SURGERY

Exploring anesthesia-related complications in pediatric neurosurgery: a comparative analysis of the sitting and park-bench positions

Oana Maria Radu[1,2], Georgeta Magdalena Balaci[2], Daniel Corneliu Leucuța[3], Ioan Ștefan Florian[1,2]

1) Department of Neurosurgery, Iuliu Hatieganu University of Medicine and Pharmacy, Cluj-Napoca, Romania

2) Clinic of Neurosurgery, Cluj County Emergency Clinical Hospital, Cluj-Napoca, Romania

3) Department of Medical Informatics and Biostatistics, Iuliu Hatieganu University of Medicine and Pharmacy, Cluj-Napoca, Romania

DOI: 10.15386/mpr-2788

Manuscript received: 09.08.2024
Received in revised form: 25.08.2024
Accepted: 15.09.2024

Address for correspondence:
Daniel-Corneliu Leucuța
dleucuta@umfcluj.ro

Abstract

Background and aims. The purpose of this study is to analyze the sitting position and the park-bench position for intra-anesthesia complications in pediatric patients undergoing neurosurgery for posterior fossa lesions. Our goal is to highlight the risks associated with each of these positions under general anesthesia to aid in clinical decision making for optimal patient outcomes with regard to postoperative complications.

Methods. We retrospectively reviewed 41 pediatric patients (1 to 18 years old) undergoing posterior fossae surgery in the sitting (32) and park-bench (9) positions between January 2015 and December 2021. The majority of patients (15) who underwent surgery in the sitting position had fourth ventricular tumors (28.12%) and cerebellopontine tumors (18.76%) that required the sitting position.

Results. Of 32 patients operated on in the sitting position, 23 (71.78%) developed anesthetic complications, compared to 8 patients in the park-bench group (88.89%). Venous air embolism occurred in only 6.25% of patients in the sitting group. Compared to the sitting position, no cases of gas embolism were documented in the park-bench position. However, transient episodes of gas embolism cannot be excluded due to the higher incidence of hemodynamic instability (44.44%), need for additional fluid therapy (44.44%) and vasopressor support (11.11%), decreased CO_2 (22.22%) and oxygen desaturation (22.22%). Patients who underwent surgery in the sitting position had a longer duration of surgery [247.5 min IQR (172.75 - 325.25)] and a longer duration of anesthesia [331 min IQR (237.5 - 423.25)]. Pneumocephalus (4, 12.5%) and postoperative hematoma (3, 9.38%) were the most common postoperative complications in patients who underwent surgery in the sitting position. In the park-bench group, three patients had postoperative complications, including postoperative hematoma (2, 25%) and hydrocephalus (1, 12.5%).

Conclusions. The incidence of anesthetic complications is lower in the sitting position compared to the park-bench position. Although there was no documented gas embolism in the park-bench position, the lower rate of venous air embolism in the sitting position may suggest a better control or a lower risk in this position. However, the sitting position has a less frequent occurrence of hemodynamic instability than the park-bench position.

Keywords: anesthesia, pediatric neurosurgery, sitting position, park-bench position, hemodynamic complications, venous air embolism

Introduction

The unique anatomical, physiological, and developmental characteristics of pediatric patients require careful consideration of positioning during posterior fossa surgeries. Patient positioning is an important aspect of anesthesia care, and considering the physical and physiological effects of positioning is crucial to prevent serious complications. The sitting and park-bench positions are two widely used positioning techniques during neurosurgical procedures.

The sitting position provides excellent surgical exposure for posterior fossa surgeries. It is therefore renowned for its advantages, such as optimal anatomical orientation, gravity-assisted blood and cerebrospinal fluid (CSF) drainage, reduced bleeding, better ventilation, access to the endotracheal tube and thorax, as well as the possibility to observe facial contractility during direct cranial nerve stimulation. However, the sitting position carries certain risks, including hemodynamic instability, venous air embolism (VAE), and pneumocephalus. Additionally, there are potential complications related to positioning, such as swelling of the tongue or larynx, sciatic nerve elongation, and quadriparesis [1-3]. Suboccipital craniotomy or craniectomy carries the highest risk, whereas cervical spine procedures tend to have lower complication rates. Intradural cervical cases pose considerably greater risks in comparison to extradural cases [4].

Conversely, the park-bench position, a lateral decubitus orientation, is frequently employed for its ability to lower the risk of VAE. However, it is not without challenges, including delayed airway obstruction resulting from neck swelling, potentially attributed to jugular vein kinking due to extreme neck flexion. Additionally, brachial plexopathy may appear as a complication of brachial plexus injury, pressure sores, vascular compression, and the possibility of vision loss [5,6].

