

# Chronic subdural hematoma: a systematic review and meta-analysis of surgical procedures

## A systematic review

\*WEIMING LIU, M.D.,<sup>1</sup> NICOLAAS A. BAKKER, M.D., PH.D.,<sup>2</sup>  
AND ROB J. M. GROEN, M.D., PH.D.<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Beijing Tiantan Hospital, Capital Medical University, China; and <sup>2</sup>Department of Neurosurgery, University Medical Center Groningen, University of Groningen, The Netherlands

**Object.** In this paper the authors systematically evaluate the results of different surgical procedures for chronic subdural hematoma (CSDH).

**Methods.** The MEDLINE, Embase, Cochrane Central Register of Controlled Trials, and other databases were scrutinized according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) statement, after which only randomized controlled trials (RCTs) and quasi-RCTs were included. At least 2 different neurosurgical procedures in the management of chronic subdural hematoma (CSDH) had to be evaluated. Included studies were assessed for the risk of bias. Recurrence rates, complications, and outcome including mortality were taken as outcome measures. Statistical heterogeneity in each meta-analysis was assessed using the  $T^2$  (tau-squared),  $I^2$ , and chi-square tests. The DerSimonian-Laird method was used to calculate the summary estimates using the fixed-effect model in meta-analysis.

**Results.** Of the 297 studies identified, 19 RCTs were included. Of them, 7 studies evaluated the use of postoperative drainage, of which the meta-analysis showed a pooled OR of 0.36 (95% CI 0.21–0.60;  $p < 0.001$ ) in favor of drainage. Four studies compared twist drill and bur hole procedures. No significant differences between the 2 methods were present, but heterogeneity was considered to be significant. Three studies directly compared the use of irrigation before drainage. A fixed-effects meta-analysis showed a pooled OR of 0.49 (95% CI 0.21–1.14;  $p = 0.10$ ) in favor of irrigation. Two studies evaluated postoperative posture. The available data did not reveal a significant advantage in favor of the postoperative supine posture. Regarding positioning of the catheter used for drainage, it was shown that a frontal catheter led to a better outcome. One study compared duration of drainage, showing that 48 hours of drainage was as effective as 96 hours of drainage.

**Conclusions.** Postoperative drainage has the advantage of reducing recurrence without increasing complications. The use of a bur hole or twist drill does not seem to make any significant difference in recurrence rates or other outcome measures. It seems that irrigation may lead to a better outcome. These results may lead to more standardized procedures. (<http://thejns.org/doi/abs/10.3171/2014.5.JNS132715>)

**KEY WORDS** • chronic subdural hematoma • review • meta-analysis • traumatic brain injury

CHRONIC subdural hematoma (CSDH) is a frequently encountered neurosurgical condition, especially in the elderly, with an incidence of 58/100,000 persons a year in people 70 years of age or older.<sup>21</sup> Although CSDH is one of the most commonly encountered conditions in neurosurgery, no consensus yet exists regarding the optimal surgical technique to treat the CSDH. All surgical strategies aim at decompression of the cerebral hemisphere and to prevent recurrence of CSDH, with minimal morbidity and mortality. Recurrence rates, however, can be high, with reported rates up to 33%.<sup>35</sup> It has already been shown by Santarius et al. that drainage after surgical evacuation of the hematoma likely leads to a better outcome.<sup>28</sup> Besides drainage, other questions

that remain imminent are the use of a regular bur hole or the use of a twist drill, the use of irrigation, the optimal duration of drainage, postoperative posture, and optimal location of the catheter used for drainage. In the available literature, results are inconsistent. In view of the aforementioned factors we aimed to perform an extensive systematic review addressing these issues.

## Methods

### Study Inclusion

A systematic search was performed in MEDLINE, Embase, the Cochrane Central Register of Controlled Trials (CENTRAL, The Cochrane Library 2012, Issue 1), LILACS (Latin American and Caribbean Center on

*Abbreviations used in this paper:* CSDH = chronic subdural hematoma; M-H = Mantel-Haenszel; RCT = randomized controlled trial.

\* Drs. Liu and Bakker contributed equally to this work.

This article contains some figures that are displayed in color online but in black-and-white in the print edition.

