Severe Venous Air Embolism Related to Positioning in Posterior Cranial Fossa Surgery in Siriraj Hospital

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Background: *Posterior cranial fossa surgery is commonly performed under sitting and horizontal position in our institution. Venous air embolism is a potentially serious complication of neurosurgery especially in the sitting position.*
Objective: *We aim to compare the incidence of severe venous air embolism and other complications of both positions.*
Material and Method: *A retrospective analysis of medical record was performed in 192 patients undergoing posterior cranial fossa craniotomy from January 2010 to December 2013. Data collected from the records included demographic profile, patient position, hemodynamic changes, venous air embolism (VAE), blood loss/transfusion, duration of surgery, postoperative complications, duration of ICU stay, and postoperative discharge status. The definition of severe air embolism was identified as suspected VAE with decreased systolic blood pressure greater than 20%.*
Results: *There were 92 patients in sitting position (SP) group and 100 patients in horizontal position (HP) group. The incidence of severe venous air embolism was significantly higher in SP group compared with HP group (41.3% vs. 11.0%, p<0.001). SP group had more complications than HP group in both central nervous system (71% vs. 34.0%, p = 0.001), and cardiovascular system (17% vs. 6%, p = 0.001). Although postoperative ventilator time in SP group was less than HP group (1.24 vs. 1.60 days, p = 0.029), ICU and hospital stay were not different in either group.*
Conclusion: *The incidence of severe venous air embolism detected by end tidal CO_2 was significantly higher in SP group. However, 11% of HP group were suspected of severe air embolism.*

Keywords: *Posterior fossa surgery, Sitting position, Horizontal positions, Venous air embolism*

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The posterior cranial fossa surgery[1] is commonly performed in sitting position and horizontal position (prone, park bench, lateral position). There are considerable controversies among neurosurgeons and neuroanesthesiologists regarding the optimal surgical position in this procedure. The sitting position[2,3] provides optimum access to midline lesion, improves venous and cerebrospinal fluid drainage, decreases intracranial pressure, lowers airway pressure, improves access to endotracheal tube. But there are also significant severe complications of sitting position including hemodynamic instability and venous air embolism. The decline of sitting position has been observed worldwide because of the severe complications as mentioned earlier.

In our institution, the sitting position is still used, although the frequency has been reduced when compared to previous years and the horizontal position especially park bench position tends to increase. The aim of this study was to compare the complications of posterior fossa surgery, especially severe venous air embolism between the sitting and horizontal positions.

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Material and Method

This is a retrospective chart review of adult patients who underwent elective posterior cranial fossa surgery in Siriraj Hospital which is a university hospital of Mahidol university from January 2010 to December 2013. In the sitting position (SP), patients were at 60-90 degrees head-up tilt. The horizontal positions (HP) include prone, park bench, lateral positions with up to 20 degrees head-up tilt.

After approval from the institutional review board, data were collected from pre-operative evaluation forms, operative notes, anesthestic records, and progression notes.

Pre-operative data included patient's gender, age, weight, height, ASA classification, underlying

diseases, and neurological conditions.

Intra-operative data included position, the requirement of a change in position, blood loss, amount of blood transfusion, operative time, special monitoring, incidence of hemodynamic parameters 'Hypotension' was defined as 20% or more reduction of systolic blood pressure (SBP) from pre-operative baseline. The incidence of 'suspected venous air embolism'[4,5] was defined as patient who has one of 4 events (1) sudden decrease of end-tidal carbon dioxide ($EtCO_2$) more than 4 mmHg for more than 5 minutes, (2) precordial Doppler ultrasound-showed mill wheel murmur, (3) Transesophageal echocardiography (TEE) detected air bubbles in right atrium, (4) aspirated air from central venous catheter. The incidence of "severe venous air embolism" was defined as a patient who has suspected venous air embolism with hypotension.

Monitoring[5,6] of VAE in authors' hospital were transesophageal echocardiography (TEE), precordial Doppler ultrasound, end-tidal carbondioxide ($ETCO_2$) and right heart catheter. $ETCO_2$ monitoring and precordial Doppler ultrasound were used in all sitting position (SP) group whereas only $ETCO_2$ monitoring was used in horizontal position (HP) group. TEE was used in some cases of sitting position with the purpose of teaching or demonstration.

