REVIEW ARTICLE
SURGICAL TREATMENT OPTIONS FOR CHRONIC SUBDURAL HAEMATOMA

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Subdural hematoma is an encapsulated collection of blood under the dura matter. This commonly encountered neurosurgical disorder is best managed by surgical evacuation; however, contemporary neurosurgery lacks a consensus regarding surgical technique of choice. Due to high incidence of the condition and associated complications, vast amount of literature is available on the subject; including studies comparing efficacy of various available treatment modalities. Herein, literature on surgical techniques employed for management of Chronic Subdural Hematoma (CSDH) has been reviewed to provide an evidence-based review on best surgical practices. Following conclusions can be made on basis of evidence of various levels provided in the studied literature: (1) Twist-drill craniostomy is a relatively safe technique that can be employed under local anaesthesia, thus can be considered as first line treatment in high risk surgical candidates. (2) Single and double burr-hole craniostomies have shown comparable results. (3) Intraoperative irrigation during burr-hole craniostomy doesn’t affect outcome. (4) Drain insertion after hematoma evacuation lowers recurrence risk. (5) Position of drain is not significant but early drain removal is associated with higher recurrence rates. (6) Craniotomy is associated with high morbidity and mortality, hence should be reserved for recurrent and large septate hematoma cases. (7) Head elevation in postoperative period reduces recurrence. (8) Embolization of middle meningeal artery (EMMA): A novel treatment modality, is promising but requires further approval in terms of large sample sized multicenter randomized control trials. In conclusion further research is required on the subject to formulate guidelines regarding management of this common neurosurgical emergency.

Keywords: Chronic Subdural Haematoma, SDH, Management, Complications

INTRODUCTION
Chronic subdural haematoma (CSDH) is an abnormal collection of liquefied degraded blood beneath the dura mater, which results in brain tissue compression and subsequent neurological sequel. Virchow first described “pachymeningitis haemorrhagica interna”. In the beginning it was considered fatal disorder but with new research advancement in technology and better understanding of pathology the outcome has improved. CSDH is a commonly encountered problem of elderly population with an incidence of 3 per 100,000. Wide spread availability of computed tomography scanners, in addition to advancement in technology has led to increase in diagnosis of the condition.

Surgical evacuation of CSDH is the cornerstone of management, but there lack consensus among neurosurgeons regarding surgical technique. Surgical options range from least invasive as endoscopic for older patients with multiple comorbidities to highly invasive such as craniotomy. These procedures vary in efficacy, invasiveness, cost effectiveness and perioperative risk to the patient. The author tried to summarize most practical recommendations.

MATERIAL AND METHODS
The author reviewed literature on CSDH management from past to present. Manuscript was searched online on PubMed and Google Scholar.

MANAGEMENT OF CHRONIC SUBDURAL HAEMATOMA

Surgical treatments options:
Surgical evacuation of CSDH is indicated for symptomatic patients or collections exerting mass effects. The most commonly used surgical approaches include Twist-drill craniostomy (TDC), Burr-hole craniostomy (BHC) and craniotomy.

Twist drill craniostomy:
Twist-drill craniostomy is opening of the skull up to a diameter of 5mm. A retrospective study by Wang et al involving a modified TDC technique, using a novel device: The YL-1 puncture needle, included 121
patients with CSDH who underwent surgery. 68 patients were treated by modified TDC and 53 patients by BHC. In patients who underwent modified TDC, complication rate was significantly lower than that in those who underwent BHC (p=0.021and p<0.001 respectively). While recurrence and reoperation rates in patients from the two groups didn’t differ significantly (p=0.566 and p<0.715). Duration of hospital stay in patients who underwent TDC was significantly shorter compared to those who underwent BHC (both p<0.001).² Weigel et al in their evidence based review found that recurrence rate after TDC (33%) was significantly higher than that noted after BHC (12.1%) or craniotomy (10.8%), with p<0.001 (1 class II and 4 class III evidence publications on TDC; 3 class II and 23 class III evidence publications onBHC). However it is relatively a safe bedside procedure under local anesthesia in patients unfit for general anesthesia.¹ In a systematic review and meta-analysis by Almenawer et al, analysis of 10 higher qualities observational studies revealed no statistical difference incur (RR, 1.05; 95% CI,0.98-1.11;I²=70%; p=0.15), morbidity (RR,0.45; 95% CI,0.98-1.11; I²=63%; p=0.05), mortality (RR,0.69; 95% CI,0.46-1.05; I²=0%; p=0.09), recurrence rate (RR,1.95; CI,0.66-1.52; I²= 49%; p=0.99) between TDC and BHC.³ Teles et al in their pooled analysis of five articles found no statistically significant difference in recurrence rate between TDC and BHC (OR,0.99; 95% CI,0.53; p=0.97).⁴

Author concludes that bedside TDC is relatively safe and can be the first line management option for high risk surgical candidates in non-septate CSDH, as it can be performed under local anaesthesia.

