PRACA ORYGINALNA

Parameters determining frequency and intensity of pneumatocele in patients with cerebello-pontine angle tumor operated in sitting position. Clinical implications

Parametry określające częstotliwość i intensywność pooperacyjnej odmy czaszkowej u chorych z guzem kąta mostowo-móżdżkowego operowanych w pozycji siedzącej. Implikacje kliniczne

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ABSTRACT

BACKGROUND

Cerebello-pontine angle (CPA) surgery is performed in a semi-sitting position of the patient – this enables spontaneous outflow of the blood and cerebrospinal fluid as well as solutions used for operation site rinsing. This restricts the necessity of coagulation and an aspirating nozzle in the operating field. The aim of this study was to find the influence of pneumatocele on the clinical outcome of patients with a CPA tumor.

METHOD

All the patients were operated on in a semi-sitting or sitting position with propofol intravenous anesthesia. Pneumatocele was evaluated on the basis of CT examination on the authors' own four-degree scale and correlated 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. The frequency and intensity of pneumatocele were correlated with such parameters as: age and sex of the patient, anesthesia hazard scale (ASA), heart rate and systolic blood pressure during operation, diuresis, the amount and type of infusions, fluid balance and duration of surgery.

FINDINGS

Pneumatocele increases the death rate ($p = 0.037$), prolongs the duration of hospitalization both in the neurosurgical ($p = 0.0001$) and intensive care ($p = 0.0022$) wards. This complication exposes patients to circulatory ($p = 0.012$) and respiratory ($p = 0.029$) failure. The frequency and intensity of pneumatocele is correlated with the age and sex of the patient, duration of the operation, type of nfusions and fluid balance.

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CONCLUSIONS
This ensures us that a TC head examination must be performed after each surgery procedure that is conducted in the up-right position. If possible, we should prevent pneumatocele by avoiding negative fluid balance and systolic blood pressure decrease below 100 mmHg.

KEY WORDS
pneumatocele, aeroembolism, intravenous anesthesia, cerebello-pontine angle tumor

STRESZCZENIE

WSTĘP
Półsiedząca pozycja pacjenta w trakcie zabiegu usunięcia guza mostowo-móżdżkowego umożliwia spontaniczny odpływ krwii, płynu mózgowo-rdzeniowego oraz płynów stosowanych w trakcie operacji do płukania pola operacyjnego. Taka pozycja zmiejsza konieczność koagulacji i ssania w polu operacyjnym. Celem pracy było zbadanie wpływu odmy czaszkowej na wyniki badań klinicznych u chorych operowanych z powodu guza kąta mostowo-móżdżkowego.

METODY
Wszyscy pacjenci po znieczuleniu byli operowani w pozycji półsiedzącej. Odmę czaszkową oceniano na podstawie badania TK według czterostopniowej skali własnej, wyniki analizowano pod kątem śmiertelności, czasu hospitalizacji, wystąpienia niewydolności krążeniowo-oddechowej, konieczności zastosowania respiratora oraz liczby koniecznych konsultacji specjalistycznych. Podjęto próbę analizy korelacji częstotliwości i intensywności pooperacyjnej odmy czaszkowej z wiekiem oraz płcią pacjentów, ryzykiem wynikającym ze znieczulenia (skala ASA), tętnem i ciśnieniem krwi w trakcie operacji, ilością oddawanego moczu, ilością i rodzajem podawanych płynów w trakcie zabiegu oraz czasem trwania zabiegu.

WYNIKI
Częstotliwość i intensywność pooperacyjnej odmy czaszkowej koreluje z: wiekiem i płcią pacjentów, czas operacj oraz rodzajem i ilością podawanych płynów.

WNIOSKI
Badania TK głowy muszą być wykonywane rutynowo po każdej operacji, która prowadzona jest w pozycji siedzącej. Mężczyźni powyżej 60 lat, których zabieg trwał dłużej niż 3 godziny są szczególnie podatni na wystąpienie odmy czaszkowej. W miarę możliwości powinno się zapobiegać wystąpieniu odmy czaskowej, unikając ujemnego bilansu płynów oraz spadku ciśnienia skurczowego poniżej 100 mHg.

