



## Sitting position awake craniostomy with drainage for chronic subdural hematoma: a viable alternative?

Kraniostomija sa drenažom u lokalnoj anesteziji i sedećem položaju za lečenje hroničnog subduralnog hematoma

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### Abstract

**Background/Aim.** Chronic subdural hematoma (CSDH) is one of the most frequent neurosurgical conditions with an overall incidence ranging from 1.72 to 20.6 per 100,000 persons per year. The surgical procedure for CSDH is relatively simple and usually performed in the supine position. Reported reoccurrence rates range from 11.7% to 28%. Postoperative pneumocephalus was previously identified as a sole predictor of reoccurrence. The aim of this study was to assess the advantage of the procedure in the sitting position in patients with CSDH and a possible impact on the reoccurrence rate. **Methods.** The study included 31 patients who underwent awake craniostomy with closed system drainage for CSDH (16 in supine and 15 in sitting position) in our department from December 2016 to March 2018. **Results.** A total of 22 males and 9 females were included in the study. The overall reoccurrence rate was 19% (22% and 18% in females and males, respectively). The reoccurrence was noted in 5 patients who had undergone surgery in the supine position, and in one case in the sitting position. Our results revealed a lower reoccurrence rate in patients undergoing surgery in the sitting position, although not reaching statistical significance [odds ratio (OR): 0.18, 95% confidence interval: 0.01–1.42,  $p = 0.172$ ]. **Conclusion.** Craniostomy in the sitting position under local anesthesia is a safe, simple, and reliable procedure for CSDH treatment. Besides being very comfortable for the patient, according to our initial results, it might also lead to a lower reoccurrence rate, probably due to the better management of the air inflow, and consequent pneumocephalus.

### Key words:

hematoma, subdural; neurosurgical procedures; posture; recurrence; sitting position; treatment outcome.

### Apstrakt

**Uvod/Cilj.** Hronični subduralni hematom (HSH) je jedan od najčešćih neurohirurških entiteta sa ukupnom incidencijom javljanja od 1,72 do 20,6 na 100 000 osoba godišnje. Hirurška procedura za lečenje HSH je relativno jednostavna i obično se izvodi u ležećem položaju. Stopa recidiva iznosi od 11,7% do 28%. Postoperativni pneumocefalus se smatra nezavisnim pojedinačnim prediktorom recidiva. Cilj rada bio je da se proceni prednost procedure u sedećem položaju u lečenju bolesnika sa HSH, kao i njen eventualnim uticaj na stopu recidiva. **Metode.** Studija je obuhvatila 31 bolesnika kojima je urađena kraniostomija sa zatvorenim sistemom za drenažu HSH pod lokalnom anestezijom (16 u ležećem položaju na leđima i 15 u sedećem položaju), u periodu od decembra 2016. do maja 2018. godine. **Rezultati.** Studijom su obuhvaćena 22 muškarca i 9 žena. Ukupna stopa recidiva iznosila je 19% (22% kod žena i 18% kod muškaraca). Recidiv se javio kod 5 operisanih u ležećem položaju i kod samo jedne bolesnice operisane u sedećem položaju. Naši rezultati su pokazali trend ređe pojave recidiva kod bolesnika operisanih u sedećem položaju, iako razlika nije bila statistički značajna [odds ratio (OR): 0.18; 95% interval poverenja: 0.01–1.42,  $p = 0.172$ ]. **Zaključak.** Kraniostomija u sedećem položaju pod lokalnom anestezijom je sigurna, jednostavna i pouzdana procedura za lečenje HSH. Pored toga što je veoma komforna za bolesnika, prema našim inicijalnim rezultatima, mogla bi da vodi i sniženju stope recidiva, verovatno zahvaljujući boljoj kontroli ulaska vazduha i pojave posledičnog pneumocefalusa.

### Ključne reči:

hematom, subduralni; neurohirurške procedure; položaj tela; recidiv; položaj, sedeći; lečenje, ishod.

