Surgical Treatment of Chronic Subdural Hematoma: Systematic Review and Meta-Analysis of the Literature

Tratamento cirúrgico do hematoma subdural crônico: revisão sistemática e metanálise da literatura

Alisson R. Teles[1] Asdrubal Falavigna[1] Jorge Kraemer[2]

[1] Department of Neurosurgery, Laboratory of Clinical Studies and Basic Models of Spinal Disorders, Universidade de Caxias do Sul, Caxias do Sul, RS, Brazil
[2] Neurosurgery Unit, Hospital São José - Santa Casa de Porto Alegre, Porto Alegre, RS, Brazil

Address for correspondence Alisson R. Teles, MD, Laboratory of Clinical Studies and Basic Models of Spinal Disorders, Universidade de Caxias do Sul, Caxias do Sul, RS, Brazil (e-mail: alisson.r.teles@gmail.com).

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Abstract

Background There are many controversies in the literature on the treatment of chronic subdural hematoma (CSDH).

Objective To assess the effects of different surgical techniques and postoperative care on recurrence of CSDH.

Methods Systematic review through Medline search of articles published between January 1990 and July 2011. Controlled observational and randomized clinical trials (RCT) regarding surgical approach, irrigation, drainage, and postoperative patient position in patients with CSDH were included. The outcome was recurrence requiring reoperation. Independent extraction of articles was conducted by 2 authors using predefined data fields, including study risk of bias indicators.

Results 35 publications met inclusion criteria. Pooled analyses did not demonstrate difference in recurrence rates when compared burr-hole craniostomy (BHC) x twist-drill craniostomy (TDC) (OR: 0.99; CI95%: 0.53–1.84; $p = 0.97$), BHC x craniotomy (OR: 1.23; CI95%: 0.78–1.95; $p = 0.36$), nor TDC x craniotomy (OR: 16.11; CI95%: 0.85–306.88; $p = 0.06$). In patients receiving BHC, pooled analysis showed a lower recurrence rate in patients receiving 2BHC compared with 1BHC (OR: 0.58; CI95%: 0.37–0.88; $p = 0.01$). The use of drainage system after evacuation of CSDH by BHC reduces the recurrence (OR: 0.41; CI95%: 0.23–0.74; $p = 0.003$).There is not enough evidence to support either a specific location of the tip of drain, nor the postoperative patient position as factors influencing on recurrence.

Conclusion Well-designed studies are urgently needed to verify the effectiveness of most neurosurgical procedures routinely performed for CSDH.

Keywords
- chronic subdural hematoma
- treatment
- surgery
- recurrence
- meta-analysis

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Resumo

Introdução Existem inúmeras controvérsias na literatura sobre o tratamento do hematoma subdural crônico (HSDC).

Objetivo Avaliar os resultados das diferentes técnicas cirúrgicas e cuidados pós-operatórios na recidiva do HSDC.

Métodos Revisão sistemática de artigos publicados no Medline entre Janeiro de 1990 a Julho de 2011. Foram incluídos estudos observacionais controlados e ensaios clínicos randomizados (ECR) relacionados à abordagem cirúrgica, irrigação, uso de dreno e posicionamento no pós-operatório de pacientes com HSDC. O desfecho estudado foi recidivo necessitando reoperação. A extração dos dados foi conduzida de maneira independente por dois autores utilizando campos pré-definidos, incluíndo indicadores de viés dos estudos.

Resultados Trinta e cinco artigos foram incluídos na análise. A metanálise não demonstrou diferença nas taxas de recorrência quando comparadas às técnicas de trepanação *burr-hole* (BHC) X *twist-drill* (TDC) (OR: 0,99; IC95%: 0,53–1,84; p = 0,97), BHC X craniotomia (OR: 1,23; IC95%: 0,78–1,95; p = 0,36), nem TDC X craniotomia (OR: 16,11; IC95%: 0,85–306,88; p = 0.06). Em pacientes operados por BHC, a metanálise demonstrou menor taxa de recidiva em pacientes operados com 2BHC em comparação a 1BHC (OR: 0,58; IC95%: 0,37–0,88; p = 0,01). O uso de dreno no pós-operatório por BHC reduziu a recidiva (OR: 0,41; IC95%: 0,23–0,74; p = 0,003). Não há evidência suficiente que aponta do dreno ou a posição do paciente no pós-operatório tenham influência na chance de recidiva.

Conclusão Estudos bem delineados são necessários para comparar a efetividade da maioria dos procedimentos neurocirúrgicos realizados rotineiramente para HSDC.