Managing anesthesia in pediatric neurosurgery is complex, as the delicate interaction between anesthesia and surgical positioning increases the risk of complications, which can vary from hemodynamic instability and respiratory problems to metabolic disturbances [7]. Therefore, the choice of patient positioning can amplify these risks: the sitting position may increase the likelihood of hypotension and venous air embolism, while the park-bench position could result in impaired ventilation and elevated intracranial pressure, requiring careful patient selection, skilled surgical and anesthesia teams, and tailored anesthetic approaches to guarantee patient safety [8]. Caution is advised for patients with cardiovascular events, hypertension, moderate to severe cervical stenosis, and intracardiac shunts [9].

This retrospective cohort study is motivated by the need to understand how surgical positioning affects anesthesia-related complications in pediatric neurosurgery. By comparing anesthesia complications associated with the sitting and park-bench position, we aim to address the existing gap and provide evidence to improve anesthetic management and enhance perioperative care for pediatric neurosurgery patients.

Patients and methods

A retrospective cohort study was conducted at the Neurosurgery Department of the Emergency County Hospital Cluj-Napoca. The study covered the period between January 2015 and December 2021; and informed consent was waived due to its retrospective nature. However, the legal representatives of children aged 1-17, as well as children aged 18 years, provided permission and informed consent for the administration of anesthesia and surgical procedures. These permissions had been recorded in the medical records. Forty-one (41) patients, both male and female, aged 1 to 18 and classified as American Society of Anesthesiologists (ASA) score I-II-III, were enrolled for posterior fossa surgery performed in either the sitting or park-bench position under general anesthesia. Exclusion criteria were as follows: (1) patients classified as ASA grade IV or those with systemic diseases unrelated to the central nervous system (CNS) such as cardiac, renal, or respiratory conditions, (2) patients with incomplete medical records, (3) surgeries conducted in positions other than sitting or park-bench. Data were collected from the patients' medical records, including preoperative, intraoperative, and postoperative records.

Data variables collected included:

• Demographic data: age, gender, weight, and classification of physical health based on the criteria set by the ASA

• Surgical data: diagnosis, type of surgical approach, duration of surgery, and surgical position (sitting vs. park-bench)

• Anesthesia data: type of anesthesia used, duration of anesthesia, airway management techniques, measures for volume therapy (volume expanders and vasopressor medication), and medication for bradycardia (anticholinergic drugs)

• Complications data: intraoperative complications (hypotension, bradycardia, venous air embolism), postoperative complications (pneumocephalus, postoperative hematoma, hydrocephalus), and any other adverse events related to anesthesia (nausea, headache, vomiting).

The preoperative evaluation involved a neurological examination to assess the patients' neurological status, with special attention given to lower cranial nerves paresis, given a possible postoperative tracheostomy. When necessary, a cardiac consultation was conducted to exclude patent foramen ovale (PFO), a contraindicated condition of the sitting position. In the case of intracranial hypertension, commonly associated with posterior fossa tumors, brain computer tomography (CT) scans were performed to detect hydrocephalus and the possibility of external ventricular drainage. When dehydration and electrolyte imbalance were present, volume therapy and hydro-electrolyte rebalancing were necessary.

Pulse-oximetry, capnography, temperature measurement, electrocardiogram, and blood pressure monitoring are the non-invasive measures used for intraoperative monitoring. The invasive measures consisted in a central venous line inserted into the right subclavian vein to ensure rapid administration of volume therapy and manage the VAE, 2-3 peripheral venous lines, and a urinary catheter for diuresis monitoring.

We administered general anesthesia, performing orotracheal intubation with a flexible metallic endotracheal tube and maintained anesthesia using sevoflurane at 1 MAC in a mixture of air and oxygen. We administered Atropine (0.01-0.02 mg/kg) to manage secretions and Midazolam (0.1-0.2 mg/kg) for mild sedation. Propofol (2-4 mg/kg) was used to induce hypnosis, while Fentanyl (1-5 mcg/kg) was given to minimize discomfort during intubation. Atracurium (0.3-0.6 mg/kg) was used for muscle relaxation. All dosages were adjusted within recommended limits by the anesthesiologist to meet the individual needs of each patient.

Head holders or supports were used to secure the head in both the sitting and park-bench positions. Proper padding and compressive stockings were used to prevent pressure injuries and to maintain venous return. Extra care were taken in the sitting position to keep the airway secure to avoid respiratory risks. Adequate support for the chest and abdomen in the park-bench position was provided for proper ventilation and to avoid abdominal compression. Continuous assessment and adjustment during surgery were useful to prevent complications and maintain optimal positioning.

The VAE diagnosis was established through carefully monitoring of End-Tidal CO_2 ($EtCO_2$), which indicated a reduction of over 2 mm Hg, concomitant with hypoxia and hemodynamic instability, resulting in hypotension, and bradycardia.