SŁOWA KLUCZOWE
odma czaszkowa, guz kąta mostowo-móżdżkowego, pozycja półsiedząca

INTRODUCTION

One of the challenges in neurosurgery is the microsurgical removal of cerebello-pontine angle tumors, which is performed using the retrosigmoid approach in patients in a sitting position with the head turned and flexed [1,2,3]. The up-right position of the patient during cerebello-pontine angle (CPA) surgery enables spontaneous outflow of blood, cerebrospinal fluid and solutions used during the surgery [4].

This position and its consequences restrict the necessity of coagulation and an aspirating nozzle in the operating field.

The usage of those surgical instruments often leads to damage of the facial nerve, cochlear nerve, labyrinthine artery and other delicate structures [5]. The disadvantage of the up-right position is the risk of pneumatocele or air embolism. The spontaneous drainage of cerebrospinal fluid predisposes the inflow of air which may be situated in the extradural, subdural or subarachnoid spaces or intracerebrally. Possible

clinical signs of massive pneumocephalus are headache, followed by epileptic seizures and respectively, severely impaired consciousness after the operation, this requires the operative evacuation of air [6,7,8,9].

The aim of this study was to find the influence of pneumatocele on the clinical outcome of patients with a CPA tumor and if any other modificative parameters determine the frequency and intensity of pneumatocele.

Fig. 1. Sitting position during operation.
Ryc. 1. Pozycja siedząca w trakcie operacji.

MATERIAL AND METHODS

We report on a series of 212 patients with CPA tumors operated on in Katowice to analyse the clinical implications of pneumatocele. The age range of this series was 15–84 years with an average age of 48 years. 83 patients were male (41%) and 119 were female (59%). This corresponds well with other researches – women are more suseptible to CPA tumors [10]. 178 patients with a CPA tumor were analysed to qualify the parameters determining the frequency and intensity of pneumatocele.

All the patients were operated on in an up-right position using the retrosigmoid approach. TIVA anesthesia with propofol was performed – this is the most suitable method in neurosurgery for its greatest advantages: fast recovery of vigilance is important to justify the neurological outcome, and stable hemodynamics with a strong trend towards a minor necessity for hemodynamic intervention. 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. TIVA also leads to faster recovery of cerebral function, which may lead to better behavior and advantages in postoperative management [11,12].

CT examination of the head was performed in all the patients 6 hours after the surgery. Pneumatocele was evaluated on the basis of CT examination using our own semi quantitative four–degree scale.

4-degree pneumatocele scale:

Fig. 2. Pneumatocele (0 – no air).
Ryc. 2. Odma czaszkowa (0 – brak powietrza).

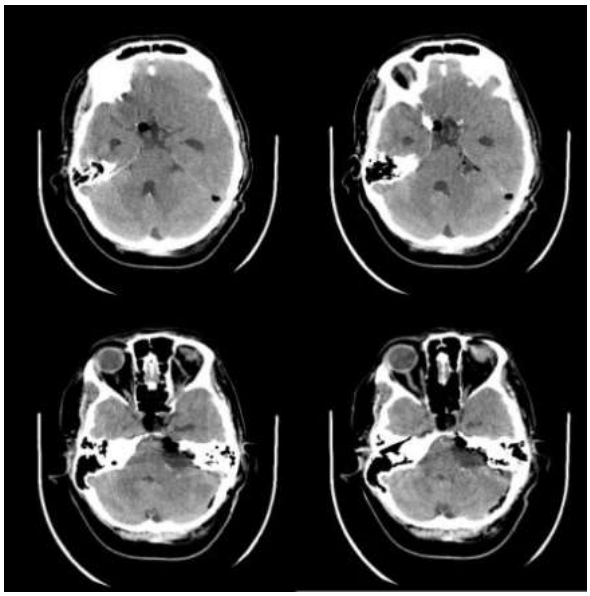

Fig. 3. Pneumatocele+ (1 – presence of air in site of CPA-tumor removal and no more than 2 cisterns of air smaller than 1 cm).
Ryc. 3. Odma czaszkowa+ (1 – obecność powietrza w miejscu usuniętego guza i nie więcej niż dwie torbiele powietrzne mniejsze niż 1 cm).