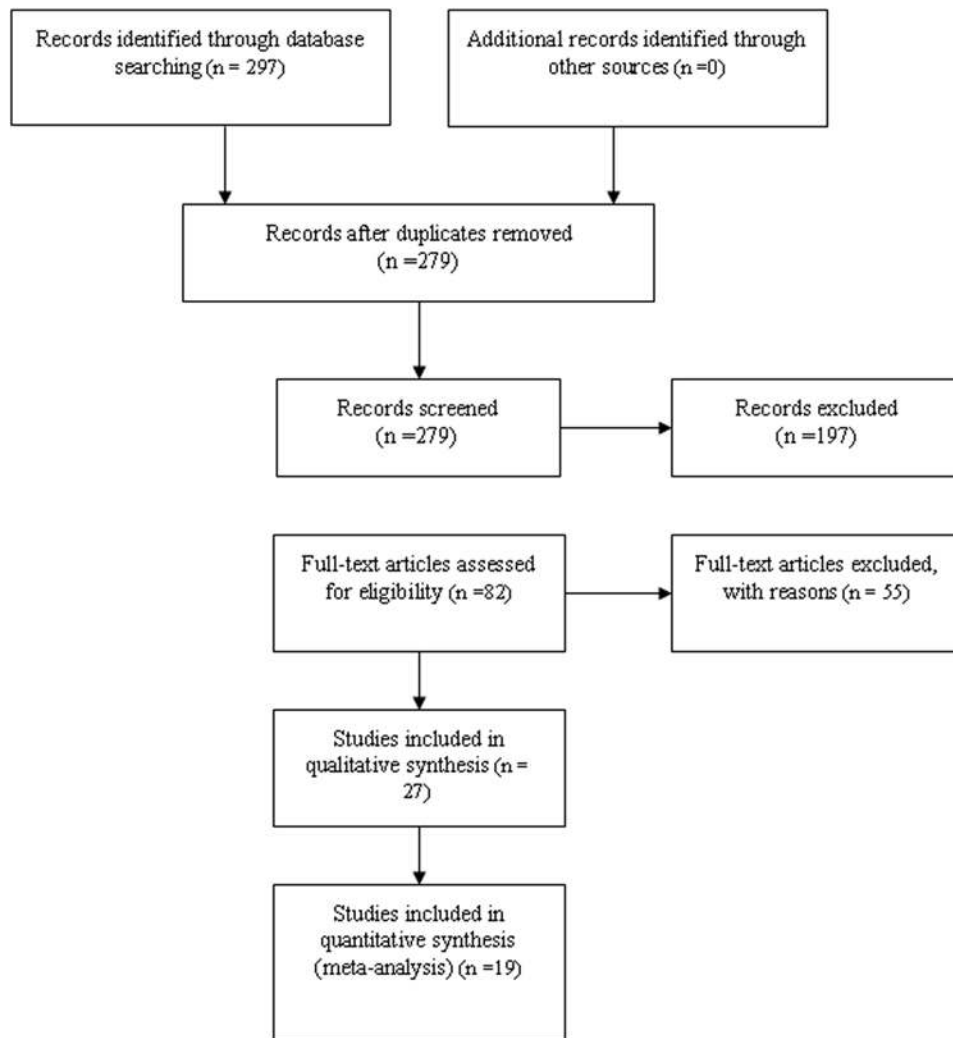


Fig. 1. Flowchart according to the PRISMA statement.

Health Sciences Information), CMB (Chinese Biomedical Database), and Google Scholar. The last search was conducted on December 1, 2013, and went back as far as data were available. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) statement was followed. In addition, references of the included studies were scrutinized for additional studies. The Cochrane Highly Sensitive Search Strategy for identifying randomized trials was used.<sup>9</sup> No language restrictions were applied. The following search terms were used: “chronic subdural hematoma”[All Fields] OR “hematoma, subdural, chronic”[MeSH Terms] OR (“hematoma”[All Fields] AND “subdural”[All Fields] AND “chronic”[All Fields]) OR “chronic subdural hematoma”[All Fields] OR (“chronic”[All Fields] AND “subdural”[All Fields] AND “hematoma”[All Fields]).

After careful evaluation, only RCTs and quasi-RCTs (pseudo-random) were included. Quasi-RCTs were defined as allocation by date of birth, day of the week, medical record number, and month of the year, among others. The included studies at least had to focus on 2 different neurosurgical procedures to treat CSDH: twist drill or

bur hole, drainage or not, irrigation or not, catheter location, duration of drainage, and/or postoperative posture. A bur hole in general leads to a craniostomy opening of approximately 10 mm; a twist-drill craniostomy may be a hole as small as 1 mm up to 5 mm.

#### Outcome Measures

Recurrence rates, complication rates, and outcome including mortality were used as outcome measures. Chronic SDH recurrence was defined as the presence of symptoms attributable to an ipsilateral hematoma and with the presence of a hematoma on a CT scan, within 6 months after the initial surgical procedure. The following conditions were considered to be complications: surgical site infections (subdural empyema, incision infections, and meningitis), infection in other parts of the body (pneumonia, urinary tract infections, and gastrointestinal infections), intracranial hemorrhage independent from CSDH (parenchymal hemorrhage and acute subdural hematoma), seizure, other organ complications (arrhythmia, myocardial infarction, and renal failure), and electrolyte imbalance. Pneumocephalus was not considered a com-