Palavras-chave
- hematoma subdural crônico
- tratamento
- cirurgia
- recidiva
- metanálise

Introduction

Chronic subdural hematoma (CSDH) is one of the most common conditions in neurosurgery. Its incidence is estimated to be 1.72/100,000/year in general and 7.35/100,000/year in the age group from 70 to 79 years.[1] With a greater proportion of elderly people over the next decades, the incidence of this pathology will further increase. Despite its relative frequency, a range of surgical techniques are currently used and low importance in the literature has been given to ascertain about the effectiveness of these practices.

Three previous meta-analyses were published regarding management of CSDH.[2–4] However, two important pitfalls arise from these publications. First, due to the variation of risk of bias across studies, it is generally accepted that criteria should be set to limit the kinds of evidence included in a systematic review.[5] Despite the disagreement about the study design criteria that should be included in absence of well designed randomized clinical trials (RCT), it is generally accepted that the strategy should be to include only the best available study designs. In this sense, all previous authors included uncontrolled studies in their analyses, such as case series together with controlled studies, which carry great risk of bias. Different designs are susceptible to different biases, and it is often unclear which biases have the greatest impact and how they vary between clinical situations.[5] Second, the statistical methods used to account for treatment effects and risk of bias among studies are in disagreement with the recent guidelines for reporting meta-analyses.[6]

Treatment of CSDH varies among neurosurgical centers,[7,8] and there is no consensus in the literature about the impact of these techniques on patient outcome. The objective of this review was to assess the effects of different surgical techniques described in the literature on recurrence of CSDH.

Methodology

Electronic Literature Database

We undertook a systematic literature review by conducting a Medline/Cochrane search of articles published between January 1990 and July 2011 using the medical subheading “chronic subdural hematoma” in combination with any of the following words: “treatment,” “surgery,” “evacuation,” “management,” “drainage,” and “recurrence.” We limited our results to humans, articles published in English language, and with available abstracts. Reference lists of key articles were also systematically checked.

We identified all articles regarding surgical approach, irrigation, drainage, and postoperative patient position. Observational studies with control groups and RCT were included in this review. Articles were excluded if: there was no report on recurrence rates or if it was not reported as reoperation; if there were no comparative analyses (e.g., irrigation x no-irrigation, drainage x no-drainage) or if comparison would not be taken without excluding any variable (e.g., drainage use comparing patients who underwent BHC and TDC); if pediatric patients were included without subgroup analyses; if the sample was composed by recurrent hematomas or those associated with ventricular shunt; or if the sample was lower than 30 patients. Others exclusions included narrative reviews, editorials, case-reports and non-English-written articles.

Data Extraction

Each retrieved citation was independently reviewed by two authors (ART, AF) using predefined data fields. Most articles were excluded on the basis of information provided by the abstract. Citations that seemed to be appropriate or those that could not be excluded unequivocally from the abstract were identified, and the corresponding full-text reports were reviewed by the two authors (ART, AF). Any disagreement between them was resolved by consensus. From the included articles, the following data were extracted: study design, sample size, surgical technique, recurrence rate, level of evidence, and risk of bias of the study. In patients with bilateral CSDH, we considered the number of affected sides in the analyses; if the article did not contemplate this information, we evaluated number of patients.

Risk of Bias Assessment

Level of evidence (LOE) ratings and risk of bias were assigned to each article independently by two reviewers (ART, AF). Any disagreement was resolved by consensus. We used the criteria set by the Centre for Evidence Based Medicine[9] to assess the level of evidence from each article. Risk of bias was evaluated with The Cochrane Risk of Bias Tool[10] for RCT and The Newcastle-Ottawa Scale[11] for observational studies. The Cochrane Risk of Bias Tool assesses five domains of bias: selection bias (random sequence generation and allocation concealment), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data) and reporting bias (selective reporting). The category other bias is included to ascertain bias due to problems not covered elsewhere.[12] The Newcastle-Ottawa consists of three parameters of risk of bias assessment: selection, comparability, and outcome. This scale assigns a maximum of 4 points for selection, a maximum of 2 points of comparability, and a maximum of 3 points for outcome. The higher the score, the lower the risk of bias of the study. We presented the results of the risk of bias assessment and level of evidence separately for each article.

Analysis

The definition of CSDH relied on the original authors' assessment of the radiographic characteristics of the subdural collection in classifying it as chronic rather than acute or subacute. Only adult patients were included in the analysis. Recurrence was primarily defined as reoperation of the hematoma. Articles that considered recurrence as reformation of subdural collection but did not report on reoperation rates were excluded from the analysis. Regarding surgical approach, cranial openings higher than 3 cm were classified as craniotomy, lower than 0.5 cm as twist-drill craniostomy, and those in between as burr-hole craniostomy.[4]

