ISSN: 0975-3583, 0976-2833 VOL15, ISSUE 01, 2024

Complications related to sitting position during pediatric neurosurgery in tertiary health care centre

Authors and Affiliations:

Khantal Nikhil[1], Kankane Kumar Vivek[2]

[1] Senior Resident, Gajra Raja Medical College, Department of Neurosurgery, Gwalior

[2] Associate Professor, Gajra Raja Medical College, Department of Neurosurgery, Gwalior

Corresponding Author:

Dr Avinash Sharma

Professor, Gajra Raja Medical College, Department of Neurosurgery, Gwalior, Madhya Pradesh, India

Mobile No: 7879782607

E-mail: nikhil.khantal@gmail.com

Running title: Complications related to sitting position during pediatric Neurosurgery in tertiary health care centre

Work attributed to: Department of Neurosurgery, Gajra Raja Medical College, Gwalior, Madhya Pradesh, India

Author's contribution:

KN- Definition of intellectual content, Literature survey, Prepared first draft of manuscript, Implementation of study protocol, data collection, data analysis, manuscript preparation and submission of article, **KVK-** Concept, design, clinical protocol, manuscript preparation, editing and revision **SA-** Review manuscript, preparation of tables and graphs, Coordination and manuscript revision

Conflicts of interest: Nil

Source of funding: There was no financial support concerning this work.

Ethical committee approval - Letter No. 1016, dated 13/03/2021

ORCID ID:

Nikhil Khantal: https://orcid.org/0009-0006-5129-6720

Vivek Kumar Kankane: https://orcid.org/0000-0001-9068-7886

Avinash Sharma: https://orcid.org/0000-0002-2178-3070

ABSTRACT

Background: The utilization of the sitting position in pediatric posterior fossa surgeries is favored for its enhanced anatomical orientation and improved visibility of the surgical field. Nonetheless, its application has experienced a decline due to the associated risk of life-threatening complications. This research seeks to examine the perioperative complications and postoperative outcomes in children undergoing neurosurgery in the sitting position. The investigation aims to provide insights into the safety and efficacy of this approach, considering factors such as patient demographics, specific surgical procedures, complications, and potential risk mitigation strategies. By conducting a thorough analysis, this study aims to contribute valuable information to the field of pediatric neurosurgery and guide future improvements in surgical practices.

Aims and Objectives : The objective of this study is to know anesthetic and surgical techniques, in which sitting position can safely be practiced in children undergoing neurosurgery

Materials and methods: The medical records of 50 pediatric patients who underwent neurosurgery in the sitting position within a two-year timeframe were retrospectively examined. The analysis encompassed various perioperative aspects, including demographic details, hemodynamic fluctuations, different complications, lengths of intensive care unit (ICU) and hospital stays, and the neurological condition upon discharge. This thorough investigation sought to provide a comprehensive understanding of the factors related to neurosurgery in the sitting position for pediatric cases, employing statistical methods to identify meaningful patterns or correlations within the recorded variables.

Results: The median age of these children was 12 (3–18) years. Hemodynamic instability was observed in 6 (12%) children. Venous air embolism (VAE) were encountered in 10 (20%) children; nine experienced multiple episodes. VAE was associated with hypotension in 20% and desaturation in 10% children. Five children presented with postoperative tension pneumocephalus; three were managed with twist drill burr hole evacuation. Brainstem handling was the most common indication (42%) for the requirement of elective postoperative ventilation. The duration of ICU and hospital stays were comparable among the children who experienced VAE and those who did not ($P > 0.05$).

Conclusions: The findings of this study revealed a lower occurrence of venous air embolism (VAE) and its related complications. Successful management of tension pneumocephalus was achieved without any adverse outcomes. Consequently, the study suggests that, with careful attention to anesthetic and surgical techniques, the sitting position can be safely employed in children undergoing neurosurgery. These results emphasize the importance of precision in both the anesthesia and surgical procedures to mitigate potential risks associated with the sitting position, supporting its continued use in pediatric neurosurgical cases.

