Published in final edited form as:
*J Clin Neurosci*. 2013 January ; 20(1): . doi:10.1016/j.jocn.2012.05.037.

# A streamlined protocol for the use of the semi-sitting position in neurosurgery: A report on 48 consecutive procedures

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## Abstract

The semi-sitting position has lost favor among neurosurgeons partly due to unproven assumptions of increased complications. Many complications have been associated with this position; the most feared: venous air embolism and paradoxical air embolism. We report on this retrospective study of the outcome over 4 years of 48 neurosurgical patients operated on consecutively using a standardized protocol: 41 (85%) in the semi-sitting position, and seven (15%) in the prone position. Procedures included: tumor resection (34), posterior fossa decompression (12), cyst resection (1) and resection of arteriovenous malformation (1). Pre-operative workup was standardized. Vigilant intra-operative observation was done by an experienced neuroanesthetist. Pertinent data was extracted from surgical records. Of the 48 patients, 10 (20.8%) were found to have a patent foramen ovale (PFO) on trans-esophageal echocardiography. Of these, four (40%) patients underwent procedures in the semi-sitting position while six (60%) did not. A clinically significant venous air embolism (VAE) was detected during 2 of the 41 semi-sitting procedures (4.9%). Neither patient suffered any obvious sequelae. No other morbidity was encountered associated with surgical position. Our study suggests that a model similar to ours is effective in preventing major complications associated with the semi-sitting position. The semi-sitting position is a safe, practical position that should be considered in appropriate cases. The fear of dreadful complications seems unwarranted.

### Keywords

Paradoxical air embolism (PAE); Position; Patent foramen ovale (PFO); Semi-sitting; Sitting position; Venous air embolism (VAE)

## 1. Introduction

Operations in the semi-sitting position are performed rarely.[1] This is due to many factors, one most likely being the perception of increased risks linked to this position. These include: tension pneumocephalus, peripheral nerve damage, quadriplegia, macroglossia and venous



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[†]The data used as a basis for this original article was presented by Dr. Tariq Lamki as an oral presentation at the North American Skull Base Society meeting in February 2011.

**6. Conflicts of Interest/Disclosures** The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

air embolism (VAE).[2,3] VAE, with its most feared sequela of paradoxical arterial embolus (PAE), is by and large the most feared complication.

The literature is inconclusive: some papers[4–7] show no increased risks and some show an increased risk associated with this position compared to other neurosurgical positions.[8,9] One retrospective study found more intra-operative and post-operative complications in children undergoing tumor resection in the prone, than in the semi-sitting, position.[3]

VAE are not limited to procedures performed in the sitting position,[10] and there are many clear-cut advantages using this position. These include: a cleaner operative field secondary to gravity-assisted blood drainage facilitating hemostasis, and also gravity-assisted cerebellar retraction. The reduced need for coagulation may be a significant benefit in maintaining a well-defined, non-coalesced, tumor–brain interface during surgery of extra-axial tumors. However, until the perception of increased complications related to this position is addressed, it is unlikely that many neurosurgeons will use it; hence further precluding trainees from being exposed to this position and learning its nuances.

Several protocols have been proposed to increase the diagnosis of VAE in patients who undergo surgery in the semi-sitting position, which include the reliance on the continuous use of transesophageal echocardiography (TEE).[11]

The purpose of this retrospective audit was to determine the incidence of clinically significant venous air embolism in craniotomy patients positioned in the semi-sitting position under the care of a single neurosurgeon and neuroanesthetist.

## 2. Materials and Methods

We report retrospectively on 48 consecutive procedures planned in the semi-sitting position from February 2006 to May 2010. The procedures included: tumor resection (34), posterior fossa decompression (12), cyst resection (1) and resection of an arteriovenous malformation (AVM) (1). The semi-sitting position was implemented following standard procedure.[11]

Data regarding intra-operative blood loss, intra-operative monitoring, surgical complications, length of post-operative Intensive Care Unit stay and hospital stay was extracted from the medical records.

All procedures were performed by the same attending neurosurgeon at the parent institution (The Ohio State University Hospital). Pre-operatively all patients received flexion–extension radiographs of the cervical spine looking for spinal instability. If instability was found, the semi-sitting position would not be used. Following induction of general anesthesia and central line placement at the mouth of the right atrium, all patients underwent a pre-operative TEE. During the TEE, a bubble study was performed to determine presence of a right-to-left cardiac shunt. The bubble study was done by foaming either the patient's blood or albumin in a syringe and reinjecting it into the central line. Although a patent foramen ovale (PFO) in and of itself was not considered a contra-indication for the position, a large PFO was. The magnitude of the PFO was determined by the anesthetist according to the amount of bubbles noted in the left atrium during the bubble study; hence, it was a qualitative metric. A "significant" right-to-left cardiac shunt, as defined above, was an absolute contraindication to the use of the semi-sitting position. The bubble study method has been used and validated as a test to determine PFO significance.[12–14]

Patients were positioned in the semi-sitting position in a similar way to described previously.[11] Once a procedure was to be executed in the semi-sitting position, the patient

was fitted with a precordial Doppler. All other standard intra-operative monitoring, including end-tidal carbon dioxide ($ETCO_2$), was employed.