We extracted recurrence rates regarding different techniques (e.g., irrigation x no-irrigation, drainage x no-drainage) from each article. Comparisons between surgical approach, number of burr-holes, drain usage, irrigation and postoperative patient position were analyzed. Statistical analyses were conducted with RevMan software version 5.1. Due to the paucity of high quality randomized clinical trials on treatment options for CSDH, meta-analyses were conducted with both observational and RCT using fixed effects models. We calculated odds ratios (OR) and corresponding confidence intervals (CI) for recurrence in all treatment comparisons. Heterogeneity between studies was tested using Chi-square test and the I2 statistic (inconsistency).[13] The last represents the percentage of total variation across studies that is due to heterogeneity rather than chance. Inconsistency of 25% is considered low, 50% moderate, and more than 75% high.[13]

Results

We identified a total of 633 articles after the Medline search (►**Fig. 1**). Of these papers, 108 underwent full-text review. After full-text review, we excluded 73 articles for the following reasons: no comparative groups or no comparisons could be done with provided data ($n = 47$); no report on recurrence rates or it was not reported as reoperation ($n = 22$); only recurrent hematomas included ($n = 1$); report on pharmacological treatment ($n = 2$); and sample size lower than 30 patients ($n = 1$) (►**Fig. 1**). After exclusions, 35 original articles were analyzed by the authors. Most of the included articles were retrospective ($N = 24$; 68.6%). There were three prospective studies (8.6%) and 8 randomized clinical trials (22.8%). Risk of bias for observational and RCTs are presented in ►**Tables 1** and **2**, respectively. It is possible to observe high risk of bias in most of the RCTs and observational studies. For example, the majority were small and underpowered RCTs

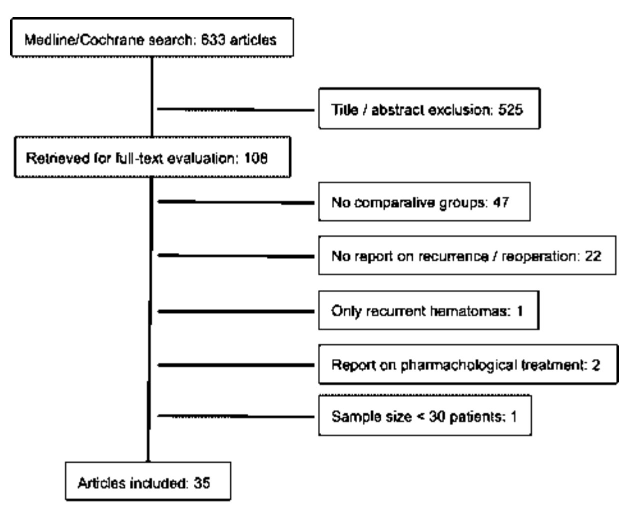

Fig. 1 Literature search and studies' selection.

Table 1 Risk of bias assessment for observational studies

Study	Newcastle-Ottawa Scale			LOE
	Selection	Comparability	Outcome	
Wakai et al[34]	3	1	2	2b
Sambasivan[19]	3	0	3	2c
Smely et al[23]	3	1	3	2b
Ernestus et al[14]	3	0	2	4
Suzuki et al[31]	3	0	2	2b
Nakaguchi et al[42]	3	0	2	2b
Tanikawa et al[20]	3	0	2	4
Oishi et al[30]	2	0	3	4
Williams et al[22]	3	0	1	4
Kuroki et al[29]	4	0	2	2b
Yamamoto et al[41]	4	2	2	2c
Lind et al[38]	4	0	1	2b
Lee et al[15]	4	0	2	4
Baechli et al[25]	4	0	1	2c
Kiymaz et al[37]	3	0	2	4
Taussy et al[28]	3	2	2	2b
Zakaraia et al[52]	4	0	2	2c
Torihashi et al[32]	4	2	2	2c
Yu et al[40]	4	0	2	2c
Lee et al[16]	4	0	2	2b
Han et al[26]	3	2	2	2b
Baé et al[43]	4	2	2	2c
Rughani et al[18]	4	2	2	2b
Kansal et al[27]	3	0	3	2b
Kurabe et al[47]	3	1	3	2b
White et al[21]	2	0	1	4
Miranda et al[17]	3	0	2	2c

Abbreviation: LOE, level of evidence.

Table 2 Risk of bias assessment for randomized clinical trials

Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias	LOE
Tsutsumi et al[33]	Low	Unclear	Low	Unclear	Low	High	High	2b
Nakajima et al[46]	Unclear	Unclear	Low	Unclear	Low	Low	High	2b
Muzii et al[24]	High	High	Low	Unclear	Low	High	Unclear	2b
Erol et al[35]	Unclear	Unclear	Low	Unclear	Low	High	Unclear	2b
Abouzari et al[44]	High	High	Low	High	Low	High	High	2b
Ishfaq et al[45]	Low	High	Low	Unclear	Low	Low	High	2b
Santarius et al[39]	Low	Low	Low	Low	Low	Low	Low	1b
Javadi et al[36]	Unclear	Unclear	Low	Unclear	Low	Low	High	2b

Abbreviation: LOE, level of evidence.