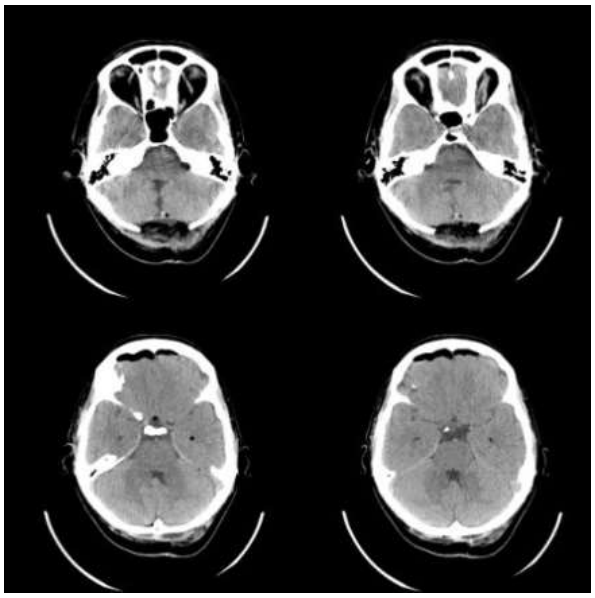

Fig. 4. Pneumatocele++ (2 – more than 2 cisterns of air smaller than 1 cm or surrounding pneumatocele in area of frontal lobes thinner than 1 cm).
Ryc. 4. Odma czaszkowa++ (2 – więcej niż dwie torbiele powietrzne mniejsze niż 1 cm lub torbiel powietrzna otaczająca okolicę płata czołowego cieńsza niż 1 cm).

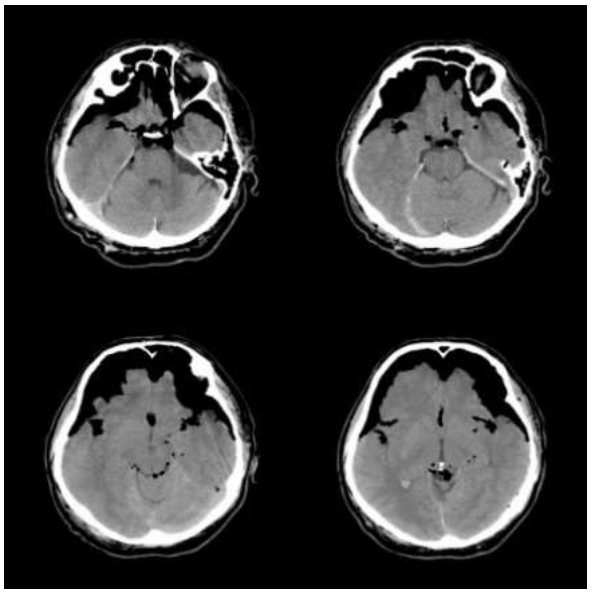

Fig. 5. Pneumatocele+++ (3 – surrounding pneumatocele thicker than 1 cm or large air cistern in different location).
Ryc. 5. Odma czaszkowa+++ (3 – torbiel powietrzna otaczająca okolicę płata czołowego grubsza niż 1 cm lub duża komora powietrzna w innej lokalizacji).

As is commonly known, air may be situated in the extradural, subdural and subarachnoid spaces or intracerebrally. Cases associated with pneumatocele or a single intracranial air bubble have a good prognosis while patients with multiple air bubbles have a bad prognosis. Pneumoencephalos is usually associated with a high mortality rate [13,14]. Due to these facts, we emphasized in our scale the presence of air in the ventricular system and the number of air cisterns.

The clinical implications of pneumocephaly have been correlated with such parameters as: death rate, duration of hospitalization in neurosurgical and intensive care wards, respiratory or circulatory insufficiency, the necessity of respirator usage and the number of specialist consultations.

In the study, we have correlated the frequency and intensity of pneumocephaly with such parameters as: age and sex of the patient, anesthesia hazard scale (ASA), heart rate and systolic blood pressure during the operation, dieresis, the amount and type of infusions, fluid balance and duration of surgery.