Concerning brainstem, cerebellopontine angle, and cranio-spinal junction tumors, we made use of intraoperative neurophysiological monitoring. Therefore, adjustments to the dosage of anesthetic agents were necessary. Anesthesia was administered either by inhalation or intravenously, under Bispectral Index (BIS) monitoring, thus avoiding interference with somatosensory evoked potentials. Additionally, when monitoring evoked motor potentials, total intravenous anesthesia was used, deliberately refraining from administering neuromuscular blockers. To monitor muscle relaxation progress, we used Train of Four (TOF).

Intraoperatively, for patients with elevated intracranial pressure, we opted for total intravenous anesthesia with Propofol. We administered 20% Mannitol or hypertonic saline during the surgical procedures to manage any signs of increased intracranial pressure, while carefully maintaining normothermia and monitoring blood loss and volume status.

Neurologically intact patients underwent smooth extubation. Hypertension was managed with care to prevent bleeding complications. Preemptive measures were taken to address postoperative nausea, vomiting, and pain, especially during infratentorial approaches that involved muscle dissection.

The study was conducted in accordance with the 1964 Declaration of Helsinki and its later amendments. Data were anonymized prior to analysis to protect patient confidentiality. Qualitative data were presented as counts and percentages. Normally distributed quantitative data were presented as means and standard deviations. Non-normally distributed quantitative data were presented as medians and quartiles 1 and 3. Comparisons between two independent groups regarding qualitative data were performed using Fisher's exact test. Comparisons between two independent groups regarding quantitative data were performed with a t-test for independent samples (for normally distributed data) and a Wilcoxon rank-sum test (for non-normally distributed data). For all statistical tests, a 0.05 level of statistical significance was used. All statistical tests were two-sided. All analyses were performed in an R environment for statistical computing and graphics (R Foundation for Statistical Computing, Vienna, Austria), version 4.3.2 [R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing: Vienna, Austria; 2024].

Results

The study sample comprised 41 children with a mean age of 10 (4.5 standard deviation) years, ranging from 1 to 18 years old. Out of them, 32 (78%) were in the sitting position, and 9 (32%) were in the park-bench position. The two groups were comparable in terms of age and gender. There was a notable statistical difference between the two groups regarding the diagnosis, with all 9 (100%) park-bench position patients having pontine focal tumors of glial origin. The surgical approach was significantly different, the most frequent approach in the park-bench position being unilateral suboccipital, 5 (55.56%), while for the sitting position, the most frequent approaches were midline, 12 (37.5%) and retrosigmoid, 12 (37.5%). Of all patients, only 3 (7.3%), operated in the sitting position required decompressive craniectomy because of post-operative hematoma, 2 (4.9%) and brainstem ischemia, 1(2.4%). Additional information is available in table I.

Table I. Patient characteristics.

Variables	Sitting position n=32	Park-bench position n=9	P-value
Age (years), mean (SD)	9.81 (4.86)	10.67 (3.16)	0.623
Female, n (%)	15 (46.88)	4 (44.44)	1
Diagnosis, no (%)	32 (100%)	9 (100%)	0.005
Pineal region tumors	1 (3.12)	0 (0)	
Thalamo-mesencephalic tumors	1 (3.12)	0 (0)	
Bulbo-pontine tumors	1 (3.12)	0 (0)	
Cerebellopontine angle tumors, n (%)	6 (18.76)	0 (0)	
Trigeminal neuralgia	1 (3.12)	0 (0)	
Cerebellar tumors	6 (18.75)	0 (0)	
Fourth ventricle tumors	9 (28.12)	0 (0)	
Focal pontine tumors	4 (12.5)	9 (100)	
Arnold - Chiari Malformation	1 (3.12)	0 (0)	
Cranial-spinal junction tumors	1 (3.12)	0 (0)	
Intramedullary tumors C2-C4	1 (3.12)	0 (0)	
Surgical approach, n (%)	32 (100%)	9 (100%)	< 0.001
Supracerebellar infratentorial	2 (6.25)	0 (0)	
Retrosigmoid	12 (37.5)	2 (22.22)	
Unilateral suboccipital	0 (0)	5 (55.56)	
Unilateral paramedian	6 (18.75)	2 (22.22)	
Midline	12 (37.5)	0 (0)	
Craniotomy, n (%)	29 (90.6)	9 (100)	
Craniectomy, n (%)	3 (9.4)		

Table II. Influence of sitting and park-bench positioning on anesthesia, surgery duration, and hospitalization length.