The ventilation settings included a positive end-expiratory pressure (PEEP) of 7 to 10 $cmH_2O$ for all patients. For patients with a proven PFO, biphasic PEEP was instituted to increase intra-thoracic pressure. These measures were undertaken to prevent negative intra-thoracic pressure. A mild hypercapnea (baseline of 35–40 mmHg) was established throughout all the procedures to allow for a change in $ETCO_2$ to be more prominent. This was done by reducing the minute volume setting on the ventilator.

Several factors were considered significant to suggest a VAE and were therefore vigilantly observed. These included a drop in $ETCO_2$ of ≥ 5 mmHg, a sudden drop in systolic blood pressure (BP) of at least 20 mmHg and a change in the sound of the precordial Doppler. Any combination of these changes was suspicious for a VAE and led to attempt at aspiration of air from the right atrium. Aspiration of air from the central line was considered diagnostic of VAE.

When a VAE was suspected, bone wax was applied to the exposed areas in the surgical cavity, jugular vein compression at the neck was instituted, a wet gauze was placed over the surgical field, ventilation with 100% oxygen was instituted, and an increase in intravenous fluids to increase venous pressure and maintain arterial pressure were started. At the same time, aspiration was also performed from the central line to diagnose and simultaneously treat any air embolism that may have occurred. If these maneuvers were not sufficient to quickly reverse the observed changes, then the head of the bed was also reclined (towards a Trendelenburg position). Upon stabilization of the parameters, the patient was resituated in the semi-sitting position and surgery recommenced.

We defined a PAE, as did other authors,[4,14] on clinical grounds.

## 3. Results

Flexion–extension radiographs showed no cervical spinal instability in any patient. Of the 48 surgeries planned in the semi-sitting position, 41 (85%) were done in the semi-sitting position and seven (15%) were done in the prone position. For six (86%) of those done in the prone position, a significant right-to-left cardiac shunt was demonstrated on the bubble test while in one patient (14%), precordial Doppler malfunction prevented the use of the semi-sitting position.

The surgeries done in the semi-sitting position included: 31 tumor resections, eight posterior fossa decompressions, one cyst resection, and one AVM resection. The surgeries originally planned in the semi-sitting position, but consequently switched to the prone position, were: three tumor resections, and four posterior fossa decompressions.

Of the 48 patients, a total of 10 (20.8%) had a PFO on TEE. Of these, four (40%) patients underwent their procedures in the semi-sitting position while six (60%) did not.

A clinically significant VAE was diagnosed by air being aspirated from the central line. This was detected during two out of the 41 procedures (4.9%) done in the semi-sitting position. It occurred once only in each of these two patients. The patients who experienced the VAE did not have a PFO. These patients underwent surgeries for an AVM and an arachnoid cyst, respectively. Both patients were female. The patient with the AVM was 57 years of age and the arachnoid cyst patient was 21 years old. For each of these patients, air aspiration from the central line was considered both diagnostic and therapeutic. Once the parameters stabilized, the patients were returned to the semi-sitting position and the surgery continued.

Both patients were stable post-operatively. Neither patient suffered any obvious sequelae directly related to the VAE. No patient suffered a PAE. Both patients had significant changes in $ETCO_2$, blood pressure and precordial Doppler (see section 2).

In the other 39 procedures conducted in a semi-sitting position, we observed a change in two or more of the worrisome parameters in five (12.8%) patients that led to attempted air aspiration from the right atrium. The air aspiration was negative in all.

Of the 41 procedures done in the semi-sitting position, 11 (26.8%) had episodes wherein the $ETCO_2$ dropped by ≥ 5 mmHg. Because air was aspirated in only two of these patients, the $ETCO_2$ decline in most could be assumed due to other factors. Of the seven patients who underwent surgery in the prone position, one (14.3%) experienced a drop in $ETCO_2$ of 5 mmHg. No patient operated on in the prone position experienced two simultaneous changes among the worrisome parameters. (Precordial Doppler was not employed during the procedures performed in the prone position).

