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Authors: Lepić, Milan*,†, Mandić-Rajčević, Stefan‡, Pavlićević, Goran†,||, Savić, Andrija*,§, Lokaj, Aleksandra||, Rasulić, Lukas*,§. Vojnosanitetski pregled (2019); Online First September, 2019.

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Running title:

Sitting position for chronic subdural hematoma
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 chronic subdural hematoma 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. This study evaluates the procedure in the sitting position and the possible impact on the reoccurrence rate. Methods. The study included 31 patients who underwent awake craniostomy with closed system drainage for chronic subdural hematoma (16 in supine and 15 in sitting position) in our department in the period from December 2016 to March 2018. Results. Twenty-two males and nine 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 underwent surgery in the supine position, and in one case operated in sitting position. Our results revealed a lower reoccurrence rate in patients undergoing surgery in the sitting position, although not reaching statistical significance (OR: 0.18, CI: 0.01-1.42, p=0.172). Conclusion. Craniostomy in the sitting position under local anesthesia is a safe, simple, and reliable procedure for chronic subdural hematoma treatment. Apart from 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 consequential pneumocephalus.

Key words:
chronic subdural hematoma; craniostomy; sitting position; outcome; reoccurrence.

Apstrakt

Uvod / Cilj. Hronični subduralni hematom 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 CSDH 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. Ova studija evaluira izvođenje procedure u sedećem položaju so eventualnim uticajem na stopu recidiva. **Metode.** Studija je obuhvatila 31 pacijenta kome je urađena kraniostomija sa zatvorenim sistemom za drenažu hroničnog subduralnog hematoma pod lokalnom anestezijom (16 u ležećem položaju na ledjima i 15 u sedećem), u periodu od decembra 2016., do maja 2018.godine. **Rezultati.** U studiju su bila uključena 22 muškarca i 9 žena. Ukupna stopa recidiva je iznosila 19% (22% kod žena i 18% kod muškaraca). Recidiv se javio kod 5 pacijenata operisanih u ležećem položaju i kod samo jedne pacijentkinje operisane u sedećem položaju. Naši rezultati su pokazali trendrede pojave recidiva kod pacijenata operisanih u sedećem položaju, iako razlika u našoj grupi pacijenata nije statistički značajna (OR:0,18, CI:0,01-1,42, p=0,172).

**Zaključak:** Kraniostomija u sedećem položaju pod lokalnom anestezijom je sigurna, jednostavna i pouzdana procedura za lečenje hroničnog subduralnog hematom. Pored toga što je veoma komforna za pacijenta, prema našim inicijalnim rezultatima, mogla bi da vodi i sniženju stope recidiva, verovatno zahvaljujući boljoj kontroli ulaska vazduha i pojave posledičnog pneumocefalusa.

**Ključne reči:**

hronični subduralni hematom; kraniostomija; sedeći položaj; ishod; recidiv.

**Introduction**

A subdural hematoma is a blood collection between the dura and arachnoid layers of meninges, which is considered chronic when developed in course of 21 days or more.[1] 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.[2] The reported reoccurrence rate, after the standard surgical procedure, ranges from 11.7% to 28%.[3] 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.[4, 5] It is considered that the incidence of CSDH is going to double in the next ten years due to the growth of the aging population.[6] 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.[4]

Craniostomy is the gold standard for CSDH treatment, although, there are many different “styles” of performing this procedure.[7] The simple procedure of craniostomy still brings many dilemmas: twist-drill or burr-holes, single or double craniostomy, or an enlarged single burr-hole.[8] 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.[7, 9, 10] Pneumocephalus is a common surgical complication, representing a significant independent predictor of CSDH treatment failure, which almost doubles the reoccurrence rate.[11, 12] If the postoperative CT images reveal significant pneumocephalus, a simple re-operation is proposed, to refill the hematoma cavity with saline.[12] Craniostomy is usually performed in semi-lateral, or supine position, with the head in the neutral position or rotated opposite of the lesion site.[8] 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 made.[8, 12]

When performing the procedure in 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 for the gas to enter the subdural cavity. Nevertheless, in neurosurgery, the sitting position is usually linked with complications (venous air embolism in particular), although recent studies demonstrated decreased rates of complications in patients undergoing surgeries in the sitting position.[13, 14] Nevertheless, anesthesiologists and surgeons continue to avoid this position.[15] Up to date, no reports of patients undergoing craniostomy in the sitting position for CSDH have been published.

Methods

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

The aim of the study was to introduce the sitting position, as at least non-inferior to the standard supine position, as well as to evaluate the possible impact of positioning (sitting vs. supine) on the outcome, with eventual influence on complications, namely the most frequent - CSDH reoccurrence.

