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Analysis of clinical implications of aeroembolism during cerebello-pontine angle tumor removal conducted in semi-sitting position

Analiza implikacji klinicznych zatoru powietrznego
 w trakcie operacji guzów kąta mostowo-mózdkowego
 w pozycji półsiedzącej

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ABSTRACT

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BACKGROUND

The semi-sitting position of the patient during cerebellopontine angle (CPA) surgery enables the spontaneous outflow of blood and cerebrospinal fluid from the operation area. This restricts the necessity of using an aspirating nozzle and other instruments which are dangerous for local delicate structures like the facial nerve or labyrinthine artery. The disadvantage of the semi-sitting position is the risk of pneumatocele and aeroembolism.

METHODS

214 patients operated on in the Department of Neurosurgery, Medical University of Silesia in Katowice were analyzed. Aeroembolism was correlated with such parameters as: perioperative death rate, duration of hospitalization in neurosurgical and intensive care wards, respiratory or circulatory insufficiency, necessity of using a respirator and the number of specialist consultations

RESULTS

Aeroembolism does not increase the death rate or duration of hospitalization in a neurosurgical ward, but it does expose patients to respiratory failure ($p = 0.014$). Aeroembolism is also correlated with hospitalization in an intensive care ward ($p = 0.002$) and increases the number of specialist consultations ($p = 0.042$). In our opinion, very important for the prevention of aeroembolism is surgeons' care on the closure of every open vein, especially those in bone, using bone wax. The elevation of venous pressure due to manual compression on the cervical veins is the best method for locating not bleeding but open veins.

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CONCLUSIONS

We have proved that a venous air embolism increases neither mortality nor the duration of hospitalization. We believe that prevention and early treatment of aeroembolism prevents further complications.

KEY WORDS

aeroembolism, cerebello-pontine angle tumor, semi-sitting position

STRESZCZENIE

WSTĘP

Pozycja półsiedząca pacjenta w trakcie operacji w obrębie kąta mostowo-mózdkowego (KMM) umożliwia samoistny odpływ krwi i płynu mózgowo-rdzeniowego z pola operacyjnego. Ogranicza to konieczność używania w polu operacyjnym ssaka i innych narzędzi, którymi można uszkodzić tak delikatne struktury jak nerw twarzowy czy tętnica błędnikowa. Niedogodnością pozycji półsiedzącej jest ryzyko zatoru powietrznego i odmy mózgowej.

METODY

Analizie poddano 214 pacjentów operowanych w Katedrze i Klinice Neurochirurgii Śląskiego Uniwersytetu Medycznego w Katowicach. Wystąpienie zatoru powietrznego skorelowano z następującymi parametrami: zgon okołoperacyjny, okres hospitalizacji na oddziale neurochirurgicznym i oddziale intensywnej terapii, zaburzenia oddechowe i krążeniowe, konieczność pooperacyjnej respiratoroterapii, liczba konsultacji specjalistycznych.

WYNIKI

Zator powietrzny nie zwiększa śmiertelności okołoperacyjnej i czasu hospitalizacji na oddziale neurochirurgicznym, ale naraża pacjentów na niewydolność oddechową ($p = 0,014$). Podwyższa też konieczność hospitalizacji na oddziale intensywnej terapii ($p = 0,002$) i częstość konsultacji specjalistycznych ($p = 0,042$).

WNIOSKI

Potwierdziłyśmy, że zator powietrzny nie wpływa na śmiertelność okołoperacyjną i czas hospitalizacji. Zapobieganie zatorowi i jego wczesne leczenie pozwala uniknąć dalszych komplikacji.

SŁOWA KLUCZOWE

zator powietrzny, guz kąta mostowo-mózdkowego, pozycja półsiedząca

INTRODUCTION

The semi-sitting position of the patient during CPA surgery enables the spontaneous outflow of blood and cerebrospinal fluid from the operation site. This restricts the necessity of using a nozzle and other instruments which are potentially dangerous for local delicate structures like the facial nerve or labyrinthine artery. The semi-sitting position of the patient during CPA surgery offers many advantages in terms of surgical access to the posterior fossa. However, these advantages must be weighed against the risks which include cerebral and myocardial ischemia secondary

to hypotension, pneumatocele, complications of the positioning itself, and the most serious disadvantage of venous and paradoxical arterial air embolism [1].