TABLE 1: Characteristics of included studies\*

Authors & Year	Study Type	Included Cases	Follow-Up	Conclusion
twist vs bur hole				
Muzii et al., 2005	RCT	46	2 mos	no significant difference
Horn et al., 2006	quasi-RCT	79	3 mos	no significant difference
Gökmen et al., 2008	RCT	68	6 mos	no significant difference
Singh et al., 2011	RCT	100	1 mo	no significant difference
drainage vs no drainage				
Laumer et al., 1989	RCT	96	3 wks	no significant difference
Wakai et al., 1990	quasi-RCT	38	1 mo	in favor of drainage
Tsutsumi et al., 1997	RCT	138	6 mos	in favor of drainage
Erol et al., 2005	RCT	70	1 mo	no significant difference
Santarius et al., 2009	RCT	215	6 mos	in favor of drainage
Javadi et al., 2011	RCT	40	6 mos	no significant difference
Ahmed et al., 2011	RCT	51	6 mos	no significant difference
irrigation vs no irrigation				
Gurelik et al., 2007	RCT	80	8 mos	no significant difference
Zakaraia et al., 2008	quasi-RCT	82	6 mos	no significant difference
Ishibashi et al., 2011	RCT	92	NR	in favor of irrigation
catheter location				
Nakaguchi et al., 2000	quasi-RCT	63	3 mos	catheter in frontal convexity better than other location
Kaliaperumal et al., 2012	RCT	50	6 mos	subperiosteal better than subdural
drainage duration				
Sindou et al., 2010	RCT	65		48-hr drainage better than 96-hr drainage
postop posture (upright vs supine)				
Nakajima et al., 2002	RCT	46	6 mos	no difference
Abouzari et al., 2007	RCT	84	3 mos	in favor of supine

\* NR = not reported.

plication, in contrast with symptomatic (tension) pneumocephalus, which was considered a complication.

A Glasgow Outcome Scale score<sup>16</sup> of 4–5 or a modified Rankin Scale score of 0–3 was considered a favorable outcome. Operative mortality was defined as any death, regardless of cause, occurring 1) within 30 days after surgery in or out of the hospital or 2) after 30 days during the same hospitalization subsequent to the operation.<sup>17</sup>

#### Selection of Studies

We each independently selected trials for inclusion in the review and cross-checked the outcome data. Two authors (W.L. and N.A.B.) independently extracted and cross-checked the outcome data. Disagreements were solved by discussion.

#### Assessment of Risk of Bias in Included Studies

Two review authors (W.L. and N.A.B.) independently assessed the risk of bias of the included trials according to the Cochrane Handbook for Systematic Reviews of Interventions<sup>9</sup> based on the following 6 domains with the rating of low risk of bias, high risk of bias, and uncertain risk of bias: random sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting, and other bias. Other criteria included the

prognostic balance between the 2 treatment arms and the completeness and length of follow-up (6 months).

#### Statistics: Assessment of Heterogeneity and Reporting Biases in Meta-Analysis

Statistical heterogeneity in each meta-analysis was assessed using the  $T^2$  (tau-squared),  $I^2$ , and chi-square tests. Heterogeneity was considered substantial if  $T^2 > 0$  or  $I^2$  was greater than 30% or in case of a  $p$  value  $< 0.10$  in the chi-square test for heterogeneity. When reporting bias was suspected, we attempted to contact study authors, asking them to provide missing outcome data. When this was not possible and the missing data were considered to introduce serious bias, the impact of these studies in the overall assessment of results was analyzed by a sensitivity analysis. In case of 5 or more studies in a meta-analysis, reporting biases (such as publication bias) were analyzed using funnel plots. Publication bias is defined as the phenomenon in which statistically significant results are more likely to be published and cited. When an unbiased sample of trials performed is studied with a funnel plot, the observed effect sizes should range symmetrically around the true effect size, which will be most accurately estimated by the largest trials, resulting in a symmetrical plot shaped like an inverted funnel.

If enough studies on a specific topic were present, a meta-analysis was performed using Review Manager 5.1 (The Nordic Cochrane Centre, The Cochrane Collaboration, 2011). The DerSimonian-Laird method was used to calculate the summary estimate<sup>4</sup> using the fixed-effect model.

## Results

### Search Results

Overall, the literature searches identified 297 clinical trials addressing CSDH (Fig. 1). Of the titles and abstracts screened, 82 relevant full papers were retrieved and assessed in detail. A total of 27 RCTs and quasi-RCTs were related to CSDH. We excluded 8 RCTs, 1 because of repeated publishing in another language,<sup>12</sup> 1 because not enough data were provided,<sup>6</sup> and 1 because prospectively collected results were compared with historical controls.<sup>22</sup> Four other studies were excluded because different nonsurgical treatments were applied in the control group.<sup>10,20,27,29</sup> Therefore, 19 studies were included in this review (Table 1). Among these trials, 4 compared twist drill with bur hole procedures, 7 compared drainage versus no drainage postoperatively, 3 compared irrigation versus no irrigation, 2 compared catheter location, 2 compared postoperative posture, and 1 compared duration of drainage.

### Assessment of Risk of Bias of the Included Studies

Details of assessment of risk of bias in included studies are shown in Fig. 2. Although some trials were declared randomized, their random sequence generation and allocation concealment were not clear. If the study was not complete—length of follow-up was less than 6 months or important data (such as recurrence, complications, outcome, and mortality) were not present—this study was considered incomplete regarding outcome data.