Postoperative data[7,8] included postoperative ventilator days, ICU length of stay, hospital length of stay and discharge status. The postoperative complications were grouped in system. Central nervous system complications such as re-craniotomy, Glasgow Coma Score (GCS) change, cranial nerve palsy, CSF leakage, meningitis were recorded. Cardiovascular complications such as incidence of postoperative inotropic drug used, arrhythmia, and cardiac arrest were recorded. The last is a respiratory system in which the incidence of Acute respiratory distress syndrome (ARDS), pneumonia, pneumothorax, airway obstruction, re-intubation, was recorded.

The primary outcome was the comparison of the incidence of severe venous air embolism between sitting position and horizontal position. The secondary outcome was the comparison of intra-operative blood loss and blood transfusion, operative times, postoperative ventilator days, ICU and hospital stay and complications.

Statistical analysis

The Chi-square test was used for qualitative data such as sex, ASA physical status, preoperative evaluation, intra-operative hemodynamic changes, VAE episodes and postoperative data between the sitting and horizontal positions. An independent student t-test was used to compare quantitative data such as age, weight, intraoperative blood loss, and duration of operations. A *p*-value of less than 0.05 was considered statistically significant. SPSS was used for analyzing the data.

Results

192 patients including 92 patients in sitting position group (SP) and 100 patients in horizontal position group (HP) which consisted of park bench position and prone position, 66 and 34 patients, respectively. Pre-operative data are presented in Table 1. The patient distribution according to sex, age, BMI was comparable between two groups. Most of the patients in both groups were ASA I and II, but ASA III in HP was higher than SP ($p = 0.008$). The schwannoma and meningioma was performed most often in SP whereas the non-tumor conditions more frequent in HP (Table 2).

The incidences of intra-operative hypotension, suspected venous air embolism, severe venous air embolism were significantly higher in SP. Six patients in SP were changed position due to hemodynamic instability or uncontrolled venous air embolism (Table 3). HP had statistically significant blood loss less than SP. The number of postoperative ventilator days in SP was significantly shorter than HP. ICU and hospital stay was comparable between the two groups (Table 4).

The incidence of Cranial nerve VII and VI palsy were more frequent in SP ($p<0.001$) (Fig. 1). Overall CNS complications were remarkably higher in SP (64.1%) compared to 39% in HP ($p = 0.001$) (Fig. 1). There was a significant postoperative CVS complication in SP (17%) compared to HP (6%) ($p<0.001$). The mortality and postoperative arrhythmia were not different between two groups but the incidence of postoperative on inotropic drug use in HP was significantly less than SP ($p = 0.011$) (Fig. 2).

The overall respiratory system complications have no significant difference between groups (SP 19%, HP12%, $p = 0.068$) but in SP has ARDS and re-intubation rate more than HP (Fig. 3).

About 80% of the patients in both groups were discharged with normal to mild disability (Table 5). Mortality was 3.3% in SP and 1% in HP.

Discussion

Venous air embolism is a potentially fatal

Table 1. Preoperative data

Factor	Sitting position (n = 92)	Horizontal position (n = 100)	*p*-value
Sex, n (%)			0.092
Male	27 (29.3)	41 (41)	
Female	65 (70.7)	59 (59)	
Age (mean ± SD)	48.25±14.48	50.05±15.56	0.404
BMI (kg/m^2)	23.06±4.58	23.54±3.52	0.419
ASA physical status, n (%)			0.020
I	23 (35.9)	27 (27)	0.008*
II	58 (63)	63 (63)	
III	1 (1.1)	10 (10)	
DM	10 (10.9)	9 (9)	0.665
HT	22 (23.9)	36 (36)	0.068
CVA	1 (1.1)	3 (3)	0.354
CAD	0	1 (1)	0.336

BMI = Body mass index; ASA = American society of anesthesiologists; DM = diabetic mellitus; HT = hypertension; CVA = cerebrovascular accident; CAD = coronary artery disease

* *p*-value compared ASA3 between sitting and horizontal group

Table 2. Diagnosis of patients

	Sitting position (n = 92)	Horizontal position (n = 100)	*p*-value
Schwannoma	56	17	<0.001
Meningioma	29	24	
Hemangioblastoma	2	11	
Metastasis	1	15	
Other	4	34	

complication of neurosurgical procedures performed in the sitting position. Early detection by continuous monitoring and prompt management is vital to reduce morbidity and mortality. Although the incidence of VAE is highest (6-45%) during surgeries performed in sitting position, it is also seen in lateral, prone and supine positions. The incidence of VAE varies widely depending on methods of detection which are transesophageal echocardiography (TEE), precordial Doppler ultrasound, end-tidal nitrogen (EtN_2); end-tidal carbondioxide ($EtCO_{2)}$ and right heart catheter in decreasing order of sensitivity.