Variables	Sitting position (n=32)	Park-bench position (n=9)	P-value
Total time surgery (min), median (IQR)	247.5 (172.75 - 325.25)	178 (167 - 328)	0.682
Anesthesia time (min), median (IQR)	331 (237.5 - 423.25)	243 (235 - 413)	0.603
Immediate post-op extubation, n (%)	21 (65.62)	7 (77.78)	0.692
Post-op ventilation (min), median (IQR)	0 (0 - 1020)	0 (0 - 0)	0.746
Intensive Care Unit hospitalization (days), median (IQR)	0 (0 - 4)	0 (0 - 0)	0.467
Duration of hospitalization (days), median (IQR)	8.5 (7 - 11.25)	9 (8 - 10)	0.783

Patient positioning may impact anesthesia procedure duration, surgery duration, and hospitalization length, which can vary significantly across hospitals. In contrast to patients who were operated on in the park-bench position, those who were operated on in the sitting position experienced a longer period surgery [247.5 min (172.75 - 325.25)] and anesthesia time [331 min (237.5 - 423.25)]. The longer duration is related to the more complex measures during the proper positioning of the patient, the progressive elevation of the patients for preventing abrupt hypotension, and the placement of neurophysiologic monitoring electrodes. The retrosigmoid and midline approaches required the longest surgeries and anesthesia compared to all other surgical approaches. The number of patients immediately extubated postoperatively was lower for patients who were operated on in a sitting position (62.65%), and the length of time they spent in the intensive care unit increased to 4 days. The duration of hospitalization does not significantly differ between the two groups. The p-values for all metrics are above the conventional threshold of 0.05, indicating that there are no statistically significant differences between the sitting and park-bench positions in terms of total surgery and anesthesia times, immediate post-op extubation rates, post-op ventilation time, ICU hospitalization days, and duration of hospitalization (Table II). This suggests that the sitting position may not have a meaningful impact on these surgical and postoperative outcomes within this dataset.

Table III. Anesthetic-related complications between the sitting and park-bench position.

Variables	Sitting position (n=32)	Park-bench position (n=9)	P-value
Anesthetic complications*, n (%)	**23** (71.88)	**8** (88.89)	0.41
Hypertension, n(%)	4 (12.5)	3 (33.33)	0.165
Hypotension, n (%)	7 (21.88)	4 (44.44)	0.217
Tachycardia, n (%)	10 (31.25)	2 (22.22)	0.702
Bradycardia, n (%)	8 (25)	1 (11.11)	0.654
Decrease $EtCO_2$ > 2 mmHg, n(%)	11 (34.38)	2 (22.22)	0.692
Hypoxemia, n(%)	0 (0)	2 (22.22)	0.044
Venous air embolism, n(%)	2 (6.25)	0 (0)	1
Aspirated air (mL), median (IQR)	0 (0 - 0)	0 (0 - 0)	0.473
Fever, n(%)	4 (12.5)	1 (11.11)	1
Hydroelectrolytic disorders, n(%)	3 (9.38)	2 (22.22)	0.299
Colloid, n(%)	1 (3.12)	4 (44.44)	0.006
Vasoactive, n(%)	3 (9.38)	4 (44.44)	0.031
Atropine, n(%)	7 (21.88)	1 (11.11)	0.659

The various anesthetic complications that occurred in both groups during surgery were quantified, with the number and percentage of occurrences in each group, along with the corresponding p-values (Table III). 23 out of the 32 patients who had surgery in the sitting position experienced anesthesia complications. The most frequent anesthetic complications in this group include decreased $EtCO_2$ (11, 34.38%), tachycardia (10, 31.25%), bradycardia (8, 25%), and hypotension (7, 21.88%). Hypertension (4, 12.5%), fever (4, 12.5%), and hydroelectrolyte imbalance (3, 9.38%) are less common complications. VAE, the most feared complication of the sitting position, was diagnosed in only 2 patients (6.25%), and it was not associated with any postoperative morbidity and mortality.

Eight of the nine patients who underwent surgery in the park-bench position had a high incidence of anesthetic complications, the most common being blood pressure oscillations (arterial hypotension 4 (44.44%) patients; arterial hypertension 3 (33.33%) patients), hypoxemia (2, 22.22%), electrolyte imbalance (2, 22.22%) patients, and heart rate oscillations. Because of hemodynamic instability, these patients required volume therapy, whereas a smaller percentage of patients undergoing sitting surgery required volume therapy. Although several complications were measured, only hypoxemia, the use of colloids, and the use of vasoactive agents showed a statistically significant difference between the two groups with a p-value of less than 0.05.

None of these patients required blood transfusion intraoperatively. There was no tongue edema, and no evidence of peripheral neuropathy caused by the sitting position. The patient's mental status did not change, and there were no new onsets of motor or sensory deficits compared to their preoperative state. Hypoxemia does not appear to be affected by the sitting position; however, patients operated on in the park-bench position might be at a higher risk for this complication. The use of colloids and vasoactive agents is significantly higher in the park-bench group, indicating a potential need for more intensive management in that position. Other complications did not show significant differences, suggesting that the sitting position may not strongly influence those outcomes. This analysis can help clinical decisions regarding patient positioning during procedures to minimize complications.