Keywords: posterior fossa surgery, sitting position,Anaesthesia complication

INTRODUCTION

Surgery involving the posterior cranial fossa and posterior cervical spine poses a unique challenge regarding surgical exposure. To access these specific surgical sites, surgeons may opt for the sitting, lateral, or prone position, each of which comes with its set of advantages and disadvantages.. At times, neurosurgeons prefer the sitting position because it allows better anatomical orientation and physical access to the lesion, improved venous drainage and gravitational drainage of cerebrospinal fluid (CSF), and better hemostasis as accumulated blood drains away from the operative site. [1-4] Likewise, the sitting position offers advantages for anesthesiologists by facilitating improved access to critical areas such as the endotracheal tube (ETT), chest wall, and extremities. This positioning also allows for more unrestricted diaphragmatic movements, resulting in lower airway pressure requirements for chest wall expansion. Additionally, the sitting position enables enhanced visibility of the patient's face, aiding in the observation of signs indicating surgical stimulation of cranial nerves during procedures involving cranial nerve monitoring.Despite the above-mentioned benefits, the use of sitting position has declined worldwide because of the potential life-threatening complications it may be associated with, such as venous air embolism (VAE), paradoxical

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE 01, 2024

air embolism (PAE), and tension pneumocephalus.[5-7] Although several studies have demonstrated the relative safety of sitting position for neurosurgery,[8,9] its use continues to remain controversial. The practice of conducting posterior fossa surgery in the sitting position persists in numerous countries, spanning both adult and pediatric patients. In our institution, the adoption of the sitting position is contingent upon the preference of the neurosurgeon. We maintain the perspective that the sitting position presents several advantages, and with reasonable risks, it remains a viable option even for pediatric patients. The primary objective of this study was to comprehensively examine the perioperative complications and postoperative progression in children who underwent neurosurgery while positioned in the sitting posture.

AIMS AND OBJECTIVES

The objective of this study is to know anesthetic and surgical techniques, in which sitting position can safely be practiced in children undergoing neurosurgery

MATERIAL AND METHODS

The available medical records of all children up to the age of 18 years who underwent neurosurgery in the sitting position within a two-year period (July 2021 to June 2023) were thoroughly analyzed. The data collection process involved a detailed review of preanesthetic evaluation, intraoperative procedures, and postoperative outcomes for each child. Preoperative data encompassed physical characteristics such as age, sex, weight, American Society of Anesthesiologists (ASA) physical status, associated medical illnesses, hemoglobin concentration, serum electrolytes, and radiological diagnoses. Routine screening for a patent foramen ovale was not conducted unless clinically indicated.

Intraoperative details included the anesthetic technique, fluids administered, blood loss, and blood transfusions. Various intraoperative complications such as hemodynamic alterations (bradycardia, tachycardia, hypotension, and hypertension), venous air embolism (VAE), and respiratory complications (bronchospasm, laryngospasm, accidental ETT dislodgement) were recorded. Postoperative parameters comprised indications for mechanical ventilation, duration of ventilation, incidence of reintubation, surgical complications, fever, seizures, duration of intensive care unit (ICU) and hospital stay, and neurological status at discharge.

A standardized anesthetic protocol was uniformly applied to all children. Premedication involved oral atropine or intramuscular glycopyrrolate. Anesthesia induction was carried out via either intravenous (IV) or inhalational techniques based on the availability of an IV cannula. Tracheal intubation utilized a reinforced ETT facilitated by nondepolarizing muscle relaxants. Anesthesia maintenance included O_2:N_2O (40:60), isoflurane or sevoflurane (MAC 0.8–1.2), and intermittent boluses of vecuronium and fentanyl. Nitrous oxide was discontinued when VAE was suspected. Mechanical ventilation without positive end-expiratory pressure was employed to maintain mild hypocapnia to normocapnia.

Monitoring involved heart rate, ECG, pulse oximetry (SpO_2), noninvasive and invasive blood pressure (NIBP and IBP), central venous pressure (CVP), $EtCO_2$, MAC, temperature, and urine output. Transesophageal echocardiography (TEE) was used based on availability and anesthesiologist preference. Leg wrapping with a compression bandage was introduced post-

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE 01, 2024

2005 to prevent blood pooling in the legs. After induction, children were preloaded with 10 ml/kg of crystalloids before gradually moving into the sitting position over 5 minutes, with continuous blood pressure monitoring.

