Use of the sitting position for pineal tumour surgery in a five-year-old child

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Abstract

The sitting position provides almost ideal access to several areas within the cranium. The high risk of air embolism has led to decreased use of the sitting position. However, improved identification of patients at risk of paradoxical embolism may allow a more calculated, safer use thereof. Despite an improved understanding of the risks, many neurosurgical centres seldom use this position, and the occasional use of a complex patient position can then create additional challenges.

This case report of a child requiring pineal surgery in the sitting position includes a review of the use of this position in children, and highlights the current emphasis on assessing the risk of paradoxical embolism before proceeding to the use of such a position.

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Introduction

Use of the sitting position, for neurosurgical procedures, was popular until evidence suggested that the potential risks might outweigh the advantages. This led to a review of its use.[1,2] Despite these concerns, several surveys have demonstrated that the use of the position persists, mainly because it provides favourable operating conditions.[3]

The surgeons in our hospitals have largely stopped the use of the sitting position, except for very specific cases whereby the position's surgical access advantages were considered to outweigh the potential complications. The consequence of this occasional use has been the creation of an additional difficulty: lack of expertise in establishing the sitting position for neurosurgery.

To set up or establish this position always requires more time than the more commonly used supine, prone, lateral, and park-bench positions. The sitting position requires the use of a standard operating table, a large portion of the standard table attachments, and also additional accessories that are seldom used. Occasional use of the position therefore requires proper attention to availability of all the components, as well as to the additional time needed to position safely.

This case describes the use of the sitting position in a young child and reviews the literature with specific reference to use of this position in children, especially the role of preoperative measures to assess the risk of paradoxical embolism. It also highlights some practical issues for occasional providers of anaesthesia in the sitting position.

Case report

A five-year-old boy, weighing 19.4 kg, presented to the hospital with a month-long history of headaches associated with vomiting, photophobia and somnolence. There was no other significant medical history, and developmental milestones had been normal. Central nervous system (CNS) examination on presentation was normal, with Glasgow coma scale of 15/15, and normal muscle power and tone globally. A computerised tomography (CT) scan of the brain revealed hydrocephalus with vasogenic cerebral oedema and a calcified mass in the pineal region.

A therapeutic endoscopic third ventriculostomy provided relief from the hydrocephalus, and included a biopsy of the pineal tumour. The biopsy results were consistent with pineoblastoma. The patient remained well and was discharged to await further surgery.

The patient was readmitted five weeks later for excision of the tumour. The surgical team felt that the sitting position would be the most suitable way to approach the pineal region. Preoperative investigation (Table I) was unremarkable, with normal haematological parameters, blood electrolytes and chest radiography.

Table I: Preoperative investigations

Haemoglobin	14.6 g/dl
Platelets	308 × 10^9/l
International normalised ratio	0.98
Sodium	133 mmol/l
Potassium	4.5 mmol/l
Urea	5.7 mmol/l
Creatinine	44 µmol/l
Urinalysis	Normal

Echocardiography was performed to exclude the presence of a patent foramen ovale (PFO).[4] The heart was demonstrated to be structurally and functionally normal, with no PFO detectable using agitated saline (without a valsalva). It was therefore considered safe to proceed with the planned use of the sitting position.

Induction of anaesthesia was routine. No premedication was given and the patient was accompanied to theatre by his mother, who remained with the patient during the induction of anaesthesia. An inhalational induction was conducted using oxygen, nitrous oxide and sevoflurane. Intravenous access was then established. To facilitate intubation, under direct vision, local anaesthetic was sprayed onto the vocal cords. Nitrous oxide was replaced by air before surgery commenced, because of the concern that nitrous oxide may compound the clinical effects of any embolism of air, by increasing the volume of embolic air caused by the lower blood-gas solubility of nitrous oxide relative to nitrogen.

Monitoring included an electrocardiogram (ECG) guided, multi-orifice, central venous catheter, placed into the right atrium, via the right internal jugular vein. Catheter position was confirmed using ECG guidance. To ensure that any embolic air could be rapidly aspirated, a wide-bore extension catheter was connected to the catheter with a three-way tap and a large syringe. An arterial catheter was placed in the right radial artery to facilitate beat-to-beat blood pressure measurement and for arterial blood-gas samples.

To limit venous pooling, the legs were firmly, but not tightly bound, using Velband® and elasticated bandages. A urinary catheter was placed, and the head was then pinned securely using a Mayfield® clamp.

The patient was then positioned in the sitting position. The back was elevated at 70-80 degrees, with the thighs flexed at the hip, and the legs flexed at the knees. Several steps were taken to prevent the patient from sliding down the operating table:

- A pillow was placed under the patient's thighs and behind bent knees, and firmly secured onto the operating table.
- Arms were kept at his side, elbows flexed at 90 degrees in armrests to support the upper thorax and prevent traction injury to the brachial plexus.
- Skull pins were used to take the weight of the head onto the operating table frame.

All pressure points were well padded. As advocated for by Albin, the head was flexed, maintaining a space between the chin and chest.[5]

Figure 1 depicts the child undergoing surgery in the sitting position.

