

The choice of the hypnotic drug (volatile or propofol) for maintenance of anesthesia does not influence surgical conditions during cranioplasty

S. Grau, C. Denizci, N. von Spreckelsen, R. Goldbrunner, B. W. Böttiger¹, J. Hinkelbein¹

Departments for Neurosurgery and ¹Anaesthesiology and Intensive Care Medicine, University Hospital Cologne, Cologne, Germany

Abstract

Background and Aims: In contrast to propofol, volatile agents are often considered harmful to maintain anesthesia due to increasing brain volume and potential deleterious effects. Patients for cranioplasty, including patients with large bone defects, could be susceptible for intraoperative complications but have not properly been investigated so far. The aim of the present study was to evaluate brain swelling, intraoperative conditions, surgical course, and postoperative complication rates of propofol-based vs. volatile-based anesthesia.

Material and Methods: In this monocentric, retrospective, and observational study, we collected demographic, clinical, and outcome data of patients undergoing cranioplasty between December 2010 and September 2014. According to the hypnotic drug used, patients were assigned to either a propofol or a volatile group. The primary outcome parameter was brain swelling. For comparison of the groups, univariate analysis was performed using Chi-square and Mann-Whitney-U test.

Results: One hundred and one patients were identified in the period. Twenty-three patients were excluded due to cerebrospinal fluid diversion. Baseline characteristics and preoperative conditions did not vary between the groups except a higher body mass index and positive end-expiratory pressure (PEEP) in the propofol group. The choice of anesthesia (volatile or intravenous) influence neither the intraoperative local conditions nor postoperative complication rate. No significant risk factor for impaired bone flap placement was identified.

Conclusions: In a well-defined cohort, the choice of the anesthetic agent does not influence the degree of intraoperative brain swelling, bone flap fit, and postoperative course.

Keywords: Anesthetic drug, anesthesia technique, cranioplasty, inhalational anesthesia, propofol

Introduction

Decompressive craniectomy (DC) is frequently performed for increased intracranial pressure (ICP) refractory to medical treatment. In surviving patients, auto- or heterologous bone flaps are usually replanted several weeks or months after stabilization of their physical condition. Due to the large defect area and, therefore, possibly altered cerebral

haemodynamics, even a mild brain swelling may severely complicate bone flap implantation/replantation from a surgical viewpoint.

In both clinical and experimental studies, various effects of propofol-based and inhalational (volatile) anesthetics on intracranial pressure (ICP), cerebral blood flow (CBF), and brain volume have been documented.^[1-5] However, published data are not congruent and insufficient for a clear decision regarding which anesthesia technique is best. Therefore, the optimal anesthetic drug for cranial procedures is still

Address for correspondence: Prof. Dr. J. Hinkelbein, Department of Anaesthesiology and Intensive Care Medicine, University Hospital Cologne, Cologne, Germany. E-mail: jochen.hinkelbein@uk-koeln.de

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Grau S, Denizci C, von Spreckelsen N, Goldbrunner R, Böttiger BW, Hinkelbein J. The choice of the hypnotic drug (volatile or propofol) for maintenance of anesthesia does not influence surgical conditions during cranioplasty. *J Anaesthesiol Clin Pharmacol* 2018;34:172-6.

Access this article online	
Quick Response Code:	Website: www.joacp.org
	DOI: 10.4103/joacp.JOACP_373_16

controversial due to the potential side effects, e.g., impairment of surgical conditions^[6,7] or higher blood loss caused by altered cerebral perfusion.^[8] As some recent literature showed at least a slightly increased risk for brain swelling during the use of volatile anesthetics,^[3] propofol is still considered the agent of choice in many neuroanesthesia centres.^[3,5]

Regarding the shortage of available literature and its focus on craniotomies for brain tumors, we concentrated on a patient cohort, which is usually in a significantly impaired clinical condition and at a high risk for peri- and postoperative complications. The aim of the present study was to analyze the number and rate of complications when using volatile versus intravenous anesthesia drugs as well as their feasibility in patients undergoing cranioplasty.