The most frequent postoperative complications among patients who had surgery in the sitting position were pneumocephalus (4, 12.5%) and postoperative hematoma (3, 9.38%), and hydrocephalus (1, 3.12%). In the park-bench group, only three patients had postoperative complications, which included postoperative hematoma (2, 22.22%) and hydrocephalus (1, 11.11%). These complications required surgery. In both groups, there were two deceased: one from an exophytic brainstem tumor who developed ischemia, and another from a cerebellopontine angle tumor who had a postoperative hematoma.

Discussion

Monitoring vital signs and specific parameters is essential during neurosurgical interventions, especially in pediatric patients positioned in sitting or park-bench positions. Maintaining stable blood pressure is vital during neurosurgery. Hypertension can increase the risk of bleeding, particularly in delicate brain tissues, while hypotension can lead to inadequate cerebral perfusion, risking ischemia or damage to the brain. Therefore, careful blood pressure management is essential to ensure adequate blood flow to the brain. Changes in circulation during neuroanesthesia can occur rapidly and have significant consequences.

This is due to age-specific differences in physiology and anatomy, which result in cardiac output being more dependent on heart rate rather than on the volume of blood pumped. Anesthetic medication can also affect myocardial contractility, and alterations in patient position have been associated with various cardiovascular changes [10-12]. Blood pressure fluctuations can significantly affect cerebral blood flow in patients with neurosurgical pathology [13]. Pediatric patients may experience increased blood pressure due to position changes and sensitivity to head holder fixation, which can be managed by administering pain relief treatment. Compared to the sitting position, the park-bench position poses a risk of increased pain due to bone pressure and brachial plexopathy [14]. In this study, the presence of hypertension was associated with both pains arising from the manipulation of the head holder as well as pain due to bone pressure following the park-bench positioning in a percentage of 33.33%, compared to the sitting position where the percentage was significantly lower, 12.5%. Cardiovascular changes, including venous accumulation in the lower extremities, vasodilation, and myocardial depression associated with general anesthesia, can decrease average blood pressure, heart rate, cardiac preload, and cerebral perfusion pressure in the sitting position [15,16]. Dehydration and hypovolemia can cause hypotension. Maintaining an adequate intravascular volume is crucial for children because fluids administered intraoperatively must include the necessary maintenance and replacement of observed losses. Hypotension can be exacerbated by anemia. Transfusions are needed after 15% of the blood volume has been lost. Blood volume should be calculated preoperatively [17]. Taking all this into account, if there is a slight pre-existing hypotension, it may be aggravated by the change in position concerning the neurosurgical intervention to be performed. According to studies, children may have a higher incidence of VAE associated with low blood pressure during pediatric neurosurgery. Cuchiarra and Bowers found a higher incidence of VAEs associated with hypotension in children (69%) compared to adults (36%) in a retrospective study [18]. However, there are conflicting results from three prospective studies in children and adolescents. Meyer et al. observed severe hypotension in 60 children with VAE, while Fuchs et al. did not observe hypotension in 30 children with VAE, and Bithal et al. reported a similar incidence of VAE associated with hypotension in both adults (37%) and children (33%) [19,20,21]. Harrisson et al. reported that 20% of VAE cases were related to hypotension [22].

In this study, a potential link has been observed between hypotension in sitting patients, VAE occurrence, and dehydration due to anesthesia. Although VAE was not observed in the park-bench position, 44.44% of pediatric patients experienced hypotension due to other factors, as mentioned above. Permanent monitoring during position changes is essential for assessing the dehydration and hypovolemia degree, which is primarily done by clinical criteria. The well-known reason for avoiding sitting is the risk of VAE associated with hemodynamic instability. Dilmen et al. published a retrospective study in 2011 on 692 cases (601 adults and 92 children) operated in a sitting position [23]. They concluded that VAEs diagnosed via capnography had an incidence of 26.3% in children and 20.45 in adults, with the sitting position associated with more frequent hypotension in the adult population. In comparison with the above studies, hypotension in the paediatric population in the present study was 21.88% in the sitting position and 44.44% in the park-bench position. For this reason, the need for additional administration of colloid and vasopressor for correction of hypotension has been analysed between the two groups.

Hypothermia, pulmonary embolism, gas embolism, hyperventilation, extubation, apnea, cardiac arrest, circuit disconnection, and hypothyroidism are some of the causes that can lead to a decrease in $EtCO_2$. Gas embolism that occurs during neurosurgical interventions in patients with posterior fossa tumors can be diagnosed using $EtCO_2$ and capnography. $EtCO_2$ is a practical and convenient method but is not sensitive to other investigations. A decrease in oxygen saturation in arterial blood and hypercapnia accompanies a low level of $EtCO_2$ in anesthetized patients. The recorded $EtCO_2$ value will decrease while the recorded $PaCO_2$ value will increase. Gas embolism can be indicated by a synchronized decrease corresponding to an $EtCO_2$ value of 2 mmHg [13].