For statistical analysis we used the U Mann Whitney test ($p < 0.05$).

RESULTS

Pneumatocele was found in 37% patients and 19.7% of patients with radiologically confirmed pneumatocele required trepanopuncture to removal air. Pneumatocele increases the death rate ($p = 0.0372$) and prolongs the duration of hospitalization in a neurosurgical ward ($p = 0.0001$).

In our work we proved a statistically significant correlation between pneumatocele and the duration of hospitalization in an intensive care ward (8 days vs. 2 days; $p = 0.0022$).

The presence of post-operative pneumatocele exposes patients to circulatory ($p = 0.012$), severe respiratory ($p = 0.029$) and minor respiratory failure ($p = 0.022$).

We also stated that the number of specialist consultations was significantly higher in the group of pneumatocele-positive patients (2.8 vs. 1.9; $p = 0.049$).

In our work we proved a statistically significant correlation between the duration of the surgery and the frequency and intensity of pneumatocele ($p = 0.00058$). Operations lasting shorter than 2 h are almost free of this complication while procedures longer than 6h, multiple (6 times) postoperative pneumatocele occur.

Significant parameters that increase the risk of pneumocele are: negative total fluid balance during the surgery ($p = 0.03$) and the male sex of patients ($p = 0.001$). Although CPA tumors more often occur in women [10] those present in men produce more postoperative complications.

We found a correlation between an intraoperative blood pressure decrease below 100 mmHg and the frequency of pneumocetale ($p = 0.022$).

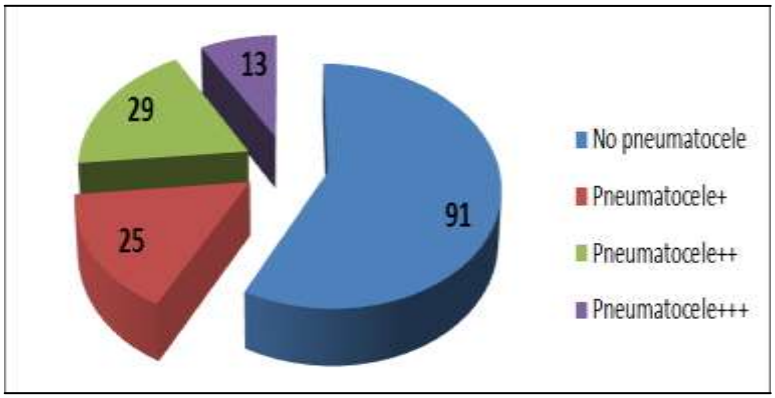

Fig. 6. Number of patients.
Ryc. 6. Liczba pacjentów.

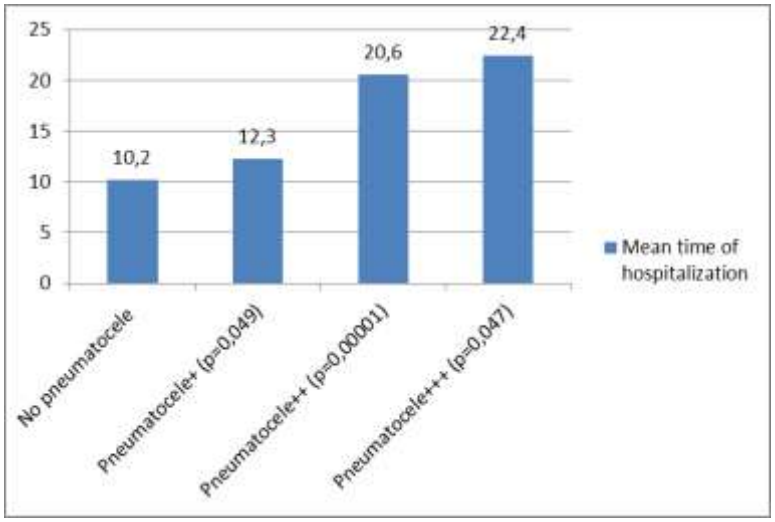

Fig. 7. Time of hospitalization.
Ryc. 7. Czas hospitalizacji.