RESULTS

The analysis involved reviewing the medical records of 50 children who underwent various neurosurgical procedures in the sitting position over a two-year period (July 2021 to June 2023). The median age of these children ranged from 3 to 18 years, with a median age of 12 years. All children belonged to ASA physical status I and II, and none showed clinical evidence of septal heart defects. Venous air embolism (VAE) occurred in 20% of the cases.

Given that sagittal sinus pressure remains positive in children up to the age of 9 years even in the sitting position, the incidence of VAE was compared between children aged 2 to 9 years and those above 9 years. However, the incidence was found to be comparable between the two groups. There were a total of 19 separate VAE episodes in 10 children, with a maximum of three episodes in a single child. Of the 10 children with VAE, 42% experienced more than one episode, predominantly during procedures involving cerebellar tumors, brainstem gliomas, and third ventricular tumors. One child had VAE during the decompression of foramen magnum for Chiari malformation type I.

VAE was associated with hypotension in 24% of cases and desaturation with $SpO_2 \leq 95\%$ in 8% of cases among the children who experienced VAE. The maximum drop in saturation (85%) was observed only in children with multiple VAE episodes. Intraoperative transesophageal echocardiography (TEE) was used in 4 children, and all VAE episodes were detected when both TEE and $EtCO_2$ were used.

Management of VAE included informing the neurosurgeon, covering the surgical field with saline-soaked sponges, switching patients to 100% oxygen, and aspirating air from the central venous catheter. Jugular compression was not required, and intravenous fluid boluses or vasopressors were administered when VAE was associated with hypotension.

Intraoperative hemodynamic instability unrelated to VAE occurred in 12% of children, mainly manifested as bradycardia, tachycardia, and occasional ventricular premature beats due to tumor manipulation near the brainstem. These instabilities resolved spontaneously after the cessation of surgical stimulation.

Postoperatively, 48% of children required elective ventilation, with 10 of them having experienced intraoperative VAE. However, VAE was not the primary indication for elective ventilation. The most common reason for postoperative ventilation was brainstem handling (42%), while other indications included preoperative lower cranial nerve palsy, disorientation, and the presence of residual tumor.

Intraoperative blood loss ranged from 2 to 80 ml/kg (median 6 ml/kg), and 24% of children required intraoperative transfusion of blood and blood products. Twelve percent of children

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE 01, 2024

needed transfusion of more than 10 ml/kg of blood. Tension pneumocephalus occurred in 10% of children and was managed conservatively. Two children with delayed recovery from anesthesia underwent twist drill burr hole evacuation, while one child who became drowsy and desaturated postoperatively underwent endotracheal intubation and twist drill burr hole evacuation of pneumocephalus.

Six children developed pneumoventricle in the postoperative period, with two having pneumoventricle in association with tension pneumocephalus. One child developed acute subdural hematoma (SDH) postoperatively, requiring surgical intervention. Reintubation was necessary in 10% of children due to various reasons such as altered sensorium, pulmonary edema, seizures following tension pneumocephalus, and SDH.

Other complications included postoperative fever, meningitis, hydrocephalus, CSF leak, and pseudomeningocele. One child required surgical re-exploration due to the development of postoperative SDH. Except for tension pneumocephalus, no other morbidities associated with the sitting position, such as macroglossia, quadriplegia, and peripheral nerve injury, were observed.

The median duration of ICU stay was 87 hours (range: 6–720), and the mean duration of hospital stay was 12.8 ± 6.2 days. There was no significant difference in the incidence of postoperative complications between children with VAE and those without it, and no mortality could be attributed to VAE.