In preparation for a significant venous air embolism (VAE), a 20 ml syringe was attached to the intra-atrial central venous

Figure 1: Established sitting position showing the flexed position of the firmly bound legs, the neck in limited flexion and the supportive positioning of arms in "gutter"-type arm-rests in relation to the torso, as well as the pressure transducers at the level of the external auditory meatus. The surgeons can be seen positioning the microscope over the top end of the operating table.

pressure (CVP) catheter using a three-way tap, and an aspiration check performed to ensure that it was possible to aspirate freely. The arterial pressure transducer was zeroed at the level of the external auditory meatus.

Anaesthesia was maintained with oxygen, air, isoflurane, cisatracurium and fentanyl. Antibiotic prophylaxis was provided with cefuroxime. The following parameters were monitored: ECG, pulse oximetry, invasive arterial blood pressure, CVP, fractional inspired oxygen, end-tidal carbon dioxide, temperature and end-tidal isoflurane. Continuous monitoring of the end-tidal carbon dioxide trace was used as the main monitor for detecting VAE. Transoesophageal echocardiography (TEE) and praecordial Doppler were not available.

Surgery proceeded uneventfully, but because of the physical characteristics of the tumour, complete removal of the tumour was not possible.

The patient remained haemodynamically stable throughout the six-hour-long procedure. Neuromuscular blockade was reversed, the patient extubated, and taken to the intensive care unit for post-operative observation.

Figure 2 illustrates surgical access before incision.

Figure 3 shows surgical access following dural opening.

Discussion

The sitting position is perhaps the most controversial position in neurosurgery. The position was introduced to neurosurgery in 1913 by Demartel. Its advocates are of the opinion that cerebrospinal fluid (CSF) and venous drainage are facilitated by gravity and that cerebellar hemispheres also are displaced inferiorly by gravity, and that these factors enhance optimal visualisation of the surgical field without use of suction or retraction.[5]

The back is elevated at approximately 60 degrees, with the thighs flexed at the hip and legs flexed at the knees. The arms should be well supported. The head is flexed, but there should be at least a 2.5 cm space between the chin and chest to preserve airway patency, and to allow venous drainage from the face and tongue.

Table II highlights the relative contraindications to the use of the sitting position.

Table II: Relative contraindications to the use of sitting position

- Intracardiac defect with right to left shunt, e.g. PFO
- Pulmonary arteriovenous fistula
- Severe hydrocephalus
- Functioning ventriculoatrial shunt
- Significant hypovolaemia
- Myocordial dysfunction.

Table III indicates what should be done to manage a suspected VAE.

Table III: Management of a suspected venous air embolism[5]

- Ventilate with 100% oxygen.
- Attempt aspiration of entrained air.
- Apply immediate bilateral jugular venous compression.
- Cover the surgical field with saline-soaked swabs.
- Administer intravenous fluids and vasopressors, and commence CPR.
- Consider turning patient into left lateral decubitus and Trendelenberg (Durant's position) for air aspiration.

The major concern with the sitting position is VAE and its sequelae. The reported incidence in adults, as detected by praecordial Doppler ultrasonography, ranges from 7-50%.[6] Harrison et al found a lower incidence of VAE in the sitting position in children, in the order of 9%, when compared to the accepted incidence in adults.[6] Thus, it may be that the

Figure 2: Surgical access before incision. The flexed neck will provide a horizontal plane beneath the tentorium, allowing good access to the pineal gland, whilst maintaining structures in anatomical positions.

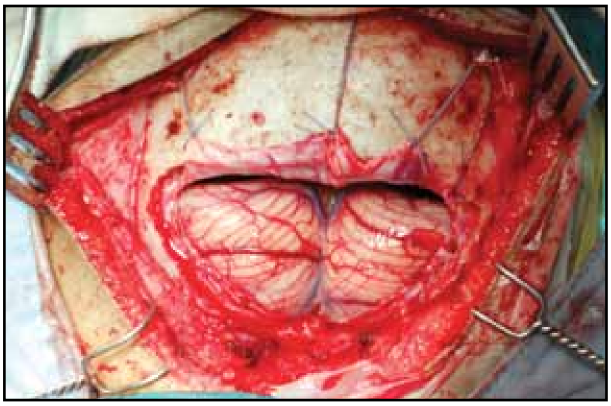

Figure 3: Surgical access following dural opening. At the top of the cerebellar hemispheres the space can be seen where a route below the tentorium can be established without significant traction on the tentorium, facilitated by the relative "slumping" of the posterior fossa structures.

incidence of VAE in the sitting position is lower in children than in adults. However, in a review of 554 neurosurgical procedures in the sitting position, Matjasko et al reported a significantly higher incidence of VAE in children (62%) compared with adults (23%). Only 13 patients were 12 years or younger.[7] It is not possible to directly compare the incidence of VAE between studies where different methods of detection are used.[6] TEE is an extremely sensitive method for detecting intracardiac air, and it is not surprising that the reported incidence of VAE is as high as 76% in adult studies when TEE is used to detect it.[8]

For air entrainment to occur, negative venous pressure relative to atmospheric pressure is necessary, and factors that might affect intracranial venous pressure in the sitting position have been studied. Iwabuchi et al examined the dural sinus pressure [confluens sinum pressure (CSP)] under various conditions in 47 cases. In the sitting position, all adults had a negative CSP, whereas all eight children younger than nine years old showed a positive pressure.[9] This difference in CSP in the sitting position between adults and children would suggest a lower risk of VAE in children in this position.