In our department, we use capnography to detect VAE, and we used it in all patients, both in sitting and in park-bench positions. Studies by Mammoto et al. have highlighted this method as satisfactory for detecting VAE [24]. In their study, 21 neurosurgical patients operated in a sitting position were continuously monitored via transesophageal echography (TOE) and capnography. All patients had air microbubbles in the right atrium, and the severity was graded according to a system regarding air bubbles. VAE was identified as a risk factor for hypotension and hypoxemia in 245 cases. Among 8 cases involving children, a decrease in SpO_2 below 95% was observed. Patients experienced hypotension and decreased $EtCO_2$ levels when operated on in a sitting position without a decrease in saturation. Reductions in $EtCO_2$ and saturation were noted in patients operated on in the park-bench position, with a possibility of experiencing temporary VAE episodes [25].

In the present study, VAE management included informing the surgeon, using compresses soaked in saline, administering 100% oxygen, compression on the jugular veins, and providing fluid boluses and vasopressors for arterial hypotension, while aspirating the air through CVC. In parallel the surgical team is searching for the source of venous bleeding and occlude as soon as possible through specific manners. In the present study, 11 children had a decreased $EtCO_2$ level when operated on in the sitting position, while only 2 children had a decreased level when operated on in the park-bench position. Two children also had gas embolism documented in the sitting position. Both patients, aged 13 and 9, were operated on in a sitting position using the middle line approach and the retrosigmoid approach. 10 ml and 40 ml of air respectively were aspirated from the CVC site.

During neurosurgical procedures, maintaining normal ventilation parameters is crucial to prevent increased carbon dioxide partial pressure, which can lead to higher intracranial pressure. Compromised respiratory function may occur due to positioning complications. Hypoxemia was observed in 22.2% of patients operated on in the park-bench position. The patients operated on in the sitting position were immediately extubated postoperatively in a percentage of 65.62%, while in the park-bench position the percentage was slightly higher, 77.78%. Thus, in our group, the rate of respiratory complications is higher in patients operated in the park-bench position.

Other complications evidenced in our study were fever - in 12.5% of cases, and hydroelectrolyte imbalances in 9.38%, associated mainly with the sitting position. Compared to other studies in which 9.2% of patients developed a fever and 1% had hydroelectrolyte imbalances, the rate of complications in our study regarding hydroelectrolyte imbalances was increased, these being associated with surgical complications [25].

The incidence of complications following surgery for posterior fossa tumors in pediatric patients can vary based on several factors, including the specific surgical approach used, the patient's overall state of health, and tumor complexity. Pneumocephalus is relatively common after posterior fossa surgery, in particular in the sitting position. Incidence can range from 10% to 30%, but most cases are asymptomatic [26]. In this study, pneumocephalus appeared in the sitting position in 4 children (12.5%). Only one patient needed surgical evacuation. The risk of postoperative hematoma may be slightly higher in patients operated in sitting and park-bench positions due to venous drainage changes, 3-6% [27]. In the present study, 5 patients developed postoperative hematoma, of which 3 were operated in the sitting position (12.5%). All patients benefited from surgical evacuation. One of the two patients operated in the park-bench position died. Two patients experienced hydrocephalus, one patient belonging to the two groups. One patient presented cerebral ischemia after exophytic brainstem tumor resection, and thus needed surgical reintervention for performing craniectomy; eventually, the patient deceased.

Several factors related to the duration of surgery and anesthesia, as well as postoperative management, can significantly impact the outcomes for patients undergoing surgery for posterior fossa pathology. Longer surgical times can lead to increased risks of complications such as infection, blood loss, and venous thromboembolism [28]. Prolonged anesthesia exposure can also affect hemodynamic stability and increase the likelihood of postoperative nausea and vomiting. Extended surgical duration may increase the risk of cerebral ischemia, particularly if there are periods of hypotension or compromised cerebral perfusion during the procedure [29]. The longest surgical interventions were those performed in the sitting position, which also caused the most anesthetic and surgical complications (247.5 min, (172.75 - 325.25) median).

Longer anesthesia duration can lead to prolonged effects of anesthetic agents, which may delay recovery and extubation. This can also increase the risk of respiratory complications and prolonged sedation. Prolonged anesthesia can affect the patient's neurological status upon emergence, potentially complicating postoperative neurological function assessment [30]. Immediate extubation can facilitate quicker neurological assessments, allowing for timely identification of any complications. However, it requires that the patient is stable and adequately ventilating. Patients who are extubated immediately may have shorter stays in the intensive care unit (ICU), which can reduce the risk of ICU-related complications such as infections. The length of the ICU stay is often determined by the need for close monitoring of neurological status, hemodynamics, and respiratory function. Prolonged ICU stays can indicate complications or instability, which can negatively impact overall recovery. Longer ICU stays can lead to increased healthcare costs and resource utilization, which may affect the overall care pathway for the patient [31]. In the present study, due to long surgery duration, patients operated in the sitting position needed admission to the intensive care unit. Their immediate postoperative extubations were less than those of patients in the park-bench position (21, 65.62%).