As venous pressure in the operation site is usually negative, air can be entrained. This air may follow any of four pathways. Most commonly it passes through the right side of the heart into pulmonary circulation, diffuses through the alveolar-capillary membrane and appears in expelled gas. It may pass through a pulmonary-systemic shunt such as a probe patent foramen ovale (paradoxical air embolism); it may collect at the superior vena cava-right atrial junction. Rarely, may it traverse through lung capillaries into systemic circulation [2].

PURPOSE

The aim of this study was to find the influence of aeroembolism on the clinical outcome of patients with a CPA tumor.



Fig. 1. Patient in semi-sitting position. Fixation in Mayfield headholder, legs elevated on elastic support. Head flexed toward and rotated in direction of tumor site.

Ryc. 1. Pacjent w pozycji półsiedzącej. Umocowanie w ramie Mayfielda, nogi uniesione i podparte elastyczną podporą. Głowa zgięta do przodu i zrotowana w kierunku strony guza.

MATERIAL AND METHODS

The study investigated patients of both sex who were operated on in the Department of Neurosurgery, Medical University of Silesia in Katowice in the last 10 years. All the patients were operated on in a semi-sitting position with installation of the Mayfield pin-head holder. The operation was performed through the retrosigmoid approach. In all the patients the total intravenous anesthesia technique (TIVA) with propofol and moderate hyperventilation (PaCO_2 30–35 mmHg) without PEEP was used. The mean propofol induction dose was 1.5 mg/kg combined with 1.7 micrograms/kg of fentanyl, and 0.08 mg/kg of vecuronium. Anesthesia was maintained with continuous infusion of propofol 6 mg/kg/h and boluses of fentanyl 100 micrograms every half an hour. We performed a prospective audit of venous air embolism evidenced by the transoesophageal echocardiography and verified with a decrease in end-tidal carbon dioxide partial pressure of 5 mmHg or more within 5 min. If air embolism occurred, we used the central venous catheter to remove air and blood from the right atrium as well as performing 100% oxygen ventilation.

When embolic episodes were accompanied by hypotension, the patients were administered vasopressors to restore arterial pressure to pre-embolic levels.

We studied the incidence of aeroembolism and its correlation with such parameters as: death rate, duration of hospitalization in neurosurgical and intensive care wards, respiratory or circulatory insufficiency, necessity of using a respirator and the number of specialist consultations.

For statistical analysis, we used the Statistica.pl® 6.1 program and U Mann Whitney test ($p < 0.05$).

RESULTS

The study was conducted on 214 patients aged 15–84, both male (84 patients – 41%) and female (120 patients – 59%). Venous air embolism occurred in 9% of the patients. None of the investigated patients showed paradoxical air embolism. Aeroembolism did not affect the death rate or duration of hospitalization in a neurosurgical ward (20.34 days vs. 21.01). The correlation between aeroembolism and respiratory failure ($p = 0.014$) showed in Fig. 1 was statistically significant.

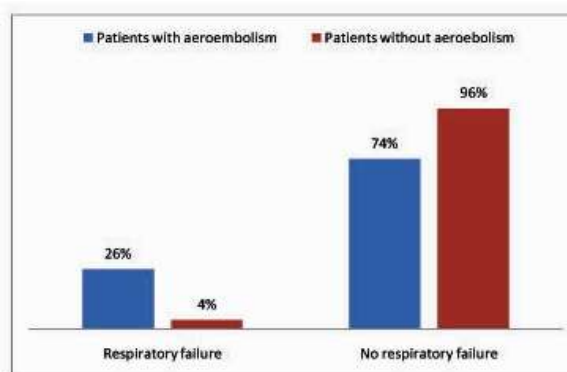


Fig. 2. Frequency of respiratory failure.

Ryc. 2. Częstość zaburzeń oddechowych.