### Postoperative Drainage

Seven trials compared drainage versus no drainage after a bur hole procedure. Three of them concluded the use of drainage to be superior.<sup>28,34,35</sup> The other 4 trials did not identify significant differences in outcome.<sup>2,5,15,23</sup> In all 7 trials, reoperation rates were considered recurrence rates. However, indications for reoperation were different. Laumer et al.<sup>23</sup> defined recurrent CSDH as either worsening of neurological symptoms or hematoma increase on CT. The other 6 trials used the presence of both worsening of neurological symptoms and hematoma increase on CT as an indication for reoperation. As such, the study by Laumer et al. was excluded from the analysis. The study by Erol et al.<sup>5</sup> used a follow-up of 1 month; the other 5 trials had a follow-up of 6 months.

These 6 trials included 523 patients. There were 23 cases of recurrent CSDH among 273 patients (8.4%) with a closed drainage system in contrast with 54 cases of recurrence CSDH of 259 patients without a closed drainage system (20.8%). A fixed-effects meta-analysis showed a pooled OR of 0.36 (95% CI 0.21–0.60;  $p < 0.001$ ), indicating a significant benefit for the use of a closed drainage

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Abouzari 2007	?		+	+	-	+	+
Ahmed 2011	+		+	+	+	+	+
Erol 2005			+	+	-	+	+
Gökmen 2008	+		+	+	+	+	+
Gurelik 2007	?		+	+	-	+	+
Horn 2006	-	-	+	+	-	+	+
Ishibashi 2011			+	+	-	+	+
Javadi 2011			+	+	+	+	+
Kaliaperumal 2012			+	+	+	+	+
Laumer 1989			+	+	-	+	+
Muzii 2005			+	+	-	+	+
Nakaguchi 2000	-	-	+	+	-	+	+
Nakajima 2002			+	+	+	+	+
Santarius 2009	+	+	+	+	+	+	+
Sindou 2010	+		+	+		+	
Singh 2011			+	+	-	+	+
Tsutsumi 1997	+		+	+	+	+	+
Wakai 1990	-		+	+	-	+	+
Zakaraia 2008	-		+	+	+	+	+

FIG. 2. Risk of bias summary showing our judgments about each risk of bias item for each included study. Green plus sign = low risk; red minus sign = high risk; yellow question mark = not reported; blank = unclear risk.

system (Fig. 3A). There was no indication of heterogeneity between the results of the different trials ( $p = 0.42$ ;  $I^2 = 0\%$ ). A funnel plot was used to test for publication bias in our meta-analysis. Figure 4 shows that the trials in meta-analysis seem approximately symmetric in both analyses.

The study by Tsutsumi et al.<sup>34</sup> did not report complications, while Wakai et al.<sup>35</sup> reported complications with-