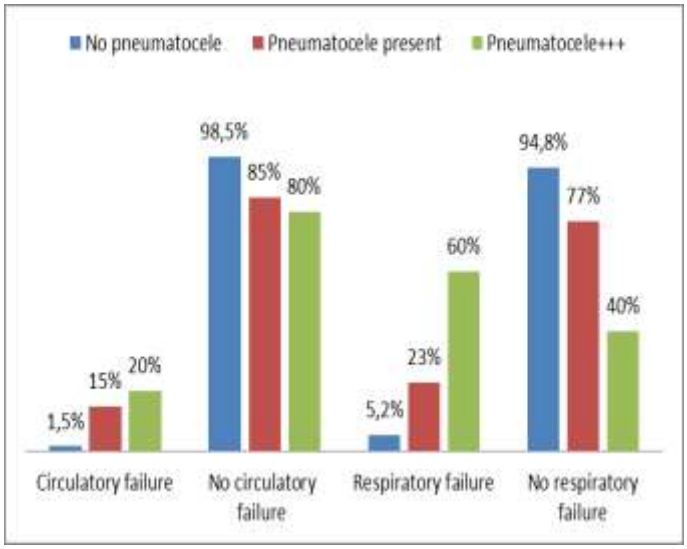

Fig. 8. Percentage of patients with circulatory-respiratory disorders.
Ryc. 8. Procentowy rozkład pacjentów z zaburzeniami krążeniowo-oddechowymi.

Table I. Correlation between age of patients and frequency of pneumatocele was statistically significant (p = 0.04)
Tabela I. Korelacja wieku pacjentów oraz częstotliwości występowania odmy czaszkowej (znamiennie statystycznie istotna p = 0,04)

Surgery duration	Number of patients	No air	Pneumatocele+	Pneumatocele++	Pneumatocele+++
1–2 h	15 (8%)	14 (93%)	–	1 (7%)	–
2–4 h	31 (18%)	21 (68%)	4 (12%)	3 (10%)	3 (10%)
4–6 h	57 (32%)	37 (68%)	9 (13%)	6 (10%)	5 (9%)
Over 6 h	75 (42%)	42 (56%)	13 (17%)	11 (15%)	9 (11%)

Table II. Significant parameters that increase risk of pneumocele (negative total fluid balance during surgery p = 0.03 and male sex of patients p = 0.001)
Tabela II. Znamiennie istotne parametry zwiększające ryzyko odmy czaszkowej to ujemny bilans płynów w trakcie operacji p = 0,03 oraz płeć męska p = 0,001

Age	Number of patients	No air	Pneumatocele+	Pneumatocele++	Pneumatocele+++
10–15	3 (1.5%)	2 (66%)	–	1 (33%)	–
16–20	5 (2.8%)	3 (60%)	1 (20%)	–	1 (20%)
21–25	9 (5%)	5 (55%)	3 (33%)	–	1 (11%)
26–30	8 (4.5%)	6 (75%)	1 (12%)	1 (12%)	–
31–35	16 (9.2%)	9 (56%)	5 (31%)	2 (12%)	–
36–40	26 (15%)	18 (69%)	3 (15%)	2 (5%)	3 (11%)
41–45	14 (8%)	8 (57%)	3 (21%)	1 (7%)	1 (7%)
46–50	19 (11.5%)	11 (55%)	2 (10%)	4 (20%)	2 (10%)
51–55	34 (20%)	26 (70%)	2 (8%)	4 (15%)	2 (6%)
56–60	16 (9.2%)	10 (62%)	3 (18%)	1 (6%)	2 (12%)
61–65	17 (10%)	12 (67%)	2 (11%)	2 (11%)	2 (10%)
66–84	11 (6%)	3 (27%)	1 (9%)	4 (36%)	3 (27%)

No correlation was found with:
- ASA scale (p = 0.3)
- Amount of infusions (p = 0.8)
- Total dieresis (p = 0.14)
- Heart rate > 100/min (p = 0.06) these parameters seem to induce postoperative complications to a lesser degree.