<table>
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<tr>
<th>Author</th>
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<th>Objective</th>
<th>Conclusion</th>
<th>OR (95% CI)</th>
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<tr>
<td>Wang et al</td>
<td>2016</td>
<td>To compare twist-drill craniostomy and burr-hole craniostomy</td>
<td>Recurrence and reoperation rates in both groups were similar.</td>
<td>p=0.566 and p=0.715, respectively.</td>
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<td>Rates of complication and pneumocrania in patients who underwent the modified TDC were significantly lower than BHC group.</td>
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<td>p=0.021 and p&lt;0.001 respectively.</td>
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<td>Weigel et al</td>
<td>2003</td>
<td>To evaluate the results of surgical treatment options for chronic subdural haematoma in contemporary neurosurgery according to evidence-based criteria.</td>
<td>Recurrence rate of TDC was greater than BHC or craniotomy.</td>
<td>OR,3.6; 95% CI, 2.8-4.5; p&lt;0.001</td>
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<td>No statistical difference in cure, morbidity, mortality or recurrence.</td>
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<td>1.05 (0.98-1.11) p=0.15, 0.45 (0.2-1.01) p=0.05, 0.69 (0.46-1.05) p=0.09, 1.06 (1.6-1.52) p=0.99</td>
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<td>Almenawer et al</td>
<td>2014</td>
<td>To compare the efficacy and safety of multiple treatment modalities for the management of CSDH patients.</td>
<td>No statistically significant difference in recurrence rate of TDC vs BHC.</td>
<td>OR,0.99; CI, 95% CI, 0.53; p=0.97</td>
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<td>Teles et al</td>
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<td>To assess the effects of different surgical techniques and postoperative care on recurrence of CSDH.</td>
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Burr-hole craniostomy:
Burr-hole craniostomy is opening of skull upto 30mm.¹ BHC is one of the most commonly practiced procedure for treatment of CSDH.⁵⁻⁸

Number of Burr-holes:
The number of burr holes (one versus two) that are required to drain CSH and to minimize the risk of recurrence of CSH remains controversial among neurosurgeons.⁹,¹⁰ A study by Taussky et al assessed number of burr holes as predictor for recurrence, they concluded that treatment of CSDH with one burr hole is associated with significantly (p<0.05) higher recurrence rate (29% vs 5%), higher wound infection rate (9% vs 0%) and longer duration of hospital stay (11 vs 9 days).¹⁰ A systematic review and meta-analysis by Teles RA found evacuation of haematoma by 2 BHC slightly superior to single burr hole (OR:0.58, 95% CI: 0.37, p=0.01).⁴

Meta-analysis by Belkhair S shows no significant difference in revision rates between double burr hole (DBHC) and single burr hole craniotomy (SBHC) in evacuating CSDH (OR,0.62; 95% CI, 0.26-1.46).¹¹ Meta-analysis by Almenawer et al pooled data of 94 cohorts which showed no difference in recurrence rates related to number of burr holes (RR,1.15; 95% CI, 0.94-1.37; I²=88.2%; p=0.62).³ Wan et al meta-analysis showed SBHC did not increase the risk of recurrence compared with DBHC (OR,1.28; CI, 95% CI, 0.92; p=0.07). DBHC was not associated with increased complication rate (OR,0.74, CI, 95% CI, 0.20, p=0.11) or increased mortality rate (OR,0.74; 95% CI, 0.55; p=0.58) compared to SBHC in patients with CSDH.¹²

Author concludes that there is no statistical difference between SBHC and DBHC.
Irrigation or no irrigation:

BHC can be done with or without intraoperative irrigation. Liu et al in their fixed-effects meta-analysis showed results in favour of irrigation (OR, 0.49; 95% CI, 0.21; p=0.10). Suzuki and associates found no significant difference in recurrence rate (OR, 1.13; 95% CI, 0.20). In a series by Kuroki’s et al, recurrence rate was 1.8% without irrigation and 11.1% with irrigation, the difference was not statistically significant (OR, 6.88; 95% CI, 0.77; p=0.049). Teles et al in their meta-analysis found no difference between two treatment groups: irrigation vs no-irrigation, concerning recurrence rates (OR, 1.54; 95% CI, 0.56; p=0.40). Xu et al concluded that irrigation is not necessary for all patients (OR, 1.17; 95% CI, 0.61–2.25). Weigel et al have type C recommendations regarding irrigation.

Author	Year	Objective	Conclusion	OR (95% CI)
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Liu et al	2014	To systematically evaluate the results of different surgical procedures for chronic subdural hematoma. Irrigation may lead to a better outcome. OR, 0.49; 95% CI, 0.21; p=0.10
Suzuki et al	1998	To determine whether irrigation influences recurrence rate. Recurrence of CSDH is not influenced by irrigation. OR, 1.13; 95% CI, 0.20
Kuroki et al	2001	To comparatively study the recurrence rate of CSDH after two treatment modalities. Strict closed system drainage has excellent outcome compared to closed-system drainage with irrigation. OR, 6.88; 95% CI, 0.77; p=0.049
Teles et al	2016	To assess the effects of different surgical techniques and postoperative care on recurrence of CSDH. No significant difference OR, 1.54; 95% CI, 0.56; p=0.40
Xu et al	2015	To determine whether irrigation or drainage is necessary for achieving a lower revision rate for the treatment of chronic subdural hematoma (CSDH) using burr-hole craniostomy (BHC) No significant difference OR, 1.17; CI95%, 0.61–2.25