In our present study, $EtCO_2$ monitoring and precordial Doppler ultrasound were used in all sitting position (SP) group whereas only $EtCO_2$ monitoring was used in horizontal position (HP) group. Suspected VAE was described in methods. There was VAE in 11% of cases in the HP group compared to 41.3% in the SP group.

The result was comparable to studies by other authors as reported by Papadopoulos et al[9] (76%) and Black et al[10] (45%). In all studies, precordial Doppler ultrasound and TEE[5] were used for detection of VAE, which were highly sensitive.

Though severe VAE in horizontal positioning in the current study was 11%, it was significantly less than in the sitting position (p<0.001). However, the incidence in our study was much higher when compared to Rath et al who reported incidence of 1.4% in patients undergoing posterior fossa craniotomy in the horizontal position. The comparable incidence of $EtCO_2$ detected VAE found in the studies by Muley[11] (17.2%) and Bithal[7] (22%). Nevertheless, there are reports supporting capnography as a satisfactory method for the detection of VAE in these clinical situations. The limitation of retrospective study was the accuracy of the data and some missing data about postoperative complications such as atelectasis. Further study needs to be done to compare the incidence and complication of each position in order to reduce mortality and morbidity.

Conclusion

The incidence of Venous air embolism in

Table 3. Intraoperative data

	Sitting position (n = 92)	Horizontal position (n = 100)	*p*-value
Hypotension	57 (62%)	44 (44%)	0.013
Suspected VAE	51 (55.4%)	17 (17%)	<0.001*
Severe VAE	38 (41.3%)	11 (11%)	<0.001*
Change position	6 (6.5%)	0 (0%)	0.009*
Blood loss (ml, min-max)	150 (10-1,600)	200 (5-4,500)	0.011*
PRC (ml, mean ± SD)	56.43±168.16	69.93±285.52	0.525
Operative time (minute, min-max)	230 (90-775)	205 (60-8-5)	0.148

VAE = venous air embolism
suspected VAE and severe VAE= number of patients in both groups, Change position = number of patient needed to changed position from sitting to horizontal position

Table 4. Postoperative data

	Sitting position (n = 92)	Horizontal position (n = 100)	*p*-value
Postoperative ventilation days	1.24±3.14	1.60±6.32	0.029
ICU stay days	2.09±3.12	2.67±6.72	0.491
Hospital stay days	9.01±4.72	11.46±10.63	0.370

Postoperative ventilation days = days of postoperative ventilation time, ICU stay = number of days in ICU, Hospital stay = number of days admitted in the hospital

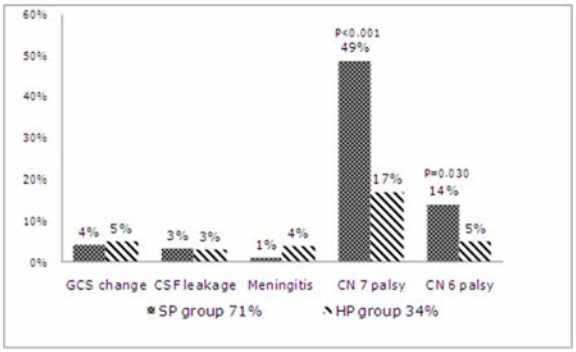

Fig. 1 Central nervous system (CNS) complications.

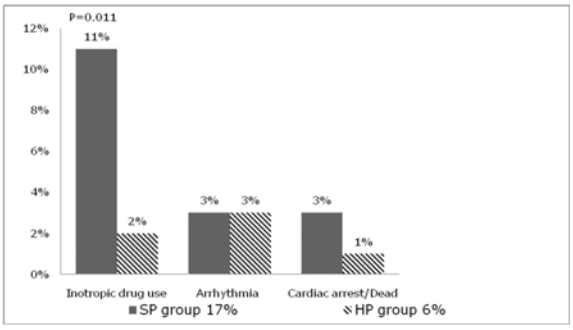

Fig. 2 Cardiovascular (CVS) complications.

posterior cranial fossa surgery was significantly higher in sitting position than in horizontal group. However the incidence and degree of VAE in horizontal group could affect the mortality and morbidity as well as in sitting group.