## Introduction

A subdural hematoma is a blood collection between the dura and arachnoid layers of meninges, which is considered chronic when developed within 21 days or more<sup>1</sup>. Chronic subdural hematoma (CSDH) is one of the most common neurosurgical occurrences, with the overall incidence reported to range from 1.72 to 20.6 per 100,000 persons per year<sup>2</sup>. The reported reoccurrence rate, after the standard surgical procedure, ranges from 11.7% to 28%<sup>3</sup>. Most likely, CSDH develops due to traumatic head injury, which is often minor and not always evident, especially in light of antiplatelet or anticoagulation therapy in older patients, although it may develop through the lysis of an acute hematoma of any origin<sup>4, 5</sup>. The incidence of CSDH may double in the next ten years due to the growth of the aging population<sup>6</sup>. The pathophysiology of the disease is controversial, being a combination of multiple interrelated mechanisms following trauma, including inflammation, membrane formation, angiogenesis and fibrinolysis, that propagate an increase in CSDH volume<sup>4</sup>.

Craniostomy is the gold standard for CSDH treatment, although, there are many different “styles” of performing this procedure<sup>7</sup>. The simple procedure of craniostomy still brings many dilemmas: a twist-drill or a burr hole, single or double craniostomy, or an enlarged single burr hole<sup>8</sup>. There is no consensus, but some evidence-based recommendations are available, suggesting to irrigate the CSDH and to place postoperative closed-system drainage to prevent reoccurrence<sup>7, 9, 10</sup>. Pneumocephalus is a common surgical complication, representing a significant independent predictor of CSDH treatment failure, which almost doubles the reoccurrence rate<sup>11, 12</sup>. If the postoperative computed tomography (CT) images reveal significant pneumocephalus, a simple re-operation is proposed, to refill the hematoma cavity with saline<sup>12</sup>. Craniostomy is usually performed in the semilateral position or in the supine position, with the head in the neutral position or rotated opposite the lesion site<sup>8</sup>. The burr hole should be kept at the vertex of the head during this procedure. Improper head posture can result in a large quantity of subdural air, no matter how many holes are drilled<sup>8, 12</sup>.

When performing the procedure on an awake patient, the sitting position is the most comfortable for the patient, while also being very convenient for the surgeon. Due to head elevation and positioning, the burr hole, which is easily made at the vertex of the patient’s head (and the vertex of the CSDH), becomes a natural barrier, preventing gas from entering the subdural cavity. Nevertheless, in neurosurgery, the sitting position is usually linked with complications (venous air embolism in particular), although recent studies demonstrate decreased rates of complications in patients undergoing surgeries in the sitting position<sup>13, 14</sup>. However, anesthesiologists and surgeons continue to avoid this position<sup>15</sup>. Up to date, no reports of patients undergoing craniostomy in the sitting position for CSDH have been published.

## Methods

A small prospective cohort study in our patients undergoing awake craniostomy for CSDH was performed. The patients were selected for either the supine or sitting position according to the treating physician’s preference.

The aim of the study was to recommend the introduction of the sitting position, as at least noninferior to the standard supine position, as well as to evaluate the possible impact of positioning (sitting vs. supine) on the outcome, with a possible influence on complications, namely the most frequent one – CSDH reoccurrence.

All patients who underwent craniostomy with drainage for primary CSDH in both supine and sitting positions at our department from December 21st 2016 to March 31st 2018 were included.

Inclusion criteria were: patients who underwent craniostomy with drainage for CSDH under local anesthesia from December 21st, 2016 to March 31st, 2018; either the sitting or supine position; CSDH verified by CT; either bilateral or unilateral hematoma/s.

Exclusion criteria were: the prone position; iatrogenic CSDH (related to previous ventriculoperitoneal shunt or surgery); CSDH with significant neomembranes or acute blood clot formation, according to CT; reoccurring CSDH.

Patients were divided into two groups, sitting and supine, according to their intraoperative positioning.