2. Patients

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

1. Inclusion criteria

- Patients who underwent craniostomy with drainage for CSDH under local anesthesia from December 21st, 2016 to March 31st, 2018
- Sitting or supine position
- Computerized tomography (CT) verified CSDH
- Either bilateral or unilateral hematoma/s

2. Exclusion criteria

- Prone position
- Iatrogenic CSDH (related to previous VP shunt or surgery)
- CSDH with significant neomembranes or acute blood clot formation, according to the CT
- Reoccurred CSDH

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

19264. Surgical procedure
A CT confirmed CSDH. When excessive neomembranes formation was detected, the patient was excluded from this study, and referred for either craniostomy and drainage with postoperative corticosteroid treatment, or craniotomy and evacuation of hematoma with neomembranes resection. Cases with significant acute blood clot underwent craniotomy and evacuation of hematoma.

After the patient’s bleeding status was checked, 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 INR to less than 1.5, and APTT to 30-40s. Patients taking anti-aggregating 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 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.

2. Patient positioning

The patient was placed on the operating table supine. To achieve supine position the head was slightly flexed, and rotated to the side opposite to the lesion. 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 was comfortably seated armrests may be helpful to further improve the patient's comfort.[13]

3. Craniostomy procedure

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

The incision was made over the hematomas highest thickness aligned with the vertex of the head, after which the burr hole was made and filled around with surgical wax. The dura was exposed, and the drain was pulled thru the skin, approximately one centimeter behind
the incision. A T-shaped dural incision was made, and a 6 cm long perforated part of the drain was pushed thru the capsule into the subdural space. 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. Afterward, the drain was connected through the distal part to the drainage bottle placed below the patient, to proceed with controlled closed system drainage.

4. Postoperative treatment

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.

5. Follow-up

The control head CT was performed one month after the surgery, together with the follow-up examination. At that time, in case that significant residual hematoma was detected, a re-operation was indicated. When 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 percentage. The χ² test and the Fisher exact test (in case the number of patients in a group was lower than 5) were used to verify the statistical significance between the various groups. Numerical data were first analyzed graphically, and the normality of their distribution was checked using the Shapiro-Wilk test. In case Shapiro-Wilk test confirmed the normal distribution, numerical data were presented as means and standard deviations, and Student’s t-test or ANOVA were used to compare between two or more groups, respectively. Otherwise numerical data were presented as median values with minimum and maximum values, and the Kruskal-Wallis test was used to compare numerical variables between different groups.
The statistical analysis was done using the R Language and Environment for Statistical Computing (v. 3.4.2 - "Short Summer"). Data was imported from Excel using the openxlsx package, processed using the Hmisc, dplyr, stringr, and tidyr packages, and presented using the compareGroups and ggplot2 packages.

**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 the previous surgery (4), and due to the significant acute clot formation (1). The remaining 6 surgeries were re-operations (two of these in a single patient), while one male left for re-operation in another institution after reoccurrence.

Nine patients were female (29%), and 22 were male (71%). *Table 1* shows the general information about the patients’ characteristics, as well as the characteristics of the surgery and the outcomes. The median age was 72 years (49-89). Most of the patients had a CSDH on the right side of the head (48%), while 32% and 19% had the CSDH on the left side or bilaterally, respectively. In the majority of cases, the patients were operated immediately after the diagnosis of the CSDH or on the following day, although in some cases the procedure was delayed for up to 10 days. Sixteen patients (52%) were operated in the supine position, while 15 patients (48%) were operated in the sitting position.

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

<table>
<thead>
<tr>
<th></th>
<th>All, N=31</th>
<th>Female, N=9</th>
<th>Male, N=22</th>
<th>p (overall)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>72 (49-89)</td>
<td>70 (59-88)</td>
<td>74 (49-89)</td>
<td>0.433</td>
</tr>
<tr>
<td><strong>Location of CSDH:</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.670</td>
</tr>
<tr>
<td>Bilateral</td>
<td>6 (19%)</td>
<td>1 (11%)</td>
<td>5 (23%)</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>15 (48%)</td>
<td>4 (44%)</td>
<td>11 (50%)</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>10 (32%)</td>
<td>4 (44%)</td>
<td>6 (27%)</td>
<td></td>
</tr>
<tr>
<td><strong>Position:</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.252</td>
</tr>
<tr>
<td>Supine</td>
<td>16 (52%)</td>
<td>3 (33%)</td>
<td>13 (59%)</td>
<td></td>
</tr>
</tbody>
</table>
Sitting 15 (48%)  6 (67%)  9 (41%)  
Outcome: 1.000  
No complications 25 (81%)  7 (78%)  18 (82%)  
Reccurent hematoma 6 (19%)  2 (22%)  4 (18%)  

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

Pneumocephalus was less frequent in the group of patients undergoing surgery in sitting position, and the two cases of massive pneumocephalus were both in group of supine positioned patients. However, there was no statistically significant correlation between the pneumocephalus formation and the hematoma reoccurrence, also, no statistically significant correlation was found between the positioning and the pneumocephalus formation.