Table 1: Gender Distribution

Gender	No. of patients
Male	35
Female	15

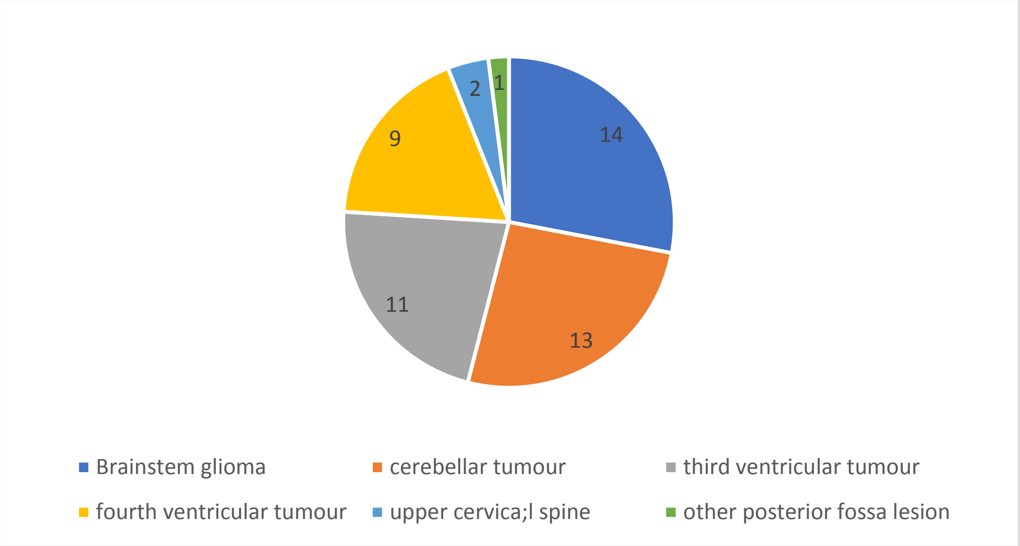

Figure1: Neurosurgical diagnosis of children

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE 01, 2024

Table 2: Post operative complication

COMPLICATION	PATIENTS
Reintubation	5
Tension pneumocephalus	5
Meningitis	3
Seizures	1
Post operative hydrocephalus	2
CSF leak	3
Reexploration	2
Sepsis	1
Electrolytre imbalance	2

DISCUSSION

The use of the sitting position for neurosurgery remains a topic of controversy, echoing the skepticism that surrounded its introduction by De Martel in 1931.
[10]While the utilization of the sitting position in neurosurgery is experiencing a decline, certain centers globally continue to adopt this approach due to its unique advantages. In our hospital, this positioning is primarily employed for posterior fossa surgeries, excluding its use in upper cervical spine procedures. The primary apprehension associated with the sitting position revolves around venous air embolism (VAE) and its consequences. However, defining the true incidence of VAE is challenging as it relies on the sensitivity of the detection method employed. Notably, the reported incidence of VAE in adults, particularly when detected using transesophageal echocardiography (TEE),[11] has been documented at
and when detected by a precordial Doppler was 50%.[12] Several articles have reported the incidence of VAE occurring during the sitting position in adults; however, there are only a limited number of studies reporting its incidence in children. A wide range of incidence in children has been proposed (9.3–33%), which is certainly less as compared to the adults.[8,13-15] The variation in reported incidences of venous air embolism (VAE) can be attributed to several factors, including differences in the monitoring methods used for VAE detection, the diverse age groups studied, the impact of age on cerebral sinus pressure, the practice of preloading patients, the utilization of antistatic stockings, and variations in the sitting (or lounging) positions adopted. Additionally, the nature of the study, whether prospective or retrospective, may also influence the observed incidence of VAE during surgeries conducted in the sitting position. Notably, two prospective studies suggested that the incidence of VAE in children, based on end-tidal carbon dioxide (EtCO2) monitoring, ranged from 22% to 26.3%, respectively. [13,14] In our study, the incidence of VAE was 20%, a result which was similar to that seen in both of these studies. However, Harrison et al.,[8] reviewed 407 children in the age group of 1.5 months to 17 years and observed a much lower incidence of VAE (9.3%), as detected by EtCO2 . The authors attributed the lower incidence of VAE detected in children to the presence of relatively higher dural sinus pressure in children as compared to the adults. On the contrary, Matjasko et al.,[16] reported an incidence of 62% of VAE in children by Doppler and capnometry as compared to 23% in adult patients.