### *Surgical procedure*

After CSDH was confirmed by CT, if excessive neomembranes formation was detected, the patient was excluded from this study, and referred for either craniostomy and drainage followed by postoperative corticosteroid treatment, or craniotomy and evacuation of hematoma by way of neomembranes resection. The patients with a significant acute blood clot underwent craniotomy and evacuation of hematoma.

After the patient had been checked for bleeding, the procedure under local anesthesia was indicated. In cases where coagulation status was altered due to anticoagulation drugs, an antidote therapy was prescribed to reduce the international normalized ratio (INR) to less than 1.5, and activated partial thromboplastin time (APTT) to 30–40 s. Patients taking antiaggregating drugs were not operated on the day of admission if the medication had been taken on that day. The first dose of prophylactic 2nd generation cephalosporin antibiotic was given at the ward or in the emergency room (ER), before the procedure. The operating field was shaved in a radius of approximately 3 cm around the incision.

The patient was informed regarding the surgical procedure, the type of anesthesia, as well as potential risks and expected outcomes. A standardized informed consent form was signed by each patient or their legal guardian.

The patient was placed on the operating table in the supine position. To achieve this position, the head was slightly flexed, and rotated to the side opposite the lesion.

The sitting position was reached by manipulating the operating table. The head was flexed towards the torso and secured using a pillow (see Figure 1). While the patient is comfortably seated armrests may be helpful to further improve the patient's comfort<sup>13</sup>.



**Fig. 1 – Illustration of a patient in the sitting position prepared for an awake craniostomy for a chronic subdural hematoma.**

Initial 5 mL lidocaine was administered locally to impregnate the area of incision and drain placement. The drainage system was prepared in the meantime.

The incision was made over the hematomas highest thickness aligned with the vertex of the head, after which a burr hole was made and filled around with surgical wax. The dura was exposed, and the drain was pulled through the skin, approximately 1 cm behind the incision. A T-shaped dural incision was made, and a 6 cm perforated part of the drain was pushed through the capsule into the subdural space. The burr hole was filled with an oxidized cellulose hemostatic agent, and sutures were placed. The same sutures were used to fix the cotton gauze. After initial hematoma release and pressure relief, 20 mL of 0.9% saline solution was then injected through the proximal part of the drain for irrigation, 3–5 times. Afterwards, the drain was connected through the distal part to the drainage bottle placed below the patient, to proceed with controlled closed system drainage.

The patient was placed in a bed, in a comfortable supine position and transferred to the ward. Solutions infusion and paracetamol were administered, and the drainage was continued. Antibiotics were continued until the drain was removed. A head CT was performed on the second morning after the procedure, and the drain was removed.

A control head CT was performed one month after the surgery, together with the follow-up examination. At that time, in cases where significant residual hematoma was detected, a re-operation was indicated. Where a head CT was normal, or with an insignificant subdural collection, only clinical follow-up was advised.

### Statistical analysis

Categorical data were presented as the number of patients in each category and the corresponding percentages. The  $\chi^2$  test and the Fisher exact test (in case the number of patients in a group was below 5) were performed to verify the statistical significance between the various groups. Numerical data were first analyzed graphically, and the normality of their distribution was checked by performing the Shapiro-Wilk test. Where the Shapiro-Wilk test confirmed the normal distribution, numerical data were presented as means and standard deviation, and the Student's *t*-test or ANOVA were applied to compare two or more groups, respectively. Otherwise, numerical data were presented as median values with minimum and maximum values. The Kruskal-Wallis test was performed to compare numerical variables between different groups.

The statistical analysis was performed in the R Language and Environment for Statistical Computing (v. 3.4.2 – "Short Summer")<sup>16</sup>. The data were imported from Excel using the *openxlsx* package, processed using the *Hmisc*, *dplyr*, *stringr*, and *tidyr* packages, and presented using the *compareGroups* and *ggplot2* packages<sup>17, 18</sup>.