Study or Subgroup	BHC Events	BHC Total	TDC Events	TDC Total	Weight	Odds Ratio M-H, Fixed, 95% CI	Year
Smely, 1997	11	33	6	33	20.0%	2.25 [0.72, 7.06]	1997
Williams, 2001	5	51	7	11	52.0%	0.06 [0.01, 0.29]	2001
Muzil, 2005	5	24	1	22	4.1%	5.53 [0.59, 51.65]	2005
Rughan, 2010	5	21	3	21	11.5%	1.88 [0.39, 9.12]	2010
Miranda, 2011	1	21	4	44	12.3%	0.50 [0.05, 4.77]	2011
Total (95% CI)		**150**		**131**	**100.0%**	**0.99 [0.53, 1.84]**	
Total events	27		21				

Heterogeneity: $Chi^2 = 17.71$, df = 4 (P = 0.001); $I^2 = 77\%$
Test for overall effect: Z = 0.04 (P = 0.97)

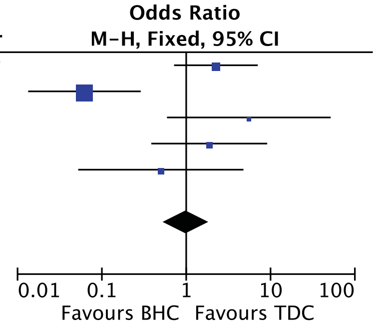

Fig. 2 Forest-plot of comparisons between burr-hole craniostomy versus twist-drill craniostomy.

and most of them did not describe methods of randomization and assessment of outcome. For observational studies, few reported analyses for confounding factors and a great part did not described adequate follow-up period. The majority of papers provided level of evidence 2b ($N = 19$; 54.2%), followed by level 2c ($N = 8$; 22.9%), 4 ($N = 7$; 20.0%), and 1b ($N = 1$; 2.9%).

Surgical Approach

Nine retrospective,[14–22] one prospective[23] and one RCT[24] were included. All of these studies performed comparative analyses of two or more surgical approaches for CSDH and reported recurrence as reoperation rates. Concerning patients who received BHC, four studies reported use of two burr-holes,[15,17,19,20] three studies used single burr-hole,[14,22,23] three papers did not specify the number of burr-holes performed in each patient,[18,21,24] and Lee et al[16] reported one burr-hole in 25 patients and two burr-holes in 32 patients. Nine studies reported postoperative drainage use[14–20,23,24] and two did not use drain.[21,22] Sambasivan[19] described craniotomy with subtemporalis marsupialization in patients who underwent craniotomy.

Regarding comparisons of recurrence rates in patients treated with BHC versus TDC, the pooled analysis of five articles[17,18,22–24] did not demonstrate statistically significant difference between the two groups (►**Fig. 2**; OR: 0.99; CI95%: 0.53; $p = 0.97$). This model proved to have significant heterogeneity (Chi-square: 17.71; $p = 0.001$, I2: 72%). If Williams' study[22] would be removed from the analysis, I2 would be 0% (Chi-square: 2.29; $p = 0.51$) and there still would be no statistically significant difference between the two surgical approaches for CSDH (OR: 1.99; CI95%: 0.94–4.25; $p = 0.07$).

We retrospectively reviewed comparisons of BHC versus craniotomy in seven publications.[14–17,19–21] In general, option to perform each technique was based on study period or preference of attending neurosurgeon. No article reported on other preoperative variable that could interfere in decision of surgical approach. A pooled analysis with all papers proved to have significant heterogeneity (chi-square: 67.69; $p < 0.00001$; I2: 91%), mainly caused by Sambasivan's study.[19] We opted to exclude that study from the analysis to reduce heterogeneity from the pooled analysis (chi-square: 6.88; $p = 0.23$; I2: 27%). The meta-analysis demonstrates that recurrence do not differ between patients receiving BHC or craniotomy for CSDH (►**Fig. 3**; OR: 1.23; CI95%: 0.78–1.95; $p = 0.36$).

Only one paper[17] reported comparisons of recurrence in patients who received TDC versus craniotomy for CSDH. We observed that 4 of 44 patients treated with TDH and none of 70 patients treated with craniotomy needed reoperation (OR: 16.11; CI95%: 0.85–306.88; $p = 0.06$).