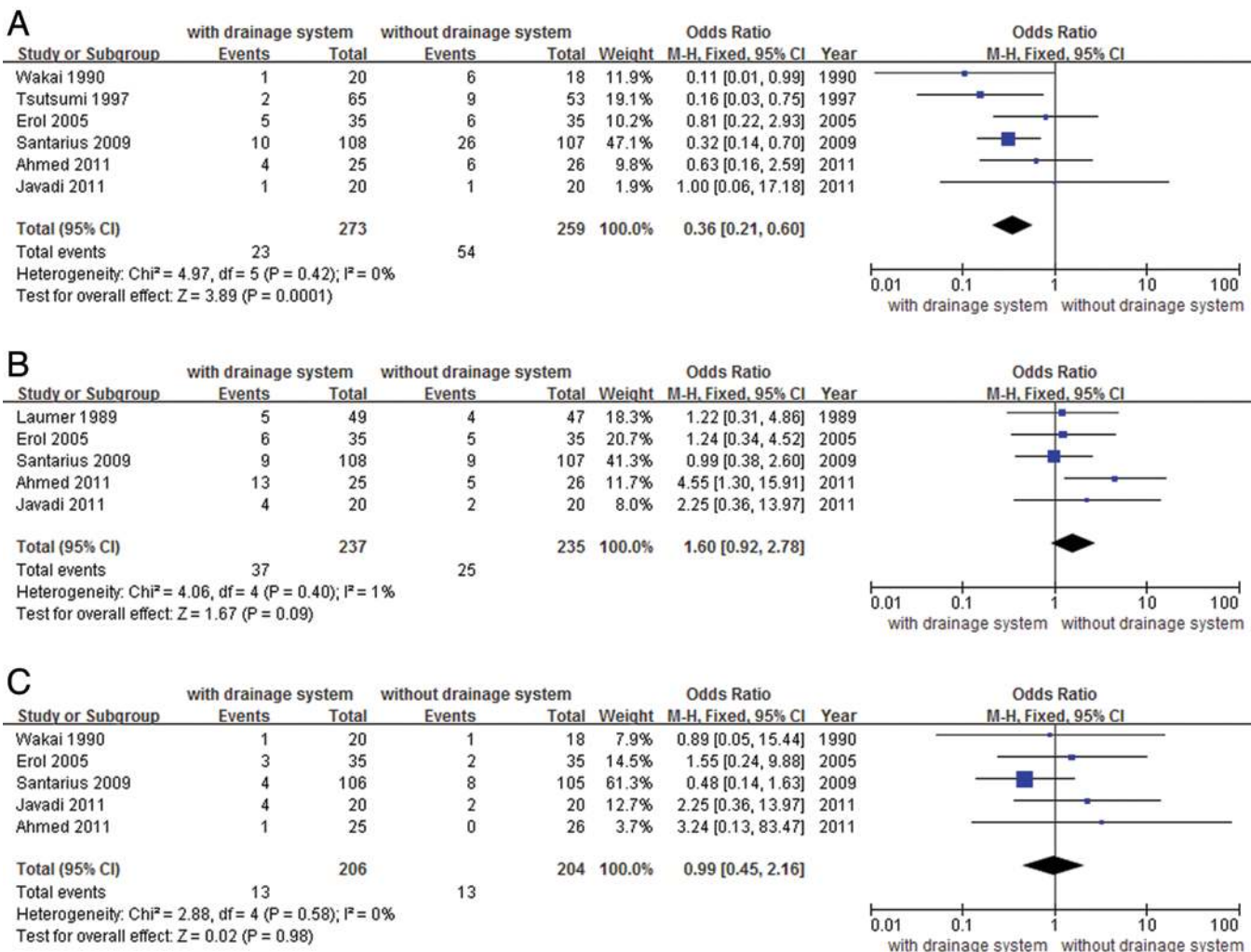


FIG. 3. Summary of the meta-analysis comparing the use of a closed drainage system in relation to recurrence of CSDH (A), complications (B), and mortality (C). Each horizontal line represents results of a single study. The square marks the OR estimate for the study and the size of the square is proportionate to the weight given to the information from the trial. The left and right end-points of the horizontal line mark the ends of the CI for the individual trial's OR estimate. In panel A, the diamond represents the pooled estimate from the meta-analysis; its center lies on the left side, showing significant difference between 2 groups ( $p < 0.001$ ).

out subgroup information. The other 5 studies were analyzed regarding complication rates. These 5 trials included 472 patients. There were 37 complications among 237 patients (15.6%) with drainage system compared with 25 complications among 235 patients (10.6%) without drainage. A fixed-effects meta-analysis showed a pooled OR of 1.60 (95% CI 0.92–2.78;  $p = 0.09$ , Fig. 3B). No indication of heterogeneity between the results of the different trials was present ( $p = 0.40$ ;  $I^2 = 1\%$ ).

Five studies (a total of 410 patients) could be analyzed for mortality. No significant differences were noted ( $p = 0.98$ , Fig. 3C). Outcome could not be analyzed because of different outcome measures and follow-up times of the included studies.

#### Bur Hole Versus Twist Drill

Four trials compared bur hole with twist drill procedures in CSDH (293 patients in total). Among these 4 studies, the twist procedures were different. Singh et al.<sup>32</sup>

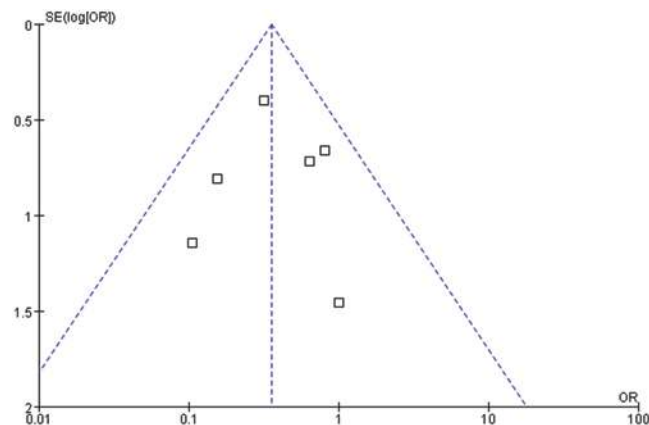


FIG. 4. A funnel plot evaluating publication bias in comparing with or without a closed drainage system in relation to recurrence of CSDH. The plot shows that the 6 included RCTs in this meta-analysis seem approximately symmetrically ranged around the overall effect size estimate, shown by the dashed line in the center.

TABLE 2: The procedural differences among studies comparing twist drill and bur hole craniostomy

Authors & Year	Type	No. of Cases	Procedure					
			Type of Anesthesia	No. of Holes	Irrigation	Catheter	Drainage System	Drainage Time
Gökmen et al., 2008	twist	37	local or general	1	no	12-Fr drain catheter	bagged soft drains	remove 2nd day of surgery
	bur hole	31	local or general	1	yes	12-Fr drain catheter	bagged soft drains	remove 2nd day of surgery
Horn et al., 2006	twist	55	NR	1	yes	ventriculostomy catheter	NR	blood adequately drained (on CT)
	bur hole	24	NR	1	yes	ventriculostomy catheter	NR	blood adequately drained (on CT)
Muzii et al., 2005	twist	22	local	1	no	subdural expansion catheter	100-ml suction reservoir	drainage ceased, average 65.3 hrs
	bur hole	24	local	1 or 2	yes	a catheter	50 cm below head	drainage ceased average 34.8 hrs
Singh et al., 2011	twist	48	local	2	yes	ventricular catheter	NR	NR
	bur hole	52	local	2	yes	ventricular catheter	NR	NR