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE 01, 2024

In the context of this study, it's crucial to acknowledge the considerable variability in the patient population, which predominantly consisted of adults. The use of transesophageal echocardiography (TEE) as a routine monitoring method might have resulted in a higher detected incidence of venous air embolism (VAE) in this study. Additionally, an essential aspect to consider is whether the entire spectrum of VAE detected by TEE would have been clinically significant. This evaluation prompts a closer examination of the potential clinical relevance of all instances of VAE identified through TEE. Iwabuchi et al.,[17] examined dural sinus pressure [confluens sinus pressure (CSP)] in 47 cases (11 were children). In the sitting position, adults exhibited a negative cerebral sinus pressure (CSP), while all children aged ≤9 years (n = 8) demonstrated a positive CSP pressure. This observation suggests that the positive CSP in younger children might contribute to the lower incidence of venous air embolism (VAE) in this age group. Grady et al. [18] studied the relationship of superior sagittal pressure (SSP) to head position in 15 children (within the age range of 1–17 years) and concluded that progressive head elevation significantly decreased the mean SSP in 5 patients; however, they did not mention the age group of these children. We did not find any significant difference in the incidence of VAE in children above or below 9 years of age, which is in accordance with the findings of our previous study.[13] There is a hypothesis that the incidence of VAE associated with hypotension in children might be higher than in adults. This is because an equivalent size of air bubble would be larger relative to the small cardiac volume in children, thus causing pronounced hypotension. This hypothesis was supported by Cucchiara and Bowers[15] as they retrospectively reviewed 96 patients undergoing suboccipital craniotomy in sitting position. They observed that the incidence of VAE associated with hypotension (fall in systolic arterial pressure more than 25 mmHg) was greater in children (69%) than in adults (36%). However, there are three prospective studies in pediatric patients reporting conflicting results. Meyer et al.,[14] observed that severe hypotension (fall in mean arterial pressure more than 25 mmHg) occurred in all 60 children with VAE, as detected by capnometry. However, Fuchs et al.,[19] did not observe any child developing hypotension associated with VAE in a series of 30 children. Bithal et al.,[13] reported that the incidence of VAE associated with hypotension was similar in both adults (37%) and children (33%). Our results were comparable to the results of the study by Harrison et al.,[8] who reported an incidence of 20% of VAE associated with hypotension. The presence of preexisting hypovolemia, even in mild form, increases the susceptibility of patients to venous air embolism (VAE) and the associated hypotension. It is particularly crucial to maintain adequate intravascular volume in children, given that air bubbles in their relatively smaller right atrium may lead to more frequent cardiovascular changes compared to adults.

Glenski et al.,[20] have shown that transcutaneous oxygen tension monitored in neurosurgical patients provided an earlier and more reliable indication of VAE than did $EtCO_2$, but no direct study has suggested that changes in SpO_2 may be regarded as an early manifestation of VAE in humans. In this study, oxygen desaturation was observed only in those patients who experienced multiple episodes of VAE. It may be hypothesized that an acute air embolism which is superimposed on an earlier incompletely resolved embolism might have caused a further increase in $PaCO_2$. This combination of an elevated $PaCO_2$ together with venous admixture resulted in clinically significant arterial desaturation. Nevertheless, in none of the