The total length of hospitalization can reflect the complexity of the case and the presence of complications. Longer hospital stays may indicate issues such as infection, delayed recovery, or the need for additional interventions. Extended hospitalization can also impact the patient's and family's psychosocial well-being, potentially affecting recovery and rehabilitation [32]. According to our study, the duration of hospitalization does not significantly differ between the two groups.

To sum up, each of these factors plays a critical role in the postoperative outcomes for patients undergoing surgery for posterior fossa pathology. Anesthesiologists must carefully manage anesthesia and monitor patients throughout the surgical and postoperative periods to minimize risks and optimize recovery. Despite the many fears and criticisms related to the sitting position,especially that of VAE or hypotension, our study emphasizes the fact that from the point of view of anesthesia, the complications do not differ from the lateral decubitus position. Consolidation of a real team of anesthesiologists-surgeons, familiarization with the advantages and risks of the sitting position, effective communication and collaboration with the surgical team and intensive care staff are essential to ensure the best possible outcomes for the patients.

Limitations of the study

The study included 41 patients, with only 9 patients operated on in the park-bench position. The small sample size limits the study's statistical power, making it difficult to detect group differences or generalize the findings for a larger population. Moreover, an imbalance between the groups, with 32 patients in the sitting position group and only 9 in the park-bench position group, can lead to biased results, making direct comparisons challenging. Consequently, the unequal distribution may also affect the reliability of statistical tests. Only 2 out of the 41 patients developed venous air embolism, indicating a low incidence of this complication. Due to this rarity, it is challenging to conduct meaningful statistical comparisons between the two groups regarding this particular complication.

The observed differences could also be due to chance rather than an actual effect. Given the small sample size, low complication rates, and unequal group sizes, the study may not have enough power to identify statistically significant differences, even if they exist. These statistical limitations reduce the ability to draw definitive conclusions about the differences in anesthesia-related risks and postoperative complications between the two groups of pediatric patients.

Conclusions

The high percentage of patients with complications suggests a strong association between the park-bench position and the likelihood of anesthetic issues. The park-bench position could contribute to hemodynamic instability, making it a significant risk factor for these complications. In contrast to the park-bench position, the sitting position appears to offer better control of anesthetic complications and hemodynamic stability, despite longer surgery and anesthesia times. The anesthesiologist's role is to ensure that the patient is safely monitored and managed throughout the surgical procedures, minimizing risks while maximizing the benefits of the chosen position.

Acknowledgments

I would like to express my sincere gratitude to my mentor, Ioan Ștefan Florian, MD, PhD, for his unwavering guidance, insightful feedback, and continuous support.

References

1. Mathur A. Abstract No.: ABS0480: A retrospective study observing outcome following posterior fossa craniotomy in patients with sitting position. Indian J Anaesth. 2022;66(Suppl 1):S8–S9.
2. Standefer M, Bay JW, Trusso R. The sitting position in neurosurgery: a retrospective analysis of 488 cases. Neurosurgery. 1984;14:649-658.
3. Kore S, Waghalkar P, Shetty A, Garasia M. A prospective study observing outcome following posterior fossa craniotomy in patients with sitting position. International Journal of Biomedical and Advance Research. 2016;7:438-442.
4. Himes BT, Mallory GW, Abcejo AS, Pasternak J, Atkinson JLD, Meyer FB, et al. Contemporary analysis of the intraoperative and perioperative complications of neurosurgical procedures performed in the sitting position. J Neurosurg. 2017;127:182-188.
5. Shimizu S, Sato K, Mabuchi I, Utsuki S, Oka H, Kan S, et al. Brachial plexopathy due to massive swelling of the neck associated with craniotomy in the park-bench position. Surg Neurol. 2009;71:504-508; discussion 508-509.
6. Bilotta F, Sergi PG, Spennati V. Patient Positioning during Neurosurgery: A Relevant Skill for Neuroanesthesiologist in a Multidisciplinary Teamwork. Journal of Neuroanaesthesiology and Critical Care, 2020;07:049-051.
7. De Cassai A, Geraldini F, Zarantonello F, Sella N, Negro S, Andreatta G, et al. A practical guide to patient position and complication management in neurosurgery: a systematic qualitative review. Br J Neurosurg. 2022;36:583-593.
8. Alibert F, Roux P. [The sitting position in neurosurgery: the viewpoint of the anesthetist]. Ann Fr Anesth Reanim. 1998;17:164-167. French.
9. Matjasko J, Petrozza P, Cohen M, Steinberg P. Anesthesia and surgery in the seated position: analysis of 554 cases. Neurosurgery. 1985;17:695-702.
10. Slbin MS, Babinski M, Maroon JC, Jannetta PJ. Anesthetic management of posterior fossa surgery in the sitting position. Acta Anaesthesiol Scand. 1976;20:117-128.
11. Marshall WK, Bedford RF, Miller ED. Cardiovascular responses in the seated position--impact of four anesthetic techniques. Anesth Analg. 1983;62:648-653
12. Warner MA, Warner DO, Matsumoto JY, Harper CM, Schroeder DR, Maxson PM. Ulnar neuropathy in surgical patients. Anesthesiology. 1999;90:54-59.
13. Prabhakar H, Mahajan C, Kapoor I. Manual of Neuroanesthesia. The Essentials. CRC Press, 2017; 91-97.
14. Rajagopalan V, Banik S, Rath GP. Positioning Children During Neurosurgery. In: Fundamentals of Pediatric Neuroanesthesia. 2021, p. 119-137.
15. Schaffranietz L, Grothe A, Olthoff D. [Use of the sitting position in neurosurgery. Results of a 1998 survey in Germany]. Anaesthesist. 2000;49:269-274. German.
16. Goldberger Ary L. Clinical Electrocardiography: A Simplified Approach 6th ed. St. Louis, MO: Mosby; 2009; p. 323-384.
17. Allman K, Wilson I. Oxford Practical Guide to Anesthesia [Ghid Practic de Anestezie]. 4th Ed. Bucharest: Hipocrate, 2017; 389-414. [Romanian]
18. Cucchiara RF, Bowers B. Air embolism in children undergoing suboccipital craniotomy. Anesthesiology.