Material and Methods

Patient identification

In a retrospective analysis, all patients undergoing cranioplasty in our institution between December 2010 and January 2014 were identified using a computerized database. Patients with preoperative (lumbar drain) or permanent cerebrospinal fluid (CSF) diversion (ventriculoperitoneal shunt) were excluded. Because data analysis was performed anonymously, the ethical board of the medical faculty of Cologne waived patient consent and a vote was not required.

Indication for cranioplasty and surgical procedure

Reimplantational surgery is usually done when the brain is completely quiescent. Therefore, surgery was indicated in all patients with radiological and clinical evidence of no brain swelling. The surgical protocol aimed at reimplantation of the autologous or custom-made bone flap. Therefore, the prior incision was re-opened, and a plane between duraplasty and scalp as well as the temporal muscle were dissected. The bone flap was fixated using bone plates or bone clamps. In case of unexpected intraoperative brain swelling, an ultrasound-guided ventriculostomy was performed.

During the period of interest, the choice of the drugs used for maintaining anesthesia (volatile or intravenous anesthesia) was left to the anesthesiologist.

Anesthesia induction was standardized with intravenous propofol in all patients.

Data retrieval from patient charts

The following parameters were retrieved from medical charts.

1. Baseline data [age, gender, time between primary surgery and cranioplasty, comorbidity, smoking status, body

mass index (BMI), labs (standard hematological, serum chemistry, coagulation parameters)]

2. Surgery-associated parameters: preoperative [pre-computed tomography (CT) scan] intraoperative [bone flap fit, ventriculostomy and amount of cerebrospinal fluid (CSF) drained], postoperative (procedural complications)
3. Anesthesiology data [anesthetic agents (propofol, volatile drugs), anesthesia depth (MAC in inhalational anesthesia), infusion volume (colloids, crystalloids), fluid balance, PEEP, P_{\max} , P_{etO_2}].

Preoperative brain level in the cerebral CT was graded in a three-step scale: below (A), at (B), or exceeding (C) the bone level at least at one site. Intraoperative fitting according to the surgical records was graded dichotomized in (A) no or slight resistance but able to place flap and (B) high resistance with an inability to place the flap or making intraoperative ventriculostomy necessary. The primary outcome parameter was brain swelling.

Prognostic factors for poor bone flap fit

Poor flap fit was defined by the necessity of unplanned ventriculostomy during surgery and the surgeon's assessment of the intraoperative condition.

Statistical analysis

Equal distribution was assessed using Levene's test. Categorical variables were analyzed using the Chi-square test. Normally distributed continuous variables were analyzed using the *t*-test, otherwise Mann-Whitney-U test was used. A *P* value of <0.05 was considered statistically significant.

Results

Patient baseline characteristics

A total of 101 consecutive patients with cranioplasty were identified. Twenty-three patients were excluded due to a permanent CSF diversion. Thus, 78 patients were included in the study.

In 75 patients (96.2%), a hemicraniectomy, and in three (3.8%) a bifrontal craniectomy was performed. The demographic data and preoperative characteristics are given in Table 1. The intraoperative data are summarized in Table 2.

General anesthesia was maintained using volatile anesthetics in 22 (28.2%) and propofol in 56 (71.8%) patients. No patient received a combination of propofol and inhalational anesthesia gas. Among anesthesia parameters, no significant differences between the groups were found except a higher PEEP in the propofol group (5.3 vs. 4.9 mmHg, *P* = 0.022) [Table 2].

The rate of impaired bone flap placement was not significantly different between the groups; neither was postoperative complication rate.

In univariate analysis, no anesthesia-related parameter showed significant differences concerning bone flap placement. Reason for decompressive craniotomy, time between decompressive craniotomy and cranioplasty and extent of decompressive craniotomy showed no significant difference [Table 2].