TEE is the diagnostic tool of choice, and can detect as little as 0.02 ml/kg.[10,11] A fall in end-tidal pCO_2 occurs with VAE. Capnography was the technique of choice for detecting VAE during the operation. The findings of Mammoto et al support capnography as a satisfactory method for the detection of VAE in the clinical situation.[8] The adult lethal volume of entrained air has been described as between 200-300 ml (or 3-5 ml/kg) aspirated acutely into the venous system, but in cases with paradoxical air embolism, even smaller amounts may be symptomatic or lethal.[12]

The differential diagnosis of a drop in end-tidal CO_2 due to hypovolaemia, or poor output from the right ventricle into the pulmonary artery, may be a difficult decision to make. A sudden drop points to VAE, whereas a slower trend is more likely due to hypovolaemia.

The rate of air entrainment is important. If the embolism is large (approximately 5 ml/kg) a gas air-lock scenario may occur immediately. There may be complete outflow obstruction from the right ventricle, which rapidly leads to right-sided heart failure and immediate cardiovascular collapse. Modest volumes of VAE may still result in significant right ventricular outflow obstruction, with an attendant decrease in cardiac output, hypotension, myocardial and cerebral ischemia, and even death. The central nervous system may be affected by one of two mechanisms: cardiovascular collapse secondary to reduced cardiac output, or paradoxical air embolism through a PFO.

The sitting position matches a high risk of air embolism with a risk of paradoxical embolism. A PFO is therefore considered to be a strong contraindication to the use of the sitting position. Current literature suggests that, before utilising the sitting position, steps are taken to exclude a PFO or other detectable causes of right-left shunts. Echocardiography is currently the investigation of choice in this regard. Whenever a PFO is demonstrated by echocardiography, clinical management should be altered either by choosing a different surgical position, or closure of the PFO with a device or surgery prior to neurosurgery, but not at the same time.

Cardiovascular instability, in addition to a fall in end-tidal CO_2, implies a larger air embolus than that detected by capnography alone. The incidence of VAE in children, based on capnography, has been defined as a sudden fall in end-tidal CO_2 greater than 0.4 kPa from the baseline.[6]

A large diameter and well-positioned right atrial catheter allows aspiration of air entering the right atrium. A suitable catheter should have a large diameter, be multi-orificed, and be positioned near the superior vena cava-atrial junction.[12]

VAE classically occurs during surgery while the neurosurgeons are operating, but can also take place as the patient is being repositioned, after surgical closure into the supine position. Monitoring vigilance for VAE should be maintained until the patient has been supine for a number of minutes.

Table IV lists practical tips for occasional users of the sitting position.

Conclusion

The sitting position still has a role in modern neurosurgical practice, but should only be used following consideration of its potential complications. For pineal surgery, it can provide excellent surgical access. Because of the uncommon use of the position in most institutions, the equipment required is not often used, and theatre personnel may have very limited experience with the position. This makes the positioning of the patient more time consuming, and also places the patient at increased risk due to unfamiliarity with the equipment, the need for monitoring and interpretation thereof, and sequencing of the positioning process.

This case reminded our team of the challenges associated with the occasional use of the sitting position. This report reviews the issues that would confront a theatre team who are requested to use this position, and highlights the importance of preoperatively assessing the risk for paradoxical embolism.

Table IV: Practical tips for occasional users of the sitting position

- Preoperative echocardiography is recommended to exclude a PFO. The use of agitated saline administered during periods of high right-sided pressure (induced by coughing) can be used to exclude a functional PFO.
- Check all equipment beforehand, particularly infrequently used operating table components.
- Plan strategies to prevent patient "slumping" (to include an assurance that legs are flexed and in a comfortable position, correct positioning and support of arms, and to prevent tension on the brachial plexus, ensuring that the head is firmly positioned with limited neck flexion).
- Place a CVP catheter, and confirm correct placement, preferably using ECG or X-ray guidance. Ensure that the catheter is ready for aspirating large volumes of air (wide-bore extension, a three-way tap and a large enough syringe).
- Use a technique to provide vascular compression of the lower limbs to limit pooling of the intravascular volume.
- Neck flexion is usually required, but must be limited to ensure adequate patency of cervical vessels, and to limit potential narrowing of the cervical spinal canal.
- The arterial pressure transducer should be placed at level of the external auditory meatus, so as to reflect the perfusion pressure of the brain.
- Attention must be paid to preventing any part of the body touching the bare metal components of the operating table and positioning frame.
- Avoid brachial plexus traction injury, through optimal positioning of torso and arms, and their relationship to one another.
- If transoesophageal echocardiography or transthoracic Doppler monitoring is not used, paying considerable attention to end-tidal CO_2 monitoring is obligatory .
- Ensure adequate and comfortable access for surgeons over the cranial end of operating table.

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