Number of Burr-Holes

Five retrospective studies[16,25–28] evaluated the influence of number of burr-holes on recurrence of CSDH. Four studies performed irrigation associated with postoperative drainage system,[16,25,26,28] and one did not use drain.[27] Despite the

Study or Subgroup	BHC Events	BHC Total	Craniotomy Events	Craniotomy Total	Weight	Odds Ratio M-H, Fixed, 95% CI	Year
Sambasivan, 1996	11	51	8	2215	0.0%	75.87 [28.96, 198.71]	1996
Ernestus, 1997	17	94	1	10	4.4%	1.99 [0.24, 16.75]	1997
Tanikawa, 2001	4	33	0	16	1.7%	5.03 [0.25, 99.43]	2001
Lee, 2004	6	38	25	134	27.7%	0.82 [0.31, 2.17]	2004
Lee, 2009	13	57	2	30	6.0%	4.14 [0.87, 19.73]	2009
White, 2010	23	130	23	116	59.5%	0.87 [0.46, 1.65]	2010
Miranda, 2011	1	21	0	72	0.6%	10.61 [0.42, 270.35]	2011
Total (95% CI)		**373**		**378**	**100.0%**	**1.23 [0.78, 1.95]**	
Total events	64		51				

Heterogeneity: $Chi^2 = 6.88$, df = 5 (P = 0.23); $I^2 = 27\%$
Test for overall effect: Z = 0.91 (P = 0.36)

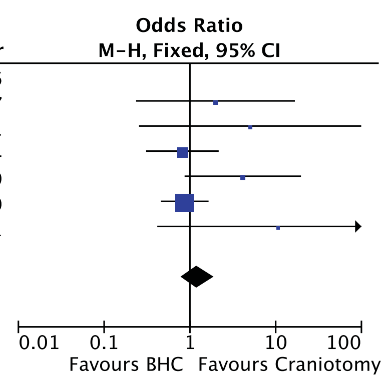

Fig. 3 Forest-plot of comparins between burr-hole craniostomy versus craniotomy.

Study or Subgroup	2 BHC Events	2 BHC Total	1 BHC Events	1 BHC Total	Weight	Odds Ratio M–H, Fixed, 95% CI	Year
Baechli, 2004	14	144	34	210	44.0%	0.56 [0.29, 1.08]	2004
Taussy, 2008	3	63	10	34	21.8%	0.12 [0.03, 0.47]	2008
Lee, 2009	7	32	6	25	9.3%	0.89 [0.26, 3.07]	2009
Han, 2009	9	129	1	51	2.3%	3.75 [0.46, 30.38]	2009
Kansal, 2010	6	72	26	195	22.6%	0.59 [0.23, 1.50]	2010
Total (95% CI)		**440**		**515**	**100.0%**	**0.58 [0.37, 0.88]**	
Total events	39		77				

Heterogeneity: $Chi^2 = 8.56$, df = 4 (P = 0.07); $I^2 = 53\%$
Test for overall effect: Z = 2.52 (P = 0.01)

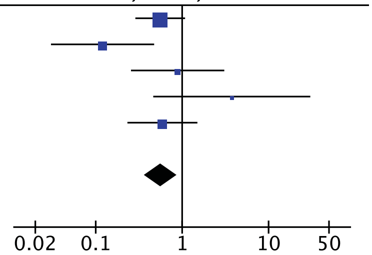

Fig. 4 Forest-plot of comparisons between one versus two burr-holes.

Study or Subgroup	Irrigation Events	Irrigation Total	No-irrigation Events	No-irrigation Total	Weight	Odds Ratio M–H, Fixed, 95% CI	Year
Suzuki, 1998	4	119	2	67	37.9%	1.13 [0.20, 6.34]	1998
Oishi, 2001	8	117	2	17	49.9%	0.55 [0.11, 2.84]	2001
Kuroki, 2001	5	45	1	56	12.2%	6.88 [0.77, 61.14]	2001
Total (95% CI)		**281**		**140**	**100.0%**	**1.54 [0.56, 4.23]**	
Total events	17		5				

Heterogeneity: $Chi^2 = 3.43$, df = 2 (P = 0.18); $I^2 = 42\%$
Test for overall effect: Z = 0.84 (P = 0.40)

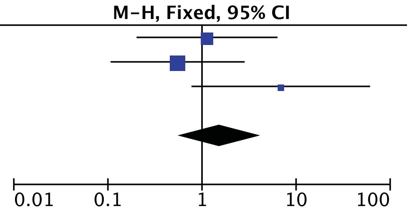

Fig. 5 Forest-plot of comparisons between intraoperative irrigation versus non-irrigation of subdural cavity.

Chi-square not having demonstrated statistically significant heterogeneity among studies ($p = 0.07$), inconsistency proved to be moderate (I2: 53%). At least two reasons could explain this percentage: the different surgical technique used in the study by Kansal et al[27] (without drain) and the absence of criteria/randomization to perform 1 or 2 BHC among the studies. The meta-analyses of such data demonstrated that 2 BHC is associated with lower recurrence rates compared with 1 BHC (►**Fig. 4**; OR: 0.58; CI95%: 0.37–0.88).