Complications occurred in 14 (17.7%) patients, of which 12 were surgical complications. One patient developed pulmonary embolism after surgery, and one postoperative sepsis occurred. Most common surgical complication was postoperative wound and bone flap infection (10/14). No anesthesia-related complications were found [Table 3].

Discussion

The ongoing discussion regarding the optimal drug for anesthesia maintenance is frequently ruled by nonobjective arguments, e.g., neurosurgeons categorically rejecting volatile anesthetics due to possible brain swelling. However, sound data (e.g., randomized controlled trials, RCT) covering this topic are still insufficient.^[2,3] Our study, therefore, aims to elucidate the impact of volatile vs. propofol-based anesthesia in a well-defined neurosurgical cohort prone to complications by intraoperative brain swelling.

Patients after decompressive craniectomy show large bony defects with brain tissue covered only by dura and skin tissues. Cranioplasty is indicated after regression of brain swelling documented by CT. Frequently, involution of the defect may result in brain surface deformity with posterior parts of parenchyma exceeding bony level.

Due to large bone defects, an increase of brain tissue volume, may easily change local conditions and aggravate bone flap positioning. Therefore, intraoperative ventriculostomy may be necessary. Both volatiles and propofol may influence CBF, cerebral metabolism, and ICP.^[2,3,5,9]

Traditionally, volatiles are believed to influence operative conditions negatively by elevating CBF and thus ICP. As a recent meta-analysis also suggested an advantage of propofol vs. volatiles due to a reduced ICP and CBF, propofol still is the agent of choice among many neuroanesthesiologists. However, valid data concerning the influence of volatiles on surgical conditions during intracranial surgery are scarce.^[2]

In our cohort, the choice of anesthetic drug was left to the anesthesiologist. This was influenced by their personal experience and temporary trends within the clinic. In contrast to some published results suggesting a negative impact of volatiles,^[2] no impact on intraoperative bone flap fitting could be observed in our series. The higher positive end expiratory positive pressure in the propofol group, being the only significantly differing parameter, did not influence surgical course.

Table 1: Comparison of both groups

Variable	Propofol anesthesia group (n=56)	Volatile anesthesia group (n=22)	All (n=78)	P
Age (years)	52.8 (20-86)	50.7	52.2 (20-86)	0.63
Male (n, %)	31 (55.4)	14 (63.6)	45 (57.7)	0.34
Active smoker (n, %)	9 (16.1)	4 (18.2)	13 (16.7)	0.53
Body mass index (BMI)	24.7 (14.8-51.9)	22.8 (17.6-30.1)	24.2 (14.8-51.9)	0.11
Anticoagulation (n, %)	23 (41.1)	3 (13.6)	26 (33.3)	0.017
Coagulation disorder	0 (0)	1 (4.5)	1 (1.3)	0.28
Time from DC (months)	4.6 (0.4-48.6)	8.9 (0.7-42.9)	5.8 (0.4-48.6)	0.027
Reason for DC (n, %)				0.64
Malignant stroke	25 (44.6)	12 (54.5)	37 (47.4)	
Traumatic brain hemorrhage	19 (33.9)	6 (27.3)	25 (32.1)	
Subarachnoid hemorrhage	6 (10.8)	2 (9.1)	8 (10.2)	
Intracerebral hemorrhage	5 (8.9)	2 (9.1)	7 (9.0)	
Others	1 (1.8)	0 (0)	1 (1.3)	
DC lateral/bifrontal	54/2	21/1	75/3	0.63
CT preoperatively				0.54
(A) Below bone level	47 (83.9)	19 (86.4)	66 (84.6)	
(B) At bone level	5 (8.9)	2 (9.1)	7 (9.0)	
(C) Overlapping	4 (7.2)	1 (4.5)	5 (6.4)	

Baseline characteristics: variables are shown in mean values (range) or numbers (percentage). P<0.05 was considered significant (Chi-square test and Mann-Whitney U-test)

