroendoscopy is used for various diagnostic procedures such as ventriculoscopy, cisternoscopy, biopsy in the intraventricular, intracystic, or cisternal spaces and therapeutic procedures such as ventriculoperitoneal shunt, excision of encysted shunt catheter, third ventriculostomy, aqueductoplasty, foraminoplasty, and evacuation of intraventricular hematoma.

The quick, simple and minimally invasive nature of ETV leads to lower morbidity and mortality compared to standard ventriculoperitoneal (VP) shunt placement[5]. It is used in the primary treatment of hydrocephalus (primary ETV) or as an alternative to shunt revision in the management of shunt complications (secondary ETV). The steps of ETV include introduction of a rigid neuroendoscope into the lat-

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eral ventricles through a standard burr hole, advancement of scope through the Foramen of Monro (FOM) into the third ventricular cavity and creation of an internal fistula between the ventricular system and the basal subarachnoid spaces through an opening in the floor of the third ventricle. Continuous irrigation with either Ringer lactate or Normal saline is used to maintain the clear visibility of the field & to achieve haemostasis.

Neuroendoscopic procedures are done routinely in neurosurgery operation theatre of our setup and we were collecting the data and keeping the records of intra operative findings since the beginning. We had observed haemodynamic changes such as fall in pulse rate or sometimes rise in pulse rate, occurring during different stages of the procedure. Some electrolyte changes were also seen intraoperatively and post operatively in the form of hypokalemia or sometimes hyperkalemia.

But it was not clear if the observed changes followed a predictable pattern. Hence we decided to study the incidence of haemodynamic as well as the electrolyte changes, mainly sodium and potassium. We aimed to study whether these changes were affected by anaesthetic techniques so that we could suggest changes, if any, to be made in anaesthetic technique for neuroendoscopic procedures.

Our study population included 35 cases. On statistical analysis of the data, our main observation was a fall in pulse rate as compared to baseline values during insertion of the neuroendoscope, 3rd ventriculostomy and removal of the scope. This fall in pulse rate was statistically very highly significant (p value $\leq$ 0.001). The fall in pulse rate occurred over a time period of few seconds and within seconds of the scope manipulation i.e. insertion of neuroendoscope, perforation of floor of the third ventricle and removal of scope. Intraoperative haemodynamic changes during endoscopic third ventriculostomy have been extensively studied with the conflicting results. El-Dawlatly A[13] in the first report on haemodynamic changes during endoscopic third ventriculostomy published in 1999, have reported bradycardia with incidence of 43 % among 14 patients. In the same study they have reported negative correlation between third ventricle pressure and intraoperative bradycardia. Since they were using saline for irrigation in an open system, they postulated that the bradycardia occurred due to direct stimulation of the floor of the third ventricle by the tip of the endoscope. This has been further supported by another study by El-Dawlatly[12] on 49 patients who underwent endoscopic third ventriculostomy, where an incidence of bradycardia was 41%. They suggested that bradycardia may be one of the first indicators of impending cardiac arrest during endoscopic third ventriculostomy which can be easily treated by pulling the scope away from the floor of the third ventricle. Derbent et al[22] encountered bradycardia in only 1 of the 24 patients for a short period during balloon inflation with possible temporary brain stem ischemia and subsequent bradycardia. Leach et al[23] reported spontaneously resolving asystole in two patients following room temperature irrigation fluid in a study of over 140 patients, advocating fluid to be strictly at body temperature. Baykan et al[24] reported bradycardia intraoperatively alone in 28.1% and the respective rates for asystole and for bradycardia following tachycardia as 0.5 % and 12.4 % with an overall incidence of arrhythmia involving bradycardia as 41%. Ozdamar et al in their study of 57 infants undergoing ETV published in 2012, found severe bradycardia during balloon dilatation.

Van Aken J et al[20], found tachycardia as frequently as bradycardia and attributed this to an increase in intracranial pressure (ICP) and systemic hypertension caused by high-speed fluid irrigation or kinking of the outflow tube. On the contrary P. Ganjoo[14] studied 260 cases during 1999-2005 and observed increase as well as decrease in heart rate and mean arterial pressure during endoscopic third ventriculostomy. Tachycardia was the common heart rate abnormality, occurring in 20% of the patients, while bradycardia was seen in 12% of patients. 10% patients developed hypertension associated either with bradycardia or tachycardia but never alone. The pattern of haemodynamic responses appeared to vary with different stages of endoscopic third ventriculostomy. Tachycardia was more common during irrigation and endoscopic manipulation in the third ventricular cavity, while bradycardia was the main response during manipulations on or near the third ventricular floor. Kawsar et al have reported haemodynamic alterations in the form of tachycardia, bradycardia, and hypertension in their study of 412 patients from 2006- 2012.

We studied the changes in blood pressure with respect to the step of neuroendoscopy. On statistical analysis we found that though blood pressure changes were observed at various steps of the procedure, there were no clinically or statistically significant changes in systolic or diastolic blood pressures throughout the procedure in any case.