Intraoperative Irrigation

Three retrospective studies[29–31] evaluated the recurrence rates between patients who underwent or did not intraoperative irrigation using BHC and postoperative drainage system. Kuroki et al[29] verified recurrence in 11.1% in irrigation group and 1.8% in no-irrigation group ($p = 0.049$; OR $= 6.875$, CI95%: 0.773–61.143). The other two papers[30,31] did not find this difference on the basis of irrigation. The analysis of all reported cases did not find difference between the two treatment groups concerning recurrence rates (►**Fig. 5**). Inconsistency among studies proved to be moderate (I2: 42%; Chi2: 3.43, $p = 0.18$).

Drainage

Nine studies[22,32–39] provided information about recurrence regarding drainage usage after BHC and irrigation for CSDH. There were four RCTs,[33,35,36,39] four retrospective[22,32,37,38] and one[34] prospective observational studies. Only one RCT was classified as providing level 1b of evidence.[39] We conducted meta-analysis with all RCT, excluding observational studies. Tsutsumi et al[33] describe, in the same article, data regarding a retrospective chart review (four-year period) and a RCT comparing 1 BHC with and without drainage system; only data regarding the RCT were included in the meta-analysis.

In relation to observational studies,[22,32,34,37,38] 3 papers[34,37,38] reported lower recurrence rates in patients who received drain compared with patients without drain. The remaining two[22,32] did not find difference in recurrence concerning the use of drain.

Study or Subgroup	Drain Events	Drain Total	No drain Events	No drain Total	Weight	Odds Ratio M–H, Fixed, 95% CI	Year
Tsutsumi, 1997	2	65	6	53	17.9%	0.25 [0.05, 1.29]	1997
Erol, 2005	5	35	6	35	14.4%	0.81 [0.22, 2.93]	2005
Santarius, 2009	10	108	26	106	66.5%	0.31 [0.14, 0.69]	2009
Javadi, 2011	1	20	0	20	1.3%	3.15 [0.12, 82.16]	2011
Total (95% CI)		**228**		**214**	**100.0%**	**0.41 [0.23, 0.74]**	
Total events	18		38				

Heterogeneity: $Chi^2 = 3.35$, df = 3 (P = 0.34); $I^2 = 10\%$
Test for overall effect: Z = 2.96 (P = 0.003)

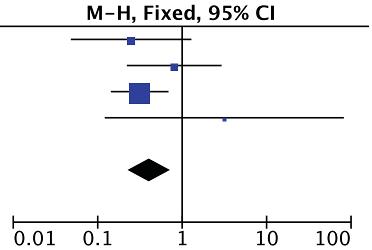

Fig. 6 Forest-plot of comparisons between use of drain versus no-drain after burr-hole craniostomy.

Santarius et al[39] performed a RCT to verify the effect of postoperative drainage after burr-hole evacuation of CSDH. They randomized 108 patients to drain group and 107 to no-drain group. The incidence of recurrence of hematoma was higher in the no-drain group (9% x 24%; $p = 0.0031$). In addition, the mortality at 6-months was higher in no-drain group (9% x 18%; $p = 0.0424$). The meta-analysis of all RCT demonstrated that the use of drain reduces the risk of recurrence after BHC for CSDH (►**Fig. 6**; $p = 0.003$; OR: 0.41; CI95%: 0.23–0.74). The I2 value was 10%, demonstrating that only 10% of variation of recurrence rates can be explained by heterogeneity among the studies.

Duration of Drainage

Only one retrospective study[40] evaluated the duration of drainage and its relation with recurrence of CSDH. Yu et al[40] performed 1 BHC with irrigation and drainage in 100 patients. The criteria for removing the drainage system were brain re-expansion on computed tomography (CT) scans or when drainage ceased. Analyses were conducted based on recurrence rates of 3 groups according to duration of drainage: $<$ 72 hours, 16.3% of recurrence; 72–119 hours, 2% of recurrence; and $\geq$ 120 hours, no recurrence. Bivariate analyses demonstrated a statistically significant difference in the groups ($p = 0.007$), that is, the risk of recurrence was higher when the drainage system was removed earlier. However, caution should be taken when interpreting these results due to its high risk of bias. First, as it was a retrospective study, all biases of a non-randomized study are present. Also, the sample size in each group is considered small for such lower incidence of recurrence found in the study.

Position of Drain

Three papers[41–43] were included in the review concerning the influence of position of the tip of drain in recurrence after surgery for CSDH, one RCT[42] and two retrospective studies.[41,43] A meta-analysis could not be performed due to discrepancy of the groups among studies.