Table 2: Intraoperative conditions

Variable	Propofol anesthesia group (n=56)	Volatile anesthesia group (n=22)	All (n=78)	P
Hemoglobin (mg/dl)	12.0 (7.2-16.1)	12.1 (7.8-16)	12.1 (7.2-16.1)	0.78
PTT (s)	26.2 (20-51)	26.5 (21-33)	26.2 (20-51)	0.36
PT (%)	96 (66-116)	96.4 (80-112)	96 (66-116)	0.92
Platelets (10 ³ /μl)	328 (112-856)	303 (143-496)	321 (11-856)	0.79
Blood loss (ml)	325 (50-1500)	356 (50-1640)	333 (50-1640)	0.77
Crystalloids (ml)	1510 (500-3500)	1522 (500-5000)	1520 (500-5000)	0.62
Colloids (ml)	695 (0-2000)	610 (0-1000)	671 (0-2000)	0.81
Fluid balance	1325 (-100-4000)	1240 (250-2510)	1302 (-100-4000)	0.722
etCO ₂ (mmHg)	33.8 (29-37)	33.8 (32-39)	33.8 (29-39)	0.51
Pmax	16.7 (15-19)	17 (15-21)	16.8 (29-39)	0.98
PEEP (mmHg)	5.3 (4-8)	4.8 (4-8)	5.2 (4-8)	0.011
Bone flap fit				0.082
No or slight resistance	35 (62.5)	18 (81.8)	53 (67.9)	
Strong resistance	21 (37.5)	3 (13.6)	24 (30.8)	
Ventriculostomy	23 (41.1)	5 (22.7)	28 (35.9)	0.10
Amount CSF drained (ml)	45 (10-85)	55 (30-80)	46 (10-85)	0.59
Surgery aborted	1 (1.8)	0 (0)	1 (1.3)	0.72
Complication	9 (16.7)	5 (22.7)	14 (17.9)	0.35

Variables are shown in mean values (range) or numbers (percentage). $P < 0.05$ was considered significant (Chi-square test and Mann-Whitney U-test)

Table 3: Postoperative complications

Complication	Propofol anesthesia group (n=9)	Volatile anesthesia group (n=5)	All (n=14)
Surgical	8	4	12
Wound infection	6	4	10
Bone flap dislocation	1	0	1
Epidural hematoma	1	0	1
Nonsurgical	1	1	2
Pulmonary embolism	1	0	1
Sepsis	0	1	1

Our findings have to be discussed in the context of the narrowly defined patient cohort; little is known about hemodynamics in infarcted or traumatically damaged brain tissue after the acute phase. However, it can be presumed that there is still a remaining (or re-established) autoregulation in these patients with an even increased CBF due to decompressed status. Thus, these patients could be considered more sensitive to regulatory changes by anesthetic drugs, and therefore, should represent an ideal patient cohort. Noteworthy, the underlying reason for DC showed no significant influence.

The effect of volatiles on CBF have been examined in both clinical and experimental conditions. A relevant vasodilatation during inhalational anesthesia is a frequently postulated phenomenon,^[2] which can be counteracted by mild hyperventilation during anesthesia maintenance.^[10] Thus, a potential risk of using volatiles depends largely on the experience of the anesthesiologist.

The present study certainly has several limitations. The study was performed in a retrospective manner from originally clinical data. Because the decision of choice of drug was made by the anesthesiologist it cannot be clearly ruled out that additional clinical factors influenced decision making which cannot be identified retrospectively. In other words, there may be a bias for using propofol in patients with ICP problems and volatile agents in noncomplex patients. Furthermore, the number of patients in the present study is limited, even though analyzing four consecutive years in a large neurosurgical centre.

Conclusion

In conclusion, our data indicate that both volatiles and propofol-based anesthesia may be feasible in neurosurgical patients for skull bone replantation. However, since the number of patients is low and the study has a retrospective design, further randomized studies should be conducted in the future.

Acknowledgments

Assistance with the study: S.G., C.D., N.v.S.: data collection; S.G.: radiological and statistical analysis, B.B. and R.G.: study idea, supervision of analysis, and critical review of the manuscript. J.H. and S.G.: study design, S.G. and J.H. wrote the final manuscript.