In 23 (56.1%) of the 41 procedures done in the semi-sitting position, the patients experienced a drop in systolic BP of at least 20 points. In six of the seven procedures performed in the prone position, a drop in BP of > 20 mmHg was observed seven times. There are many factors which could have contributed to this change.

There was no other morbidity associated with surgery in the semi-sitting position such as tension pneumocephalus, macroglossia, peripheral nerve damage or quadriplegia.[2]

## 4. Discussion

The semi-sitting position is rarely used today.[1] It is considered a controversial position and hence, “neuroanesthesiologists and neurosurgeons (have become) increasingly reluctant to use the semi-sitting position”.[11]

The reported incidence of VAE in patients operated on in the semi-sitting position ranges from 7% to 82.6%.[6,7,15–17] VAE are also observed in the prone or supine position with reported incidence varying from 10% to 17%[8,10,18,19] with figure as high as 83% in children undergoing craniosynostosis operations.[20] Certainly, the pathophysiological conditions for VAE exist in all instances where the head is above the heart level and positioning the head above the heart to facilitate venous return is recommended in many supine neurosurgical operations.[1]

Our incidence of VAE, 4.9%, was lower than that reported in the literature. This is probably due to the criteria we used to make a positive diagnosis of VAE (that is, aspiration of air from the right atrium).

There are numerous other ways to detect a VAE described in the literature, including TEE, $ETCO_2$ drop, precordial Doppler changes, pulmonary artery catheter pressure increase and direct observation of the surgical field.[10] The most sensitive one relies on continuous intra-operative TEE.[16,21] This method seems to be the most sensitive form of monitoring – being able to detect 0.02 mL/kg of injected air or bubbles 5 μm to 10 μm in size.[10] However, “TEE is too sensitive and not necessarily specific for VAE”.[11]

Continuous TEE has its own complications such as, among others, esophageal bleeding, endotracheal tube dislocation and risk of glottic injury with prolonged use;[10,11,17,22] moreover from a review of the literature it appears that the majority of positive TEE studies are not linked to hemodynamic changes.[11,16,20] Also, the association between positive intra-operative TEE and air aspiration has not been documented. Indeed the intra-operative

diagnosis of positive TEE is different from the diagnostic pre-operative bubble or contrast-TEE used to demonstrate a PFO and often the level of expertise present during the diagnostic step is not available during the intra-operative monitoring. Hence the possibility of false positive intra-operative TEE is real. Clearly, it is expensive to continuously monitor intra-operative TEE and it is expensive and not practical to have continuous availability of highly trained personnel to monitor intra-operative TEE.[10]

Undoubtedly, with the increased use of intra-operative TEE, the risk of false positive increases.[11] False positives can be interpreted as the cases found to have a positive TEE and negative air aspiration and/or no instability in vital signs. It can be safely assumed – based on the clinical significance of VAE detected in our and other studies[11,17,18] – that a set-up similar to ours is sufficient to detect and treat any clinically significant VAE.

The absolute contraindication of the semi-sitting position in patients with a PFO, for fear of PAE,[11] must be tempered by at least 20% of the population having a PFO. In addition, most neurosurgical supine craniotomies are done with the head above the heart level,[1] therefore facilitating a VAE and possibly a PAE – yet the clinical incidence of PAE is very small even in semi-sitting craniotomies.[11] We used the semi-sitting position in four patients with a PFO because the PFO was not considered “significant”. The relativity of the contraindication of a PFO, while considering the semi-sitting position, is not well studied. This is a difficult factor to address because of the complexity of neuroanesthesia and all factors that must be considered when deciding upon a position for the neurosurgical patient.

Our favorable results concerning VAE and PAE can be attributed to many factors, including a well-rehearsed “game plan” (as outlined in section 2). Interestingly, some measures taken to decrease the occurrence of VAE may facilitate the occurrence of PAE if an air embolus occurs. Specifically, the use of PEEP, although it may decrease the occurrence of air emboli may also, by raising right atrial pressure, increase the risk of a right-to-left intra-cardiac shunt and hence of a PAE.[10,23]

From a logistical perspective, getting used to the semi-sitting position and the subtleties associated takes about 10 cases (for example, the surgeon becoming accustomed to operating with arms outstretched). Once the surgeon is comfortable with these distinct maneuvers, it becomes easier and more comfortable. Incidentally, many surgeons develop a true penchant for the semi-sitting position once this learning curve has been overcome.

## 5. Conclusion

Our study seems to suggest that in the clinical setting, a model based on the combination of factors described here is effective, from a clinical point of view, in preventing major complications associated with the semi-sitting position. It is also associated with a limited, but clinically effective, use of resources. The semi-sitting position is a safe, practical position that should be considered in appropriate cases.

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