Nakaguchi et al[42] designed a RCT to compare recurrence in patients with different locations of the tip of the drain after evacuation of CSDH by BHC and irrigation. In the period of study, 135 patients with CSDH were treated in their institution, but in only 63 patients the tip of catheter was randomly decided and then precisely determined using CT on the day after surgery. The patients were randomized to receive a drain in frontal or occipital region. However, as mentioned by the authors, each catheter was blindly inserted into the subdural space at surgery and it was unclear where the tip was placed. Therefore the catheter position was checked by a postoperative CT. The data were analyzed regarding the location of drain according to that CT. Patients with drains in the frontal region had lower recurrence rates (1/21; 5%), in comparison with parietal (⅜; 38%), occipital (5/25; 20%), and temporal base (3/9; 33%) regions ($p = 0.04$). This study has some biases that should be considered. First, the lack of details on the non-randomization and non-inclusion of a large amount of patients treated in the study period in that institution could represent a selection bias. Also, the authors did not provide information considering an intention to treat analysis, no details on randomization were provided, and the study is underpowered due to the small sample size.

Yamamoto et al[41] underwent a retrospective chart review of 105 consecutive patients with CSDH who underwent surgery. Multivariate analyses on risk factors for recurrence of CSDH demonstrated that the position of drain was not related to recurrence in the analysis (10/94 frontal $\times$ 1/11 other; $p = 0.874$). Baé et al[43] retrospectively reviewed 312 patients treated with TDC and drainage system. Recurrence rates were not different whether the drain was located in the frontal region (24%) or the parietal region (21%). In both of these two retrospective studies, the authors did not provide information on the selection of drainage location nor on determination of drain location postoperatively.

Patient Postoperative Position

Three RCTs were included in the analysis.[44–46] Abouzari et al[44] conducted a RCT with 84 patients to compare flat head position versus elevated head position in the postoperative period of BHC, irrigation, and drainage for CSDH. They report that the percentage of patients with reformation of subdural collection was higher in patients who underwent elevated head position compared with flat head position (19%% x 2.3%; $p = 0.02$). However, reoperation was performed in only one patient who underwent flat head position in the postoperative period. As our meta-analysis considered recurrence as reformation of a symptomatic CSDH requiring reoperation, only that patient was classified as having recurrence in our final analysis. Data provided in ►**Fig. 7** demonstrate that there is no statistically significant difference between two postoperative patient positions regarding recurrence after BHC for CSDH.

Study or Subgroup	Flat head Events	Flat head Total	Elevated head Events	Elevated head Total	Weight	Odds Ratio M–H, Fixed, 95% CI	Year
Nakajima, 2002	4	25	3	21	40.2%	1.14 [0.23, 5.80]	2002
Abouzari, 2007	0	42	1	42	21.7%	0.33 [0.01, 8.22]	2007
Ishafq, 2009	4	30	3	30	38.1%	1.38 [0.28, 6.80]	2009
Total (95% CI)		**97**		**93**	**100.0%**	**1.06 [0.37, 3.01]**	
Total events	8		7				

Heterogeneity: $Chi^2 = 0.63$, df = 2 (P = 0.73); $I^2 = 0\%$
Test for overall effect: Z = 0.10 (P = 0.92)

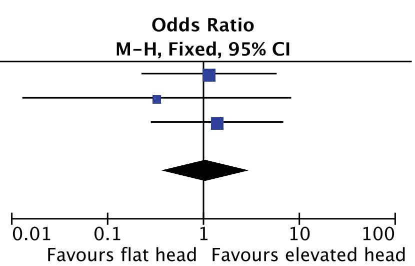

Fig. 7 Forest-plot of comparisons between flat and elevated head in postoperative period.

Timing to Patient Mobilization

One[47] retrospective study provided information regarding duration of bed rest and recurrence after evacuation of CSDH. Kurabe et al[47] assessed timing of bed rest in patients older than 65 to verify if early mobilization in these patients would affect recurrence rates and postoperative complications. The authors performed BHC with irrigation and closed drainage system in 182 patients. Half of them were maintained in supine position for at least two days after the operation (delayed mobilization group), while 91 patients had the drainage system removed and were able to walk the day after the operation (early mobilization group). Recurrence was observed in 6 patients of delayed mobilization group and in 8 patients of early mobilization group (6.6% x 8.8%, respectively; $p = 0.58$). The incidence of patients who suffered from at least one complication was higher in the delayed mobilization group compared with early mobilization group (26.4% x 12.1%, respectively; $p = 0.015$). The results of this retrospective study demonstrate that early mobilization in elderly patients may have benefits in reducing postoperative complications without increasing recurrence rates after evacuation of CSDH. A RCT is encouraged to prove these findings.

Discussion

Despite the epidemiological importance of CSDH, high quality studies on the treatment of this condition are scarce in the neurosurgical literature. In our review, only 8 RCTs were found and most of them presented high risk of bias. The majority of the analyses were performed using comparative analyses of observational studies. Nonetheless, the strengths of our review include the comprehensive and reliable search, data extraction, and appropriate and widely acceptable methodology of meta-analysis and risk of bias assessment. Strict identification of patients who underwent reoperation aside from radiographic reformation of subdural collection is also an important factor of this review. Re-expansion of brain tissue in elderly patients is sometimes delayed due to absence of cerebral complacency and some subdural collection is found in postoperative exams in most cases of patients not requiring reoperation.