### Results

Out of 36 patients who underwent 42 surgeries in the observed period, this study included a total of 31 patients, each with a single operation (31 in sum) for primary CSDH. Five patients were excluded due to the CSDH related to a previous surgery (4), and due to significant acute clot formation (1). The remaining 6 surgeries were reoperations (two of these in a single patient), while one of the male patients was referred to another institution for reoperation after reoccurrence.

Nine patients (29%) were female, and 22 (71%) were male. Table 1 shows general information about the patients' characteristics, as well as the characteristics of the surgery and the outcomes. In the majority of cases, the patients were operated immediately after the diagnosis of CSDH or on the following day, although in some cases the procedure was delayed for up to 10 days. Sixteen (52%) of the patients were operated in the supine position, while 15 patients (48%) were operated in the sitting position.

Most of the patients (81%) had no complications during the follow-up period, while reoperation for recurrent CSDH was necessary for 6 patients (19%). One patient, operated on in the sitting position developed a headache that lasted for 2 weeks postoperatively and resolved with the use of paracetamol. No other complications occurred in the group of patients undergoing primary craniostomy and drainage for CSDH.

Pneumocephalus was less frequent in the group of patients undergoing surgery in the sitting position, and the two cases of massive pneumocephalus were both in the group of supine-positioned patients. However, there was no statistically significant correlation between pneumocephalus formation and hematoma reoccurrence; neither was there any statistically significant correlation between positioning and pneumocephalus formation.

**Table 1****General characteristics of the patients and surgical procedure by gender**

Parameter	All patients (n = 31)	Female (n = 9)	Male (n = 22)	p (overall)
Age (years)	72 (49–89)	70 (59–88)	74 (49–89)	0.433
Location of CSDH:				0.670
bilateral	6 (19)	1 (11)	5 (23)	
right	15 (48)	4 (44)	11 (50)	
left	10 (32)	4 (44)	6 (27)	
Position, n				0.252
supine	16 (52)	3 (33)	13 (59)	
sitting	15 (48)	6 (67)	9 (41)	
Outcome				1.000
no complications	25 (81)	7 (78)	18 (82)	
recurrent hematoma	6 (19)	2 (22)	4 (18)	

All values are expressed as median (minimum–maximum) or number (percentage).

**Table 2****General characteristics of the patients with chronic subdural hematoma (CSDH) and surgical procedure by the outcome**

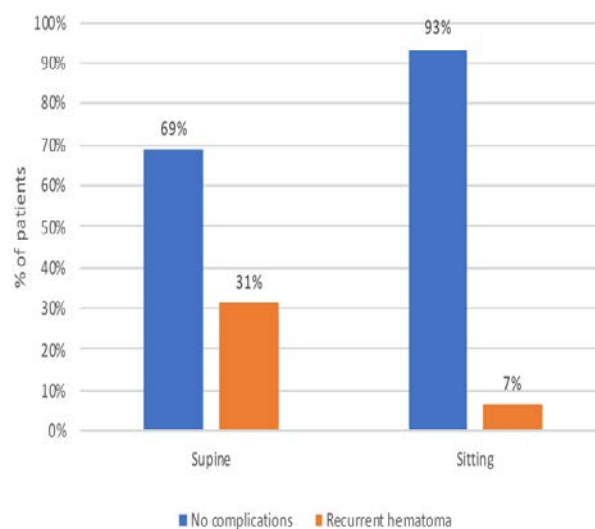
Parameter	All patients (n = 31)	No complications (n = 25)	Recurrent hematoma (n = 6)	p (overall)
Age, years	72 (49–89)	70 (49–89)	76 (63–78)	0.920
Gender:				1.000
female	9 (29)	7 (28)	2 (33)	
male	22 (71)	18 (72)	4 (67)	
Location of CSDH:				0.833
bilateral	6 (19)	5 (20)	1 (17)	
right	15 (48)	11 (44)	4 (67)	
left	10 (32)	9 (36)	1 (17)	
Position:				0.172
supine	16 (52)	11 (44)	5 (83)	
sitting	15 (48)	14 (56)	1 (17)	

All values are expressed as median (minimum–maximum) or number (percentage).