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE 01, 2024

children was the surgical position changed or the surgery was abandoned owing to the occurrence of VAE, which implies that this complication is quite manageable. The sitting position may reduce blood loss by facilitating drainage of venous blood away from the operating site.[2] Black et al.,[21] reported in adult patients that intraoperative blood loss and volume of blood transfused were significantly lesser in patients undergoing posterior fossa craniectomy in sitting position as compared to those operated in horizontal position. In our study, blood loss was relatively lesser (6 ml/kg); only one patient had massive blood loss (80 ml/kg), as the tumor was large and highly vascular. Orliaquet et al.,[22] compared perioperative complications in children undergoing posterior fossa surgery in sitting and prone positions and concluded that the volume of intraoperative blood transfusion was significantly larger in the prone position as compared to the sitting position. Intraoperative hemodynamic instabilities can occur during surgery conducted in sitting position, particularly, during positioning, episodes of VAE, and brainstem or cranial nerve handling. Harrison et al. [8] documented the occurrence of intraoperative hemodynamic instabilities (excluding those related to venous air embolism in 24% of children undergoing posterior fossa surgery in the sitting position. However, the incidence reported in their study was notably higher than that found in our investigation This difference could potentially be attributed to variations in the criteria used to define hemodynamic instability; the two studies employed different thresholds (10% vs. 20% change in heart rate or systolic blood pressure).

In our study, a substantial proportion (10%) of children required postoperative mechanical ventilation. It has been recommended that extubation in children undergoing posterior fossa surgery should only be considered after confirming the integrity of bulbar and lower cranial functions, in addition to ensuring adequate recovery from anesthesia. Otherwise, the child should be kept intubated for 24 hours. Notably, the children presenting to our hospital often have large tumors at the time of admission, as our institution serves as an apex referral center. The challenging dissection of these large tumors during surgery increases the likelihood of intraoperative brainstem handling.

The development of tension pneumocephalus is identified as a severe and life-threatening emergency. This complication has been linked to factors such as the reduction of brain volume due to mannitol administration, hyperventilation, removal of space-occupying masses, and contraction of intravascular blood volume resulting from intraoperative hemorrhage. The practice of intraoperative drainage of cerebrospinal fluid, commonly via subarachnoid drainage, combined with the gravitational effect of the sitting position, may elevate the risk of air entry into the subdural space.

Lunsford et al. [23] introduced the "inverted pop bottle" analogy to illustrate the phenomenon of tension pneumocephalus. Symptoms of tension pneumocephalus may manifest 2–4 hours after surgery, presenting as delayed recovery, severe restlessness, consciousness deterioration, and seizures. The incidence of symptomatic tension pneumocephalus in our study resembled that found in the investigation conducted by Orliaquet et al. [22], where most children had a preoperative ventriculoperitoneal (VP) shunt installed. Both studies suggested that, in children with a similar clinical profile, the use of the sitting position should be avoided.

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE 01, 2024

Postoperative seizures are relatively uncommon in posterior fossa surgery. In our study, one children experienced seizures due to tension pneumocephalus, aligning with the hypothesis proposed by Suri et al. [24].

While macroglossia is a recognized but infrequent complication of neurosurgical procedures in the sitting position, none of the children in our study exhibited macroglossia. This might be attributed to the use of a soft (cotton) bite block, preventing compression of the tongue by the teeth, and maintaining an adequate distance between the chin and sternum.

Peripheral nerve injuries have been reported in association with the sitting position for neurosurgery. In a series of 488 patients, the incidence of peripheral nerve injury (specifically, foot drop following common peroneal nerve injury) was reduced when a VP shunt was in place in children. This suggests that the presence of a VP shunt may mitigate the incidence of tension pneumocephalus.

The study also noted a decreased need for blood transfusion in children operated upon in the sitting position. Overall, the reported intraoperative complications in this study were minimal. Hence, with careful anesthetic and surgical planning, the sitting position can be safely employed in pediatric patients.