used 2 twist holes for drainage, Muzii et al.<sup>24</sup> used 1 or 2 twist holes, and the other 2 trials used only 1 twist hole. Gökmen et al.<sup>7</sup> and Muzii et al.<sup>24</sup> did not use saline irrigation after twist hole procedures, while the other 2 trials did use irrigation. Three of 4 trials used a ventriculostomy catheter for drainage, while Muzii et al.<sup>24</sup> used a subdural expansion catheter. Drainage time was also different: Gökmen et al.<sup>7</sup> removed the catheter on the 2nd day after surgery, while Muzii et al.<sup>24</sup> and Horn et al.<sup>11</sup> removed the catheter when draining stopped. Singh et al.<sup>32</sup> did not report on drainage time. The study by Horn et al.<sup>11</sup> did not meet our predefined criteria for a clear definition of recurrence of hematoma. As such, this study was not used for the quantitative analysis. The procedural differences among included studies are shown in Table 2.

Because studies did not have a uniform operative procedure, study heterogeneity was analyzed, showing significant heterogeneity ( $p = 0.11$ ,  $I^2 = 54\%$ ). As such, Mantel-Haenszel (M-H) random models were used to analyze recurrence rates between the 2 groups. The meta-analysis showed a pooled OR of 0.76 (95% CI 0.26–2.25;  $p = 0.62$  [Fig. 5A]). Outcome was also defined in distinct ways among the included studies, leading to significant heterogeneity ( $p = 0.20$ ;  $I^2 = 36\%$ ). Using M-H random models, a pooled OR of 1.10 (95% CI 0.60–2.00;  $p = 0.76$ ) was observed (Fig. 5B). Regarding mortality, study heterogeneity was acceptable ( $p = 0.28$ ,  $I^2 = 21\%$ ). The meta-analysis showed a pooled OR of 1.38 (95% CI 0.55–3.43;  $p = 0.49$  [Fig. 5C]). Complication rates could not be analyzed because too little information was provided in the studies included.

#### Irrigation During the Operative Procedure

Three of the included studies addressed irrigation during the procedure.<sup>8,13,37</sup> These trials compared recurrence rates between studies using drainage with and without irrigation. Data on complications, outcome, and mortality were not available for analysis. These 3 trials

included 254 patients. There were 9 recurrences among 112 patients (8.0%) in the irrigation group compared with 20 recurrences among 142 patients (14.1%) in the drainage without irrigation group. A fixed-effects meta-analysis showed a pooled OR of 0.49 (95% CI 0.21–1.14;  $p = 0.10$  [Fig. 6]).

#### Postoperative Posture

Abouzari et al.<sup>1</sup> compared supine and sitting positions for 3 days postoperatively in a study with 84 patients. After follow-up of 3 months, the recurrence rate was 2.3% in the supine position group compared with 19.0% in the sitting position group. However, only 1 patient (1 [12.5%] of 8 total patients in whom there were recurrences) needed a reoperation. According to definitions used in this review, only this case is considered a recurrence. Nakajima et al.<sup>26</sup> did not find differences between postoperative positions. When analyzing the trials together, heterogeneity was acceptable ( $p = 0.49$ ;  $I^2 = 0\%$ ), with a pooled OR of 0.86 (95% CI 0.21–3.48;  $p = 0.83$  [Fig. 7]).

#### Position of Draining Catheter

Two studies focused on the position of the catheter used for drainage. One trial was performed by Nakaguchi et al.<sup>25</sup> The authors observed significantly fewer recurrences when the tip of the drain was placed in a frontal position (5% recurrences) compared with the temporal (33% recurrences), occipital (36% recurrences), or parietal (38% recurrences) position in a study with 63 patients. Another trial was performed by Kaliaperumal et al.<sup>18</sup> In this prospective randomized study including 50 patients, 2 types of drainage were compared: subperiosteal drainage and subdural drainage following bur hole. No significant differences were detected.