Aeroembolism was also correlated with hospitalization in an intensive care ward (20% vs. 7%; $p = 0.002$) (Tab. I) and increased the number of specialist consultations (3.2 vs. 1.9; $p = 0.042$).

Table I. Frequency and length of hospitalization in ICU
Tabela I. Częstość i długość hospitalizacji na oddziale intensywnej terapii

	Mean duration of hospitalization in ICU	Number of patients hospitalized in ICU
Patients with aeroembolism present	2 days	6/21 (28.5%)
Without aeroembolism	0.4 days	10/193 (5.1%)

DISCUSSION

Venous air embolism is a potentially serious complication in neurosurgery that occurs more commonly when the patient is in the sitting position [4]. In our study, venous air embolism occurred in 9% of patients, which corresponds well with other investigations [4,5]. With an incidence of a patent foramen ovale in nearly one fourth of the normal population, neurosurgical procedures in the semi-sitting position are associated with the risk of paradoxical air embolism [6]. None of the investigated patients showed this complication.

In all the patients, TIVA anesthesia with propofol was performed – this is the most suitable method in neurosurgery for its greatest advantages: fast recovery of consciousness is important to justify the neurological outcome, and stable hemodynamics with a strong trend towards a minor necessity for hemodynamic intervention [10,11,12]. This is also the best method from the subjective point of view of the anesthesiologist due to the easy handling and the low number of interventions [3,12]. TIVA also leads to a faster recovery of cerebral function, which may result in better behavior and advantages in postoperative management [3]. Many studies show that the ability to maintain appropriate levels of anesthesia, adequate analgesia, and hemodynamic stability was assessed in all patients who undergo a standard dosage of propofol combined with fentanyl and vecuronium [1,9,14,15,16,17,18]. Vascular air embolism is a potentially life-threatening event that occurs more commonly when the patient is in the sitting position during the operation. Advances in monitoring devices coupled with an understanding of the pathophysiology of vascular air embolism should enable the physician to successfully manage these potentially challenging clinical scenarios [7]. Many monitors such as the precordial Doppler, capnography, pulmonary artery catheter, transoesophageal echocardiography are useful for venous air embolism detection [2] with capnography being most frequently used – this method not only provides global monitoring (metabolic, haemo-

dynamic and respiratory) but also allows early detection of any significant migration of air or gas into the blood vessels [8].

If an air embolism is present, the use of a central venous catheter is recommended, with the tip positioned close to the superior vena cava junction with the right atrium, to aspirate intravascular gas [8,19]. Venous air embolism places an acute load on the right ventricle and may provoke right-side heart failure, even in the absence of total cardiovascular collapse. The treatment that supports right-side heart function may allow sufficient time for redistribution of embolized air and produce a good outcome when the aspiration of gas is insufficient [19,20].

Measures to minimize hypotension associated with the sitting position include slow, staged positioning over 5–10 min [8,13]. When following these rules, the sitting position is safe and the advantages of its usage outweigh the potential risk.

In our opinion, very important for the prevention of aeroembolism is surgeons' care on the closure of every open vein, especially those in bone, using bone wax. Special care to not destroy sigmoid and transverse sinuses during retrosigmoid craniotomy or craniectomy is necessary. Using surgical and cotton on the margins of bone and sinuses works well. The elevation of venous pressure due to manual compression on the cervical veins is the best method for locating not bleeding, but open veins. This maneuver should be repeated by the anesthesiologist a few times while approaching and also during tumor removal. The most commonplace complication in the operating field of ear penetration to the venal system is petrosal vein rupture during the procedure. If such a situation occurs, the petrosal vein must be cut and coagulated.

CONCLUSIONS

We proved that the venous air embolism increases neither mortality nor the duration of hospitalization. We believe that the prevention of air embolism and early treatment prevent further complications.