REFERENCES

1. Albin MS, Babinski M, Maroon JC, Janetta PJ. Anaesthetic management of posterior fossa surgery in the sitting position. Acta Anaesth Scand 1976;20:117-28.
2. Black S, Cucchiara RF. Tumor Surgery In: Cucchiara RF, Michenfelder JD, editors. Clinical Neuroanesthesia. Edinburgh: Churchill Livingstone; 1990.p. 285-308.
3. Drummond JC, Patel PM. Neurosurgical Anaesthesia. Miller RD, editors. Anesthesia. 7th ed. Philadelphia: Churchill Livingstone; 2010. p. 2045-88.
4. Duke DA, Lynch JJ, Harner SG, FaustRJ, Ebersold MJ, et al. Venous air embolism in sitting and supine patient undergoing vestibular schwannoma resection. Neurosurgery 1998;42:1282-6.
5. Elton RJ, Howell RS. The sitting position in neurosurgical anaesthesia: A survey of British practice in 1991. Br J Anaesth 1994;73:247-8.
6. Leonard IE, CunninghamAJ. The sitting position in neurosurgery-not yet obsolete! Br J Anaesth 2002;88:1-3.
7. Liutkus D, Gouraud JP, Blanloeil Y. The sitting position in neuro-surgical anaesthesia: A survey of French practice. Ann Fr Anesth Reanim 2003;22:296-300.
8. Harrison EA, MackersieA, Ewan MC, Facer E. The sitting position for neurosurgery in children: A review of 16 years' experience. Br J Anaesth 2002;88:12-7.
9. Rath GP, Bithal PK, ChaturvediA, Dash HH. Complications related to positioning in posterior fossa craniectomy. J Clin Neurosci 2007;14:520-5.
10. DeMartel T. Surgical treatment of cerebellar tumors: Technical considerations. Surg Gynecol Obster 1931;52:381-5.

11. Mammato T, Hayashi Y, Kuro M. Incidence of venous and paradoxical air embolism in neurosurgical patients in the sitting position: Detection by transesophageal echocardiography. Acta Anaesth Scand 1998;42:643-7.
12. Voorhies RM, Fraser AR, Van Poznak. Prevention of air embolism with positive end expiratory pressure. Neurosurgery 1983;12:503-6.
13. Bithal PK, Pandia MP, Dash HH, ChouhanRS, MohantyB, Padhy N. Comparative incidence of venous air embolism and associated hypotension in adults and children operated for neurosurgery in sitting position. Eur J Anaesthesiol 2004;21:517-22.
14. Meyer PG, Cuttarree H, Charron B, Jarreau MM, Perie AC, Sainte-Rose C. Prevention of venous air embolism in paediatric neurosurgical procedures performed in sitting position for combined use of MAST suit and PEEP. Br J Anaesth 1994;73:795-800.
15. Cucchiara RF, Bowers B. Air embolism in children undergoing suboccipital craniotomy. Anesthesiology 1982;57:338-9.
16. Matjasko J, Petrozza P, Cohen M, Steinberg P. Anesthesia and surgery in seated position: Analysis of 554 cases. Neurosurgery 1985;17:695-702.
17. Iwabuchi MS, Sobata E, Ebina K, Tsubakisha H, Takiguchi M. Dural sinus pressure: Various aspects in human brain surgery in children and adults. Am J Physiol 1986;250:389-96.
18. Grady MS, Bedford RF, Park TS. Changes in superior sagittal pressure in children with head elevation, jugular venous compression and PEEP. J Neurosurg 1986;65:199-202.
19. Fuchs G, Schwarz G, Stein J, Kaltenbock F, Baumgartner A, Oberbauer RW. Doppler color flow imaging: Screening of a patent foramen ovale in children scheduled for neurosurgery in sitting position. J NeurosurgAnesthesiol 1998;10:5-9.
20. Glenski JA, Cucchiara RF, Michenfelder JD. Transesophageal echocardiography and transcutaneous O2 and CO2 monitoring for detection of VAE. Anesthesiology 1986;64:541-5.
21. Black S, Ockert DB, Oliver WC Jr, Cucchiara RK. Outcome following posterior fossa craniectomy in patients in the sitting or horizontal positions. Anesthesiology 1988;69:49-5.
22. Orliaquet GA, Hanafi M, Meyer PG, Blanot S, Jarreau MM, Bresson D, et al. Is the sitting or the prone position best for posterior fossa tumors in children? Paediatr Anaesth 2001;11:541-7.
23. Lunsford LD, Maroon JC, Sheptak PE, Albin MA. Subdural tension pneumocephalus: Report of two cases. J Neurosurg 1979;50:525-7.
24. Suri A, Mahapatra AK, Bithal P. Seizures following posterior fossa surgery. Br J Neurosurg 1998;12:41-4.