#### Duration of Drainage

One trial including 65 patients could be included to

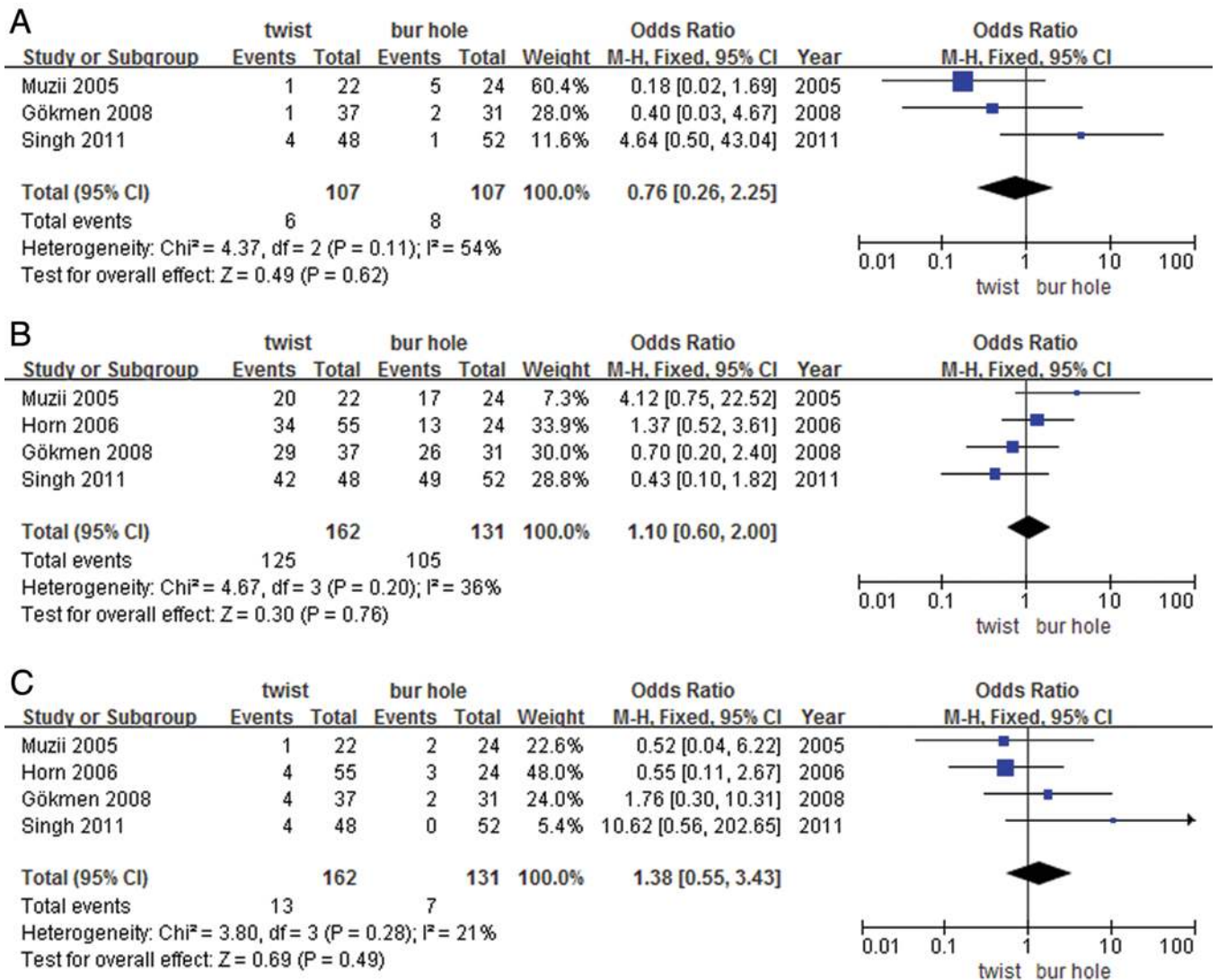


FIG. 5. Summary of the meta-analysis comparing the use of a bur hole versus a twist drill in relation to recurrence of CSDH (A), outcome (B), and mortality (C).

address the question of duration of drainage.<sup>31</sup> Using a twist drill technique with closed-system drainage, the duration of drainage was compared: 48 hours versus 96 hours. The rate of recurrence and outcome did not dif-

fer significantly. The postoperative complication rate was 26.9% in the 96-hour group and 10.7% in the 48-hour group, with mortality rates of 11.4% and 3.8%, respectively ( $p < 0.001$ , data not shown).

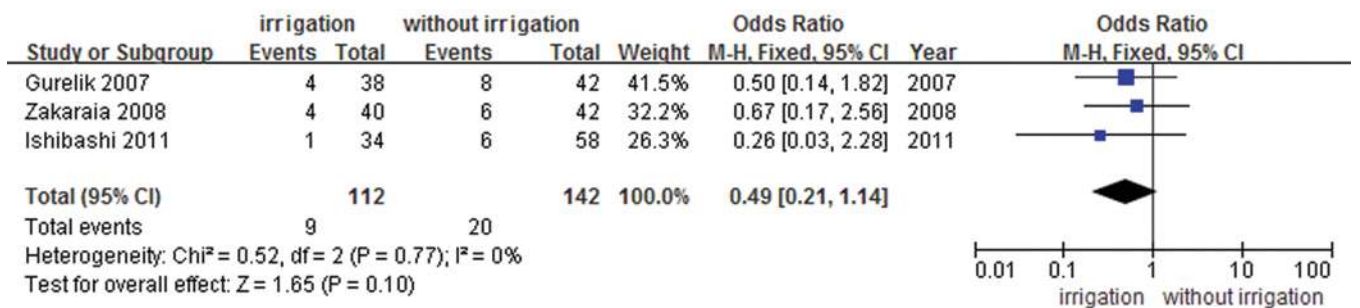


FIG. 6. Summary of the meta-analysis comparing the use of irrigation versus no irrigation in relation to recurrence of CSDH. The diamond represents the pooled estimate from the meta-analysis; its center lies on the left side, and it crosses the vertical line, showing no significant difference between the 2 groups ( $p = 0.10$ ). There was no indication of heterogeneity between the results of the different trials ( $p = 0.77$ ;  $I^2 = 0\%$ ).