DISCUSSION

Pneumatocele is rather common complication after posterior fossa surgery [15] and particularly after CPA tumor removal in a sitting position [16]. This may result in headache, impairment of the level of consciousness and psychomotor agitation, as well as deep coma [13,17]. Having in mind that pneumatocele is a common complication of CPA surgery, in our study we put emphasis on the analysis of its presence and postoperative complications in relation to: death rate, duration of hospitalization in neurosurgical and intensive care wards, respiratory or circulatory insufficiency, the necessity of respirator usage and the number of specialist consultations.

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 vigilance is important to justify the neurological outcome and stable hemodynamics with a strong trend towards a minor necessity for hemodynamic intervention. 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. TIVA also leads to faster recovery of cerebral function, which may lead to better behavior and advantages in postoperative management [11,12].

In this study pneumatocele was evaluated on the basis of CT examination on our own semi-quantitative four--degree scale. CT examination of the head was performed on all the patients 6 hours after the surgery. Air may be situated in the site of CPA tumor removal, basis cisterns, cranial vault and ventricular system. The cases associated with a pneumatocele or a single intracranial air bubble have a good prognosis while patients with multiple air bubbles have a bad prognosis. Pneumoencephalos is usually associated with a high mortality rate. Due to these facts we emphasized in our scale the presence of air in the ventricular system and the number of air cisterns [13,14].

We showed in our study the correlation between the frequency and intensity of pneumatocele and duration of surgery, age and sex of operated patients, negative total fluid balance and intraoperative systolic blood pressure decrease below 100 mmHg. When CPA tumor removal procedures are prolonged, the site of tumor removal, basis cisterns and other cerebrospinal-fluid cisterns, are more exposed to the inflow of atmospheric air. That may result in the accumulation of a larger volume of air, and therefore in a worse clinical state of operated patients. Long duration of CPA surgery also increases the incidence of a blood pressure decrease below 100 mmHg. This fact may explain the increase in the frequency and intensity of pneumatocele in patients who underwent CPA tumor removal surgery of a longer duration (over 6 h) in comparison to those who underwent a shorter-period operation. The oldest patients show greater perioperative mortality as well as longer recovery from surgery compared with younger patients. We link this situation with the greater hemodynamic instability of older patients who undergo anesthesia [18, 19,20]. The up-right position of patients and the usage of intraoperative monitoring of different electrophysiological functions of the central and peripheral nervous system, require carrying out TIVA anesthesia with propofol. Men statistically more often complain about circulatory system diseases, including coronary artery disease (CAD) than women. That may explain the higher frequency and intensity of pneumatocele in elder men compared to women.

The level of blood pressure is directly associated with circulation blood volume. This explains why a negative total fluid balance is an independent risk factor of pneumatocele.

CONCLUSIONS

1. As tension pneumocephalus has been reported most frequently after posterior fossa surgery performed in the sitting position [21], TC head examination must be performed routinely after each surgery procedure that is conducted in this position. It is proved that the up-right position influences an individuals blood pressure parameters. The blood pressure tends to drop in the sitting position compared with the supine position [22,23].
2. The oldest patients show greater perioperative mortality as well as longer recovery from surgery compared with younger patients [18]. We link this situation with the greater hemodynamic instability in older patients who undergo anesthesia [19,20].
3. If possible, we should prevent pneumatocele by avoiding negative fluid balance and a systolic blood pressure decrease below 100 mmHg. The main method of pneumatocele treatment is prevention performed by the anesthesiologist during surgery.

REFERENCES

1. Yonekawa Y. Operative neurosurgery: personal view and historical backgrounds (2) acoustic neurinoma. No Shineki Geka 2006; 34: 1265–1280.

2. Akhavan-Sigari R., Bellinzona M., Becker H., Samii M. Epidermoid cysts of the cerebellopontine angle with extension into the middle and anterior cranial fossae: surgical strategy and review of the literature. Acta Neurochir. 2007; 149: 429–432.

3. Yoshida K. Problematical issues in management of cerebellopontine angle tumors. Nihon Rinsho. 2005; 63 Suppl 9: 310–314.