In the study done by P. Ganjoo et al[14], one patient had hypotension which responded to cessation of manipulation and drainage of the irrigating fluid. In nearly half number of patients who had tachycardia, there was associated hypertension.

Atypical Cushing response attributed to compression of hypothalamus by dilated third ventricle may explain the frequency of tachycardia during ETV. Tachycardia may occur when the increase in intracranial pressure is too fast for adaptation as with high flow irrigation or outflow obstruction.

The haemodynamic variations occur more often in post infective cases where the surgeons encounter difficulties in performing endoscopic third ventriculostomy due to a distorted third ventricle or a narrow foramen of Monro or a thickened third ventricular floor. During neuroendoscopy continuous irrigation is required to maintain the clear visibility of the field & to achieve haemostasis. We observed use of Ringer Lactate (RL) as an irrigation fluid in 23 cases & normal saline in 7 cases. In 5 patients no irrigant was used. Neither the composition nor the duration of irrigation affected the serum electrolytes.

El-Dawlatly A[21] in a study on small number of patients who underwent endoscopic third ventriculostomy, have reported postoperative electrolyte disturbances, namely hypokalemia. On the contrary Anandh[11] et al, have reported postoperative hyperkalemia and intraoperative bradycardia during fenestration of the third ventricle and during reversal.

El-Dawlatly A[21] attributed hypokalemia to a disturbance related to the hypothalamic nuclei situated in the floor of the third ventricle. However, the hyperkalemic response in these patients has been noticed in isolation, without any change in the serum sodium level. Also it was transient and late in onset which suggests a hormonal dysfunction. In that report they found that they were using lactated ringer solution for irrigation, which might have contributed

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to the hyperkalemic response following endoscopic third ventriculostomy.

Derbent et al[22] study reported that although they were using Ringer Lactate solution for irrigation and 0.9 % normal saline for intravenous fluid replacement during endoscopic third ventriculostomy, there was no significant difference between the pre and post-operative serum sodium and potassium . A balanced electrolyte solution such as Ringer lactate has reported to be a better choice as compared to saline, because it caused only a mild temporary hypotension. El-Dawlatly[21] continued the use of normal saline and not Ringer Lactate for irrigation, and reported hypokalemia and hypernatremia in the second and third postoperative days following endoscopic third ventriculostomy with no clinical significance. Also they have reported negative correlation between the serum sodium level postoperatively and the volume of irrigation fluid (normal saline) used.

On comparison of anaesthetic technique we found that a fall in pulse rate occurred with both Fentanyl and Pentazocine. The fall in pulse rate was statistically significant with Fentanyl as compared to Pentazocine. However Fentanyl was used in 25 of our study cases while Pentazocine was used in 10 cases. Thus more studies are needed to establish clinical correlation. Use of Thiopentone Sodium for induction of anaesthesia was the preferred technique in our study group. However Propofol and Sevoflurane can also be used. Several authors agree that inhalational induction should be used in children without venous access or when the use of pre-anaesthetic medication is contraindicated. There is also no consensus on the most suitable maintenance technique. Either total intravenous anaesthesia, inhalational anaesthesia or combined anaesthesia can be used. The anaesthesiologist should be aware of the possible adverse effects that such techniques might pose on cerebral haemodynamics and their implications in patients with increased intracranial pressure.

Anaesthesia for neuroendoscopy is a challenging task. Statistically significant bradycardia can occur, which needs anticipation and treatment including cessation of manipulation, egress of irrigating fluid and pharmacological treatment with atropine in extreme cases. Close communication between the neurosurgeon and the anaesthetist is extremely essential at these stages. More number of studies need to be performed on this fast evolving technique before practice guidelines can be laid down for anaesthetic management of neuroendoscopy.

CONCLUSION

In our study of 35 cases undergoing neuroendoscopic third ventriculostomy under general anaesthesia, we found In our study of 35 cases undergoing neuroendoscopic third ventriculostomy under general anaesthesia, we found that intraoperative fall in pulse rate was the commonest haemodynamic event. intraoperative fall in pulse rate was the commonest haemodynamic event. This was related to the three stages of the procedure- scope insertion, third ventriculostomy and removal of scope. However there were no clinically or statistically significant changes in blood pressure. The electrolyte changes were also of no clinical or statistical significance. We believe that either normal saline or lactated ringer solutions could be safely used for intraoperative irrigation with minimal postoperative impact. Fall in pulse rate with Fentanyl as compared to Pentazocine was statistically significant but more studies are needed to establish clinical correlation.

We conclude that close communication between the neurosurgeon and the anaesthesiologist is extremely essential in certain stages of the ETV for anticipation of bradycardia and that the choice of irrigant fluid made no difference to the serum electrolyte levels. More studies are needed to establish clinical correlation between the anaesthetic technique and haemodynamic changes.

ACKNOWLEDGEMENTS

We are thankful to Dr. Alok Sharma and the Department of Neurosurgery and Dr. Bharati Tendolkar, Professor and Head of Department of Anaesthesiology for helping us conduct and publish the study.

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