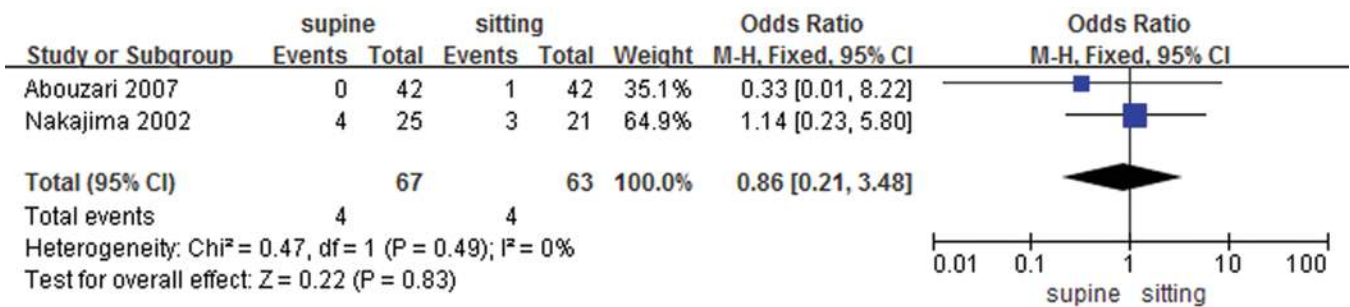


Fig. 7. Summary of the meta-analysis comparing the postoperative posture (supine vs sitting) in relation to recurrence of CSDH. The diamond represents the pooled estimate from the meta-analysis; its center lies on the left side, and it crosses the vertical line, showing no significant difference between the 2 groups ( $p = 0.83$ ). There was no indication of heterogeneity between the results of the different trials ( $p = 0.49$ ;  $I^2 = 0\%$ ).

## Discussion

In recent years, a significant number of controlled trials were performed on different aspects of the surgical treatment of CSDH. Also, some meta-analyses were performed;<sup>3,36</sup> however, some questions on optimal treatment remain. As such, we aimed to perform a systematic review and meta-analysis of the available literature in a modern fashion, using the PRISMA statement, to provide clarity regarding the evidence for different aspects of surgical procedures to treat CSDH. In the present meta-analysis, it is clearly shown that postoperative drainage is useful in the treatment of CSDH. Drainage reduces recurrence by approximately 60%, without an increase in complications and mortality. This is consistent with most neurosurgeons' experience in everyday clinical practice. As such, postoperative drainage should be recommended in the treatment of CSDH. Whether irrigation should be performed prior to postoperative drainage is less clear; recurrence rates were 8.0% in the irrigation group and 14.1% in the irrigation-free group ( $p = 0.10$ ). Although not significant, there was a trend in favor of irrigation. This makes sense in our opinion as this provides a washout of blood products and other factors possibly involved in maintaining the hematoma. In this respect, it has been shown that the hematoma fluid contains high concentrations of coagulation factors (plasminogen activator)<sup>14</sup> and inflammatory factors (vascular endothelial growth factor),<sup>33</sup> and both factors are shown to be predictive of recurrence.<sup>19,30</sup> These mechanisms remain speculative, however.

There seemed to be no differences in results using a twist drill or a burr hole for hematoma drainage. It seems that the holes on the skull, being 5 mm (twist) or 10 mm (burr hole), are both sufficient for adequate drainage of the hematoma fluid.

Regarding postoperative posture, no definitive conclusions can be drawn from this review. Additional comparative studies are needed to find evidence in favor of one of the positions. Catheter location was only investigated by 2 studies. Although no overall differences were detected between subperiosteal drainage and subdural drainage, it was clearly shown that in case of subdural drainage, the catheter tip should be placed in the frontal position. Only 1 study investigated optimal drainage duration; it was shown that 48 hours of drainage instead of 96 hours led to

significantly fewer complications. It is unclear, however, whether a shorter drainage time would also suffice.

Some limitations of this review have to be mentioned. Some of the included trials are quasi-(pseudo) RCTs, in which allocation took place by medical record number or the order of operation. Most of the studies did not report on random sequence generation and allocation concealment. Also, follow-up among the investigated trials varied. Unfortunately, in almost half of the included studies follow-up time was rather short, precluding us from drawing firm conclusions on outcome. Also, differences in recurrence and outcome criteria were present among studies, making it difficult to evaluate the results in a standardized way.

## Conclusions

This review clearly demonstrates the benefit of postoperative drainage after treatment of CSDH. The use of irrigation seems to be beneficial, while both a twist drill and a burr hole seem to be reliable treatment options. As such, more studies addressing irrigation, duration of drainage, and postoperative position with uniform follow-up times of at least 6 months are needed.

## Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Groen, Liu. Acquisition of data: Liu. Analysis and interpretation of data: Liu, Bakker. Drafting the article: Liu, Bakker. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Statistical analysis: Liu. Study supervision: Groen.

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Address correspondence to: Rob J. M. Groen, M.D., Ph.D., Department of Neurosurgery AB71, University Medical Center Groningen, P. O. Box 30.001, Groningen 9700 RB, the Netherlands. email: r.j.m.groen@umcg.nl.