What is already known on this topic?

The incidence of severe VAE is higher in operation with sitting position.

What this study adds?

The incidence of severe VAE in HP was less than SP, however, it can affect the mortality and morbidity of patient as well as sitting group. The practice of VAE monitoring may be changed to more sensitive equipment than current practice due to the

Table 5. Discharge status: neurological status of all patients when discharge from the hospital

Status	Sitting position (n = 92)	Horizontal position (n = 100)
Neurologically normal	13 (14.1%)	40 (40%)
Mild disability	64 (69.6%)	42 (42%)
Moderate disabled but independent	8 (8.7%)	8 (8%)
Severe disabled and dependent	4 (4.3%)	9 (9%)
Dead	3 (3.3%)	1 (1%)

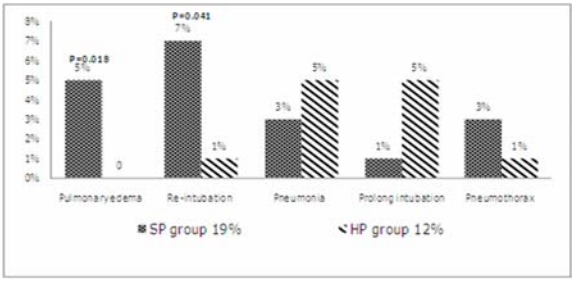

Fig. 3 Respiratory (RS) complications.

significant number of VAE in horizontal position.

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Potential conflicts of interest

None.

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ภาวะ venous air embolism ขั้นรุนแรงที่เกิดในท่าผ่าตัดต่าง ๆ ในการผ่าตัดสมองส่วนหลังในโรงพยาบาลศิริราช

ปราณี รัชตามุขยนันต์, ภัทชนน เซียนโห, สายพิณ เมืองแมน, มานี รักษาเกียรติศักดิ์

ภูมิหลัง: การผ่าตัดสมองส่วนหลังมักจะทำในท่านั่งและท่าแนวนอนมักจะพบ venous air embolism ซึ่งเป็นภาวะที่มีความเสี่ยงสูง

วัตถุประสงค์: เพื่อศึกษาเปรียบเทียบภาวะ venous air embolism และภาวะแทรกซ้อนอื่นของท่านั่งและนอน

วัสดุและวิธีการ: การศึกษาแบบย้อนหลังโดยดูจากแฟ้มผู้ป่วย 192 คนที่มารับการผ่าตัดสมองส่วนหลังระหว่าง เดือนมกราคม พ.ศ. 2553 ถึง ธันวาคม พ.ศ. 2556 เก็บฐานข้อมูลทั่วไปท่าผ่าตัดการเปลี่ยนแปลงของความดันเลือด venous air embolism (VAE) ปริมาณเสียเลือดและให้เลือดระยะเวลาผ่าตัดและเวลานอนโรงพยาบาลข้อมูลหลังผ่าตัด คำนิยามของ VAE ขั้นรุนแรงคือ รายที่สงสัยร่วมกับความดันลดลงมากกว่าร้อยละ 20

ผลการศึกษา: มีผู้ป่วยในกลุ่มท่านั่ง 92 คน ท่านอน 100 คน อุบัติการณ์ของ VAE ขั้นรุนแรงพบมากในท่านั่งอย่างมีนัยสำคัญทางสถิติ (41.3% vs. 11% p<0.001) ผลแทรกซ้อนต่อระบบประสาท (71% vs. 34%, p = 0.001) และระบบหัวใจ (17% vs. 6%, p = 0.001) พบในท่านั่งมากกว่าตามลำดับ แม้ว่าท่านั่งจะพบผู้ป่วยที่ต้องช่วยหายใจในเวลาที่น้อยกว่าแต่ระยะเวลาในไอซียูและการอยู่โรงพยาบาล ไม่มีความแตกต่างของผู้ป่วยทั้ง 2 กลุ่ม

สรุป: อุบัติการณ์ของ VAE ขั้นรุนแรงพบมากในท่านั่งอย่างมีนัยสำคัญทางสถิติโดยดูจากก๊าซคาร์บอนไดออกไซด์ขณะหายใจออก