Table 2 shows the characteristics of the patients and the surgery by the outcome. Reoperation was necessary for a total of 6 patients, of which two were female, and 4 were male. There were no statistically significant differences between male and female patients regarding their basic characteristics and the outcome of the surgery. The reoperated patients had a median age of 76 years (63–78), and those with a positive outcome a median age of 70 years (49–89). Still, there was no statistically significant difference in the age of the patients with or without a complication. None of the previously recognized factors such as age, gender, time to surgery, or position, had a significant influence on the reoccurrence of CSDH during the follow-up period. As for the position of the patients, 5 out of 6 of the patients with reoccurring CSDH were initially operated on in the supine position, while only one patient was operated on in the sitting position (see Figure 2). As for other characteristics of the patients and the surgical procedure, there were no statically significant differences between the patients with a positive outcome and those with reoccurring CSDH.

The influence of the patients' characteristics and surgical procedure on the outcome was quantified by calculating odds ratios (OR) with 95% confidence interval (CI), as reported in Table 3. The patients' characteristics,

such as age and gender, were not significant predictors of the reoccurrence. As far as the surgical procedure is concerned, the location of CSDH, time to surgery, as well as the position (supine or sitting), in our study neither of these had any influence on the outcome.



**Fig. 2 – The number of reoperations according to the intraoperative position.**

Table 3

Factors influencing the outcome of the surgery in patients with chronic subdural hematoma (CSDH)						
Parameter	All patients (n = 31)	No complications (n = 25)	Recurrent hematoma (n = 6)	OR	p (ratio)	p (overall)
Age, years	72 (49–89)	70 (49–89)	76 (63–78)	1.00 (0.91; 1.09)	0.973	0.920
Gender:						1.000
female	9 (29)	7 (28)	2 (33)	Ref.	Ref.	
male	22 (71)	18 (72)	4 (67)	0.77 (0.11;7.31)	0.796	
Location of CSDH:						0.833
bilateral	6 (19)	5 (20)	1 (17)	Ref.	Ref.	
right	15 (48)	11 (44)	4 (67)	1.65 (0.17;53.5)	0.698	
left	10 (32)	9 (36)	1 (17)	0.58 (0.01;25.8)	0.750	
Position:						0.172
supine	16 (52)	11 (44)	5 (83)	Ref.	Ref.	
sitting	15 (48)	14 (56)	1 (17)	0.18 (0.01;1.42)	0.111	

All values are expressed as median (minimum–maximum) or number (percentage); OR – odds ratio (95% confidence interval).

### Discussion

CSDH drainage is one of the simplest neurosurgical procedures, sometimes even performed by general surgeons<sup>19</sup>. Apart from infection, a reoccurrence rate of up to 28% after surgical treatment is one of the most common and the most significant complications<sup>3</sup>. We performed awake craniostomy and drainage for CSDH in 31 patients, 9 females, and 22 males. The median age of patients was 72 years, and the gender distribution was in accordance with previously published studies<sup>2</sup>. Our study groups, based on the position during surgery, were homogenous according to age and gender distribution. Sixteen patients underwent the surgical procedure in the supine position, while 15 patients underwent surgery in the sitting position. The overall reoccurrence rate was 19% (22% and 18% in females and males respectively), 76 years being the median age of patients with the reoccurrence, similar to previously published studies<sup>20–22</sup>. There was no statistically significant difference in the hematoma reoccurrence based on the patients' general characteristics. We noted hematoma reoccurrence in 5 patients operated on in the supine position, and only in one patient operated on in the sitting position. The intraoperative sitting position was related to the reduced rate of reoccurrence, although this difference in our group of patients was not statistically significant (see Table 3).