Table 2 shows the characteristics of the patients and the surgery by the outcome. Re-operation 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, as well as the outcome of the surgery. The re-operated 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 the 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 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.
Table 2. General characteristics of the patients and surgical procedure by the outcome

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>No complications</th>
<th>Recurrent hematoma</th>
<th>p (overall)</th>
</tr>
</thead>
<tbody>
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<td>N=31</td>
<td>N=25</td>
<td>N=6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>72 (49-89)</td>
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<td>76 (63-78)</td>
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<td>Gender:</td>
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<td></td>
</tr>
<tr>
<td>Female</td>
<td>9 (29%)</td>
<td>7 (28%)</td>
<td>2 (33%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>22 (71%)</td>
<td>18 (72%)</td>
<td>4 (67%)</td>
<td></td>
</tr>
<tr>
<td>Location of CSDH:</td>
<td></td>
<td></td>
<td></td>
<td>0.833</td>
</tr>
<tr>
<td>Bilateral</td>
<td>6 (19%)</td>
<td>5 (20%)</td>
<td>1 (17%)</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>15 (48%)</td>
<td>11 (44%)</td>
<td>4 (67%)</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>10 (32%)</td>
<td>9 (36%)</td>
<td>1 (17%)</td>
<td></td>
</tr>
<tr>
<td>Position:</td>
<td></td>
<td></td>
<td></td>
<td>0.172</td>
</tr>
<tr>
<td>Supine</td>
<td>16 (52%)</td>
<td>11 (44%)</td>
<td>5 (83%)</td>
<td></td>
</tr>
<tr>
<td>Sitting</td>
<td>15 (48%)</td>
<td>14 (56%)</td>
<td>1 (17%)</td>
<td></td>
</tr>
</tbody>
</table>

The influence of the patients’ characteristics and surgical procedure on the outcome were quantified by calculating odds ratios, reported in Table 3. Patients’ characteristics, such as the age and gender were not significant predictors of the reoccurrence. As far as the surgical procedure is concerned, the location of the CSDH, time to surgery, as well as the position (supine or sitting) also had no influence on the outcome in our study, although the sitting position was close to statistical significance to represent a protective factor (OR: 0.18, CI: 0.01-1.42, p=0.172).

Table 3. Factors influencing the outcome of the surgery

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>No complications</th>
<th>Recurrent hematoma</th>
<th>OR</th>
<th>p (ratio)</th>
<th>p (overall)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>N=25</td>
<td>N=6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>72 (49-89)</td>
<td>70 (49-89)</td>
<td>76 (63-78)</td>
<td>1.00</td>
<td>0.973</td>
<td>0.920</td>
</tr>
<tr>
<td></td>
<td>[0.91;1.09]</td>
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</table>
Gender:

<table>
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<th></th>
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<th>Male</th>
<th>( \text{Ref.} )</th>
<th>( \text{Ref.} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>9</td>
<td>22</td>
<td>7 (28%)</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>(29%)</td>
<td>(71%)</td>
<td>2 (33%)</td>
<td>0.796</td>
</tr>
<tr>
<td>Male</td>
<td>22</td>
<td>18</td>
<td>( 0.77 )</td>
<td>( 0.796 )</td>
</tr>
<tr>
<td></td>
<td>(71%)</td>
<td>(72%)</td>
<td>4 (67%)</td>
<td>[0.11;7.31]</td>
</tr>
</tbody>
</table>

Location of CSDH:

<table>
<thead>
<tr>
<th></th>
<th>Bilateral</th>
<th>Right</th>
<th>( \text{Ref.} )</th>
<th>( \text{Ref.} )</th>
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<tbody>
<tr>
<td>Bilateral</td>
<td>6</td>
<td>15</td>
<td>5 (20%)</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>(19%)</td>
<td>(48%)</td>
<td>4 (67%)</td>
<td>0.698</td>
</tr>
<tr>
<td>Right</td>
<td>15</td>
<td>11</td>
<td>( 1.65 )</td>
<td>( 0.17;53.5 )</td>
</tr>
<tr>
<td></td>
<td>(48%)</td>
<td>(44%)</td>
<td>4 (67%)</td>
<td>( 0.17;53.5 )</td>
</tr>
<tr>
<td>Left</td>
<td>10</td>
<td>9</td>
<td>1 (17%)</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>(32%)</td>
<td>(36%)</td>
<td>1 (17%)</td>
<td>0.750</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( [0.01;25.8] )</td>
<td></td>
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</tbody>
</table>