1982;57:338-339.

19. Meyer PG, Cuttaree H, Charron B, Jarreau MM, Perie AC, Sainte-Rose C. Prevention of venous air embolism in paediatric neurosurgical procedures performed in the sitting position by combined use of MAST suit and PEEP. Br J Anaesth. 1994;73:795-800.
20. Fuchs G, Schwarz G, Stein J, Kaltenböck F, Baumgartner A, Oberbauer RW. Doppler color-flow imaging: screening of a patent foramen ovale in children scheduled for neurosurgery in the sitting position. J Neurosurg Anesthesiol. 1998;10:5-9.
21. Bithal PK, Pandia MP, Dash HH, Chouhan RS, Mohanty B, Padhy N. Comparative incidence of venous air embolism and associated hypotension in adults and children operated for neurosurgery in the sitting position. Eur J Anaesthesiol. 2004;21:517-522.
22. Harrison EA, Mackersie A, McEwan A, Facer E. The sitting position for neurosurgery in children: a review of 16 years' experience. Br J Anaesth. 2002;88:12-17.
23. Dilmen OK, Akcil EF, Tureci E, Tunali Y, Bahar M, Tanriverdi T, et al. Neurosurgery in the sitting position: retrospective analysis of 692 adult and pediatric cases. Turk Neurosurg. 2011;21:634-640.
24. Mammoto T, Hayashi Y, Ohnishi Y, Kuro M. Incidence of venous and paradoxical air embolism in neurosurgical patients in the sitting position: detection by transesophageal echocardiography. Acta Anaesthesiol Scand. 1998;42:643-647.
25. Gupta P, Rath GP, Prabhakar H, Bithal PK. Complications related to sitting position during Pediatric Neurosurgery: An institutional experience and review of literature. Neurol India. 2018;66:217-222.
26. MacGillivray RG. Pneumocephalus as a complication of posterior fossa surgery in the sitting position. Anaesthesia. 1982;37:722-725.
27. Kalfas IH, Little JR. Postoperative hemorrhage: a survey of 4992 intracranial procedures. Neurosurgery. 1988;23:343-347.
28. Zaben M, Richards A, Merola J, Patel C, Leach P. Surgical site infection in paediatric posterior fossa surgery: does pathology matter? Childs Nerv Syst. 2021;37:1859-1861.
29. Hoffman WE, Charbel FT, Edelman G. Brain tissue oxygen, carbon dioxide, and pH in neurosurgical patients at risk for ischemia. Anesth Analg. 1996;82:582-586.
30. Rabinstein AA. Neurologic complications of anesthesia. Continuum (Minneap Minn). 2011;17(1 Neurologic Complications of Systemic Disease):134-147.
31. Bösel J. Who Is Safe to Extubate in the Neuroscience Intensive Care Unit? Semin Respir Crit Care Med. 2017;38:830-839.
32. Khan RB, Patay Z, Klimo P, Huang J, Kumar R, Boop FA, et al. Clinical features, neurologic recovery, and risk factors of postoperative posterior fossa syndrome and delayed recovery: a prospective study. Neuro Oncol. 2021;23:1586-1596.