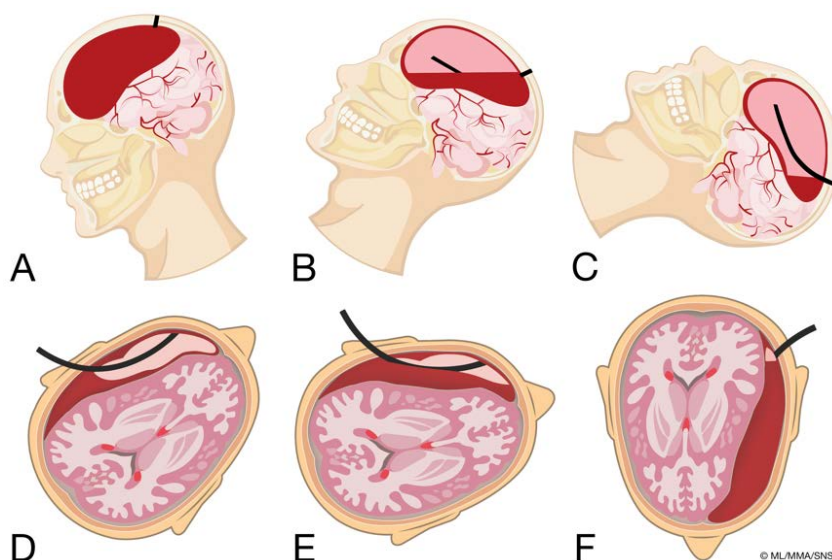
The most common patient-related risk factors for an undesirable outcome of this procedure are chronic alcoholism, seizure disorders, and history of a ventriculoperitoneal shunt<sup>20, 23</sup>. The impact of diabetes mellitus remains controversial<sup>23, 24</sup>. Most studies suggest that age, sex, hypertension, cardiac disease, and use of anticoagulants or antiplatelets do not affect the reoccurrence rate<sup>23, 25</sup>, but do influence the overall outcome<sup>26</sup>. Considering the age of the patients suffering from CSDH, it can be expected that some patients undergoing surgery for CSDH may not be able to undergo awake surgery under local anesthesia in the supine or prone positions due to age-related pathology (e.g. severe cardiac or pulmonary disease). In this specific group of patients, the sitting position preserves the benefits of the procedure under local anesthesia regardless of

the underlying condition, therefore avoiding general anesthesia and related complications.

Radiologic risk factors for CSDH reoccurrence include a preoperative appearance of heterogeneous hematoma or higher-density hematoma, greater midline shift, bilateral hematomas, or postoperative appearance of poor brain reexpansion or greater subdural air accumulation<sup>11</sup>. Only one of these risk factors, subdural air collection (pneumocephalus) developed in the course of burr-hole craniostomy, which is considered a sole predictor of hematoma reoccurrence, can be prevented during the surgical procedure<sup>12</sup>. Controlled blood evacuation when the dural incision is made at the vertex of CSDH, precludes the air ingress into the subdural space. The CSDH vertex exposure and incision are performed simply and reliably in the sitting position through the burr hole positioned at the vertex preventing uncontrolled blood spill and air ingress (Figure 3). Although head tilting also prevents air ingress, it is much less comfortable for the patient, and is therefore difficult to maintain in an awake patient. Our results suggest that significant pneumocephalus formation is less likely to occur in the sitting position with the head flexed. However, no statistically significant correlation was found.

Surgical risk factors for CSDH reoccurrence include the use of twist-drill as opposed to burr hole craniostomy or craniotomy, although craniotomies predispose patients to higher morbidity rates<sup>27</sup>. Burr hole craniostomy is considered to be related to shorter hospital stay, as well as to lower reoccurrence rate<sup>9</sup>. Other surgical risk factors include lack of or poor postoperative closed-system drainage. The impact of intraoperative irrigation and postoperative patient position (flat vs. upright) is controversial, although some studies found no significant influence of postoperative patient posture on the hematoma reoccurrence<sup>20, 22, 28, 29</sup>. Our surgical technique was uniform in both groups of patients, and included burr hole craniostomy and closed system drainage and irrigation with saline solution to achieve the best possible outcome in both groups of patients<sup>27</sup>.