4. Cueva R.A., Mastrodimos B. Approach design and closure techniques to minimize cerebrospinal fluid leak after cerebellopontine angle tumor surgery. Otol. Neurotol. 2005; 26: 1176–1181.

5. Sarrazin J.L., Marsot-Dupuch K., Chaŷas A. Pathology of the cerebellopontine angle. J. Radiol. 2006; 87: 1765–1782.

6. Obrador S. Clinical features of the cerebellopontine angle tumors. Acta Neurochir. 1965; 12: 543–553.

7. Arnason O., Jakobsson K.E., Lindgren S. Extracerebral non-haemorrhagic expansive complications of intracranial surgery. Acta Neurochir. 1983; 67: 231–238.

8. Witcombe B., Torrens M.J., Gye R.S. Intracerebral pneumatocele: An unusual complication following intraventricular drainage in a case of benign intracranial hypertension. Neuroradiology 1976; 12: 161–163.

9. Glatz. K., Berger C., Schwab S. Management and causes of pneumocephalus. Case report and review of the literature. Nervenarzt 2005; 76: 1532, 1534–1538.

10. Baguley D.M., Beynon G.J., Grey P.L., Hardy D.G., Moffat D.A. Audio-vestibular findings in meningioma of the cerebello-pontine angle: a retrospective review. J. Laryngol. Otol. 1997; 111: 1022–1026.

11. Weninger B., Czerner S., Steude U., Weninger E. Comparison between TCI-TIVA, manual TIVA and balanced anasthesia for stereotactic biopsy of the brain. Anasthesiol. Intensivmed. Notfallmed. Schmerzther. 2004; 39: 212–219.

12. Gaggero G., Ravussin P., Borgeat A., Wilder-Smith O. Use of propofol in intracranial surgery in 83 consecutive patients. Neurochirurgie 1994; 40: 127–131.

13. Nolla Salas J., Balaguer Martinez E., Carrasco Gomez G., Llovet Tapies J., Sole Llenas J. Pneumoencephalos: etiology, pathologic significance and diagnosis. Apropos of 13 observations. Neurologia 1989; 4: 12–18.

14. Steudel W.I., Hacker H. prognosis, incidence and management of acute traumatic intracranial pneumocephalus. A retrospective analysis of 49 cases. Acta Neurochir. 1986; 80: 93–99.

15. Tucker A., Slattery W.H. 3rd, Solcyk L., Brackmann D.E. Intraoperative auditory assessments as predictors of hearing preservation after vestibular schwannoma surgery. J. Am. Acad. Audiol. 2001; 12: 471–477.

16. Schlake H.P., Milewski C., Goldbrunner R.H. et al. Combined intraoperative monitoring of hearing by means of auditory brainstem responses (ABR) and transtympanic electrocochleography (ECochG) during surgery of intra- and extrameatal acoustic neurinomas. Acta Neurochir. 2001; 143: 985–995.

17. Markham J.W. The clinical features of pneumocephalus based upon a survey of 284 cases with report of 11 additional cases. Acta Neurochir. 1967; 16: 1–78.

18. Voss N.F., Vrionis F.D., Heilman C.B., Robertson J.H. Meningiomas of the cerebellopontine angle. Surg Neurol. 2000; 53: 439–446.

19. Cillo J.E. Jr., Finn R. Hemodynamics in elderly coronary artery disease patients undergoing propofol sedation. J. Oral Maxillofac. Surg. 2006; 64: 1338–1342.

20. Gunnarsson L., Tokics L., Brismar B., Hedenstierna G. Influence of age on circulation and arterial blood gases in man. Acta Anaesthesiol. Scand. 1996; 40; 237–243.
21. Satapathy G.C., Dash H.H. Tension pneumocephalus. Br. Anaesth. 2000; 84: 115–117.
22. Eser I., Khorshid L., Yapucu Gunes U., Demir Y. The effect of different body positions on blood pressure. J. Clin. Nurs. 2007; 16: 137–140.
23. Prabhakar H., Anand N., Chouhan R.S., Bithal P.K. Sudden asystole during surgery in the cerebellopontine angle Acta Neurochir. 2006; 148: 699–700.