Results from our meta-analyses demonstrate the absence of evidence to support superiority of any surgical technique (BHC x TDC x craniotomy) in reducing recurrence rates after evacuation of CSDH. These results are in disagreement with the other systematic reviews already published.[2–4] In the analyses of Weigel et al[4] BHC and craniotomy were associated with lower recurrence rates. Lega et al[3] used Monte Carlo simulation model and concluded that BHC balances a low recurrence rate with a low incidence of highly morbid complications. However, those papers included uncontrolled studies in their review. This kind of publication has a high risk of confirmation bias, the tendency of publishing positive results. Also, for systematic reviews without existing well designed RCTs, the inclusion criteria should consider only the best available study designs, because different designs are susceptible to different biases, and it is often unclear which biases have the greatest impact and how they vary between clinical situations.[5] Our review included the best of existing evidence in the literature regarding management of this disease. Due to the paucity of well designed RCTs, we included observational controlled studies.

BHC is the most common surgical technique to evacuate CSDH in neurosurgical centers.[7,8,48] Our pooled analyses demonstrated that 2 burr-holes presents best results when compared with only 1 burr-hole. However, this result are based on retrospective studies,[16,25–28] and majority of them have a high risk of comparability bias; for example, patients were not paired by radiographic features. Also, the Despite of irrigation of subdural cavity being a common practice during evacuation of CSDH, 3 retrospective studies[29–31] compared results of patients who received or not intraoperative irrigation. The pooled analyses of these data did not demonstrate difference in recurrence rates between these two techniques. The only high quality RCT found assessed the effectiveness of drain use in patients receiving BHC.[39] Our analysis demonstrates that the use of drain is associated with a low risk of recurrence in such patients.

CSDH is commonly associated with cerebral atrophy and the associated increase in potential space in the subdural area. This fact results in some practitioners placing the patient's head flat during treatment in an attempt to decrease this potential space. In fact, the majority of studies report the use of a flat head position for preventing hematoma recurrence. On the other hand, there are other theoretical explanations to support the use of elevated head in the management of CSDH. First, as performed in acute subdural hematomas, some authors raise patients' head to reduce intracranial pressure improving the cerebral perfusion pressure[48]; besides, one mechanism thought to explain the growth of CSDH is an increased oncotic pressure within the encapsulated space secondary to partial clot liquefaction,[48] therefore raising the patients' head could possibly reduce this pressure gradient. Finally, a secondary hypothesis suggests that expansion of hematoma is caused by recurrent bleeding,[49,50] and this would be caused by dilated and abnormal vessels contained in the outer membrane of the hematoma,[51] hence keeping the patients' head elevated could decrease this source of hemorrhage. Another theoretical superiority of elevated head position includes reduction of aspiration and early mobilization of the patient. Our results do not support superiority of any of these patient positions in reducing recurrence of CSDH. After a pooled analysis of three low quality RCT, there was no statistically significant difference in recurrence rates in patients who underwent this position compared with patients who underwent elevated head position. Well-designed RCT are needed to verify the influence of head position in recurrence and complications after drainage of CSDH.

Our review has some limitations that must be pointed. Most of them are relative to the evidence itself, requiring attention for both interpreting the results and conducting future research. Many of the identified studies had a high risk for observational study bias due to the lack of control for confounders and covariates (such as the lack of adjustment for age, hematoma volume or radiographic features). For example, confounding by indication of each surgical technique (e.g., 1 $\times$ 2 BHC; BHC or TDH x craniotomy) could therefore have a greater likelihood that larger hematomas would be treated with craniotomy or 2 BHC besides 1BHC. In adittion, due to the paucity of high quality RCT, and majority of observational studies have high risk of bias when reporting other outcomes such as surgical morbidity and clinical complications, we opted to do not included these outcomes in our meta-analysis.

Conclusions and Implications for Future Research

There is very low quality evidence for the efficacy of most neurosurgical procedures for CSDH because of high risk of bias of the trials. The pooled analysis of the best existing evidence in the literature does not demonstrate differences in recurrence rates for CSDH treated either by BHC, TDC nor craniotomy. If BHC is performed, the use of a drainage system reduces the risk of recurrence. There is not enough evidence to support a specific location of tip of drain, nor the duration of drainage and its impact on recurrence. Regarding postoperative management, the best existing evidence does not demonstrate difference in recurrence rates in patients kept with flat compared with elevated head position. Also, there is not enough evidence to support that longer duration of bed rest reduces the risk of hematoma recurrence after drainage in elderly patients. Well designed studies are urgently needed.

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