REFERENCES

1. Gale T., Leslie K. Anaesthesia for neurosurgery in the sitting position. *J. Clin. Neurosci.* 2004; 11: 693–696.
2. Domaingue C.M. Anaesthesia for neurosurgery in the sitting position: a practical approach. *Anaesth. Intensive Care* 2005; 33: 323–331.
3. Weninger B., Czerner S., Steude U., Weninger E. Comparison between TCI-TIVA, manual TIVA and balanced anaesthesia for stereotactic biopsy of the brain. *Anesthesiol. Intensivmed. Notfallmed. Schmerzther.* 2004; 39: 212–219.
4. Leslie K., Hui R., Kaye A.H. Venous air embolism and the sitting position: a case series. *J. Clin. Neurosci.* 2006; 13: 419–422.
5. Engelhardt M., Folkers W., Brenke C. et al. Neurosurgical operations with the patient in sitting position: analysis of risk factors using transcranial Doppler sonography. *Br. J. Anaesth.* 2006; 96: 467–472.
6. Kwapisz M.M., Deinsberger W., Muller M. Transoesophageal echocardiography as a guide for patient positioning before neurosurgical procedures in semi-sitting position. *J. Neurosurg. Anesthesiol.* 2004; 16: 277–281.
7. Mirski M.A., Lele A.V., Fitzsimmons L., Toung T.J. Diagnosis and Treatment of Vascular Air Embolism. *Anesthesiology* 2007; 106: 164–177.
8. Porter J.M., Pidgeon C., Cunningham A.J. The sitting position in neurosurgery: a critical appraisal. *Br. J. Anaesth.* 1999; 82: 117–128.
9. Gaggero G., Ravussin P., Borgeat A., Wilder-Smith O. Use of propofol in intracranial surgery in 83 consecutive patients. *Neurochirurgie* 1994; 40: 127–131.
10. Bilgin H., Basagan Mogol E., Bekar A., Iscimen R., Korfali G. A comparison of effects of alfentanil, fentanyl, and remifentanyl on hemodynamic and respiratory parameters during stereotactic brain biopsy. *J. Neurosurg. Anesthesiol.* 2006; 18: 179–184.

11. Del Gaudio A., Ciritella P., Perrotta F. et al. Remifentanyl vs fentanyl with a target controlled propofol infusion in patients undergoing craniotomy for supratentorial lesions. *Minerva Anesthesiol.* 2006; 72: 309–319.
12. Manninen P.H., Balki M., Lukitto K., Bernstein M. Patient satisfaction with awake craniotomy for tumor surgery: a comparison of remifentanyl and fentanyl in conjunction with propofol. *Anesth. Analg.* 2006; 102: 237–242.
13. Huse K., Wiecken H. Circulatory changes in the sitting position during neurosurgical anaesthesia (NLA). *Anaesthesist* 1979; 28: 557–563.
14. Alibert F., Roux P. The sitting position in neurosurgery: the viewpoint of the anesthetist. *Ann. Fr. Anesth. Reanim.* 1998; 17: 164–167.
15. Hernandez-Palazon J., Martinez-Lage J.F., de la Rosa-Carrillo V.N., Tortosa J.A., Lopez F., Poza M. Anesthetic technique and development of pneumocephalus after posterior fossa surgery in the sitting position. *Neurochirurgia (Astur)* 2003; 14: 216–221.
16. Venkatraghavan L., Manninen P., Mak P., Lukitto K., Hodaie M., Lozano A. Anesthesia for functional neurosurgery: review of complications. *J. Neurosurg. Anesthesiol.* 2006; 18: 64–67.
17. Knuttgen D., Stolzle U., Koning W., Muller M.R., Doehn M. Air embolism in the sitting position. Oxygen/nitrogen versus oxygen/laughing gas. *Anaesthesist* 1989; 38: 490–497.
18. Smelt W.L., de Lange J.J., Booij L.H. Cardiorespiratory effects of the sitting position in neurosurgery. *Acta Anaesthesiol. Belg.* 1988; 39: 223–231.
19. Archer D.P., Pash M.P., MacRae M.E. Successful management of venous air embolism with inotropic support. *Can. J. Anaesth.* 2001; 48: 204–208.
20. Bithal P.K., Pandia M.P., Dash H.H., Chouhan R.S., 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.