Complications are the main reason for avoidance of wider use of the sitting position in surgery in general, especially in neurosurgery<sup>13</sup>. There are even guidelines and protocols for anesthesiologists to reduce the complication

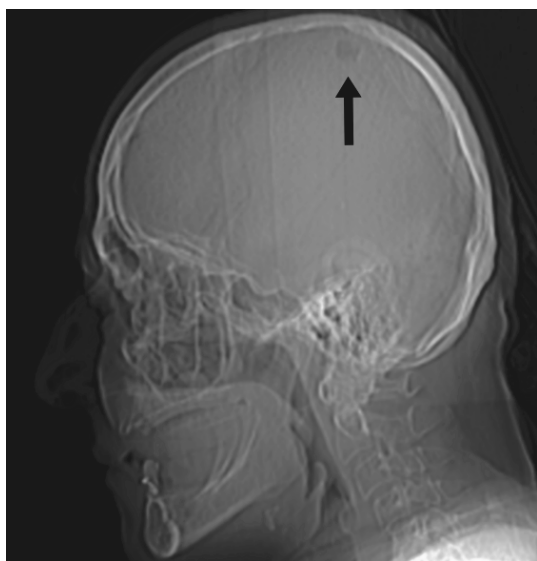


**Fig. 3 – Patient’s head positioning and potential air ingress during craniostomy. The impact of flexion: A) Head in the sitting position with craniostomy positioned at the vertex (prevents air ingress); B) Head in the supine position and posteriorly positioned craniostomy (significant air ingress may occur); C) Head in the supine position without flexion (significant air ingress may occur). The impact of rotation: D) Head tilted towards the contralateral side (air ingress may be prevented); E) Head tilted towards the contralateral side, nearly parallel to the table (air ingress may be prevented); F) Prone position head appearance (prevents air ingress).**

rates in patients positioned this way during surgery<sup>14, 15</sup>. Previous studies have analyzed the sitting position within general anesthesia; therefore, many of the complications may be related to the duration of the procedure and prolonged sitting<sup>14, 15</sup>. On the other hand, specific complications such as tension pneumocephalus occur in the sitting position only during the posterior *fossa* surgeries, when cerebrospinal fluid (CSF) leak is not maintained under control<sup>13, 30</sup>.

Our study is the first to assess the sitting position when craniostomy for CSDH is performed. No particular

complication which could be attributed to the sitting position was noted or revealed, probably due to the short duration of the procedure (less than half an hour for single-sided, or less than 45 min for bilateral CSDH), the awake state of the patient (able to move the extremities when feeling the need), and the burr hole placed at the vertex (Figure 4). For the same reasons and because of uniqueness of our study, the complications related to the sitting position in awake craniostomy for CSDH cannot be compared to other studies on procedures usually performed in the similar positions until other studies on this procedure become available.



**Fig. 4 – Cranial roentgenogram after craniostomy in the sitting position (the arrow points at the burr hole).**

#### *Study limitations*

Regarding the limitations of the study, the most notable is the small size of the group of patients. Being an initial group undergoing CSDH treatment in the sitting position, the results are encouraging but not statistically significant, and should be taken with caution. Some bias avoidance was achieved through the exclusion of patients with any competing factors, considered to influence the outcome. The impact of bilateral hematomas was considered in the analysis, but these patients were considered as a single patient, rather than two independent hematomas.

Future studies, preferably multicentered, randomized, and performed on a larger number of patients, could verify these findings. Multivariate analysis with the inclusion of more factors affecting outcomes may provide additional strength to the conclusions of the studies and should be performed. This would allow for wider implementation and use of the sitting position in CSDH treatment.

## Conclusion

The sitting position is comfortable and easily accepted by the patient, leading to better patient-surgeon compliance and cooperation, even if the patient is disoriented, which is common in elderly neurosurgical patients. This study showed that this positioning of patients during craniostomy may reduce CSDH reoccurrence, possibly owing to the prevention of subdural air formation. Therefore, the sitting position for

craniostomy in CSDH could represent a viable alternative to the more commonly used supine position, not resulting in a higher percentage of complications.

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