Financial support and sponsorship

None.

Conflicts of interest

Bernd W. Böttiger is European Resuscitation Council (ERC) Board Director Science and Research; Chairman of the German Resuscitation Council (GRC); Member of the Advanced Life Support (ALS) Task Force of the International Liaison Committee on Resuscitation (ILCOR); Member of the executive committee of the German Interdisciplinary Association for Intensive and Emergency Medicine (DIVI); Associated Editor of the European Journal of Anaesthesiology (EJA), Co-Editor of "Resuscitation"; Editor of the Journal "Notfall + Rettungsmedizin". He received professional fees for lectures from the following companies: Medupdate GmbH, "Forum für medizinische Fortbildung (FomF)", Baxalta Deutschland GmbH, Bayer Vital GmbH, ZOLL Medical Deutschland GmbH, C. R. Bard GmbH.

References

1. Bastola P, Bhagat H, Wig J. Comparative evaluation of propofol, sevoflurane and desflurane for neuroanaesthesia: A prospective randomised study in patients undergoing elective supratentorial craniotomy. *Indian J Anaesth* 2015;59:287-94.
2. Borrelli V, Grau S, Hinkelbein J. Changes in intracranial pressure and cerebral blood flow during volatile anaesthesia: Fact or fiction? *Eur J Anaesthesiol* 2016;33:468-9.
3. Chui J, Mariappan R, Mehta J, Manninen P, Venkatraghavan L. Comparison of propofol and volatile agents for maintenance of anaesthesia during elective craniotomy procedures: Systematic review and meta-analysis. *Can J Anaesth* 2014;61:347-56.
4. Engelhard K, Werner C. Inhalational or intravenous anesthetics for craniotomies? Pro inhalational. *Curr Opin Anaesthesiol* 2006;19:504-8.
5. Sneyd JR, Andrews CJ, Tsubokawa T. Comparison of propofol/remifentanyl and sevoflurane/remifentanyl for maintenance of anaesthesia for elective intracranial surgery. *Br J Anaesth* 2005;94:778-83.
6. Cole CD, Gottfried ON, Gupta DK, Couldwell WT. Total intravenous anesthesia: Advantages for intracranial surgery. *Neurosurgery* 2007;61:369-77.
7. Gruenbaum SE, Bilotta F. Propofol versus thiopental use in patients undergoing craniotomy. *Minerva Anesthesiol* 2014;80:753-5.
8. Albertin A, Colla L La, Gandolfi A, Colnaghi E, Mandelli D, Fravhini G, *et al.* Greater peripheral blood flow but less bleeding with propofol versus sevoflurane during spine surgery: A possible physiologic model? *Spine (Phila Pa 1976)* 2008;33:2017-22.
9. Liao R, Li J, Liu J. Volatile induction/maintenance of anaesthesia with sevoflurane increases jugular venous oxygen saturation and lumbar cerebrospinal fluid pressure in patients undergoing craniotomy. *Eur J Anaesthesiol* 2010;27:369-76.
10. Leech P, Miller JD. Intracranial volume-pressure relationships during experimental brain compression in primates. 3. Effect of mannitol and hyperventilation. *J Neurol Neurosurg Psychiatry* 1974;37:1105-11.

"Quick Response Code" link for full text articles

The journal issue has a unique new feature for reaching to the journal's website without typing a single letter. Each article on its first page has a "Quick Response Code". Using any mobile or other hand-held device with camera and GPRS/other internet source, one can reach to the full text of that particular article on the journal's website. Start a QR-code reading software (see list of free applications from <http://tinyurl.com/yzlh2tc>) and point the camera to the QR-code printed in the journal. It will automatically take you to the HTML full text of that article. One can also use a desktop or laptop with web camera for similar functionality. See <http://tinyurl.com/2bw7fn3> or <http://tinyurl.com/3ysr3me> for the free applications.