Position:

<table>
<thead>
<tr>
<th></th>
<th>Supine</th>
<th>Sitting</th>
<th>( \text{Ref.} )</th>
<th>( \text{Ref.} )</th>
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</thead>
<tbody>
<tr>
<td>Supine</td>
<td>16</td>
<td>15</td>
<td>11 (44%)</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>(52%)</td>
<td>(56%)</td>
<td>5 (83%)</td>
<td>0.698</td>
</tr>
<tr>
<td>Sitting</td>
<td>14</td>
<td>14</td>
<td>( 0.18 )</td>
<td>( 0.111 )</td>
</tr>
<tr>
<td></td>
<td>(56%)</td>
<td>(56%)</td>
<td>1 (17%)</td>
<td>( [0.01;1.42] )</td>
</tr>
</tbody>
</table>

Discussion

The CSDH drainage is one of the simplest neurosurgical procedures, sometimes even performed by general surgeons.[19] Apart from infection, a reoccurrence rate of up to 28% after surgical treatment is one of the most common and the most significant complication.[3] We have 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.[2] Our study groups, based on the position during surgery, were homogenous according to age and gender distribution. Sixteen patients underwent the surgical procedure in supine, while 15 patients underwent surgery in sitting position. The overall reoccurrence rate was 19% (22% and
18% in females and males respectively), with the median age of patients with the reoccurrence of 76 years, similar to previously published studies.[20-22] There was no statistically significant difference in the hematoma reoccurrence based on the patients’ general characteristics. We noted hematoma reoccurrence in 5 patients operated in supine, and only one patient operated in sitting position. 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).

1. Risk factors for reoccurrence

Most common patient-related risk factors for the worse outcome of this procedure are chronic alcoholism, seizure disorders, and history of a ventriculoperitoneal shunt.[20, 23] The impact of diabetes mellitus remains controversial.[23, 24] Most studies suggest age, sex, hypertension, cardiac disease, and use of anticoagulants or antiplatelets do not affect the reoccurrence rate[23, 25], but do influence the overall outcome.[26] 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 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 of CSDH reoccurrence include a preoperative appearance of heterogeneous hematoma or higher-density hematoma, greater midline shift, bilateral hematomas, or postoperative appearance of poor brain re-expansion or greater subdural air accumulation.[11] Only one of these risk factors, the 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.[12] Controlled blood evacuation when the dural incision 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 the 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 hard to maintain in awake patient. Our results suggest that the 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 a twist drill as opposed to burr hole craniostomy or craniotomy, although craniotomies predispose patients to higher morbidity rates.[27] Two burr-hole craniostomy is considered to be related to shorter hospital stay, as well as to lower reoccurrence rate.[9] 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 revealed no significant influence of postoperative patient posture on the hematoma reoccurrence.[20, 22, 28, 29] Our surgical technique was uniform in both groups of patients and included burr-hole craniostomy, closed system drainage and irrigation with saline solution to achieve the best possible outcome in both groups of patients.[27]

2. Complications related to the sitting position in neurosurgery

Complications are the main reason for avoidance of wider sitting position use in surgery in general, and especially in neurosurgery.[13] There are even guidelines and protocols for anesthesiologists to reduce the complication rates in patients positioned this way during surgery.[14, 15] 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.[14, 15] On the other hand, specific complications like tension pneumocephalus occur in sitting position only during the posterior fossa surgeries, when CSF leak is not maintained under control.[13, 30]

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 were noted or revealed, probably due to the short duration of the procedure (less than half an hour for single sided, or less than 45 minutes for bilateral CSDH), awake state of 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 uniqueness of our study, the complications related to the sitting position in awake craniostomy for CSDH may not be compared to other studies on procedures usually performed in the similar positions, while there are no other studies on the same procedure.
3. **Study limitations**

Regarding the limitations of the study, the most notable is a small group of patients. Being an initial group undergoing CSDH treatment in 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 the two independent hematomas.

Future studies, preferably multi-centered, 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 revealed that positioning patients this way during the craniostomy procedure 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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REFERENCES


FIGURES LEGENDS

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

Figure 2. The number of reoperations according to the intraoperative position.

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

**Figure 4.** Cranial RTG after craniostomy in sitting position (the arrow points to the burr-hole).