Drainage or no drainage:

Weigel et al in their review recommended use of drains; Type B and C recommendations. Wakai et al had significantly fewer recurrences with drainage (5% vs 33%). Markwalder et al in their series of 21 patients noticed progressive improvement in those with drains compared to those without drains. Results of Cambridge chronic subdural haematoma trial showed decreased recurrence rate at 6 month in drain group (9.3%) vs non-drain group (24%), also lower mortality in drain group both at 30 days (3.7%) and at 6 month interval (8.6%) compared to no-drain group which showed 7.6% mortality at 30 day and 18.1% at 6 month interval. Meta-analysis by Almenawer of 5 randomized trials showed significant reduction in recurrence rates when drains were inserted following haematoma evacuation (RR, 0.46; 95% CI, 0.27–0.76; P=34%; p=0.002). Meta-analysis by Teles et al demonstrated that use of drains reduces risk of recurrence (OR, 0.41; 95% CI, 0.23–0.74; p=0.003). Peng et al in their meta-analysis noticed significant reduction in recurrence risk with use of subdural drains. Liu et al meta-analysis favours use of post-operative drainage system (OR, 0.36; 95% CI, 0.21–0.60). Alcala-cerra et al meta-analysis found statistically significant reduction in the risk of symptomatic recurrence (OR, 0.5; CI95%, 0.36–0.75), reoperation (OR, 0.5; CI95%, 0.34–0.74) and poor functional outcome (OR, 0.61; CI95%, 0.39–0.98).

Author concludes that use of drainage reduces recurrence risk.
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<td>The use of drains following CSDH drainage resulted in significant decrease in recurrence.</td>
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<td>care on recurrence of CSDH.</td>
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<td>Peng et al</td>
<td>2016</td>
<td>To assess the effects and safety of use of external drains versus no drains</td>
<td>Significant reduction in the risk of recurrence with subdural drains</td>
<td>OR, 0.45; 95%CI, 0.32-0.61</td>
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<td>Alcala-Cerra et al</td>
<td>2014</td>
<td>To determine the effect of a subdural drain after burr-hole evacuation on</td>
<td>Statistically significant reduction in the risk of symptomatic recurrence, reoperation and poor functional outcome</td>
<td>Symptomatic recurrence: (OR, 0.51; 95%CI, 0.36-0.75), Reoperation: (OR, 0.5; 95%CI, 0.34-0.74), Poor functional outcome: (OR, 0.61; 95%CI, 0.39-0.98)</td>
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<td>symptomatic recurrence, reoperation, poor functional outcome, mortality</td>
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<td>and post-operative complications</td>
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**Position of drain:**
Nakaguchi et al studied relationship between catheter location and postoperative recurrence of chronic subdural. They noticed results were better when the tip of the drain was in a frontal position (5% recurrences) than in a temporal (33% recurrences), occipital (36% recurrences), or parietal position (38% recurrences). As mentioned by authors catheter was placed blindly intraoperatively; however, catheter positioned was checked post-operatively.22 Yamamoto et al retrospective chart review demonstrated that the position of drain was not related to recurrence (10/94 frontal, 1/11 others; p=0.874).23 Bae et al retrospectively reviewed 312 patients with TDC and drainage system, and noticed no difference in recurrence with respect to drain location (frontal 24% vs parietal 21%).24 Author concludes that position of drain tip has relation to recurrence.

**Duration of drainage:**
Yu et al performed a retrospective study in 100 patients undergoing single BHC with irrigation and drainage. The criteria for drainage system removal was brain re-expansion evident on CT or when drainage ceased. Recurrence rates of 3 groups according to duration of drainage was analyzed. They noticed recurrence rate of 16.3% in <72 hours, 2% in 72-119 hours and no recurrence in >120 hours. Bivariate analysis demonstrated statistically significant difference in groups (p=0.007); where early drain removal resulted in higher recurrence rate.25 Author concludes that early removal of drain is associated with recurrence.

**Craniotomy:**
Craniotomy is opening of the skull greater than 30 mm.1 Until mid-1960 craniotomy was most commonly practiced technique for the treatment of CSDH.26 In organized or calcified CSDH, craniotomy seems to be a better option than BHC. Markwalder recommended craniotomy for solid haematoma, recurrent CSDH or in cases where brain fails to re-expand.27 Meta-analysis by Almenawer et al confirms that craniotomy was associated with lower secondary recurrence rates (RR, 0.22; 95%CI, 0.05-0.85; I² = 0%; p=0.003).3 Tanikawa et al reported craniotomy an effective treatment option for CSDH with multilembranes.28 Weigel et al suggested craniotomy as second line treatment option due to high morbidity and mortality rates in comparison to TDC and BHC.1 Teles et al in their meta-analysis found no statistical difference in recurrence rate when compared craniotomy and BHC (OR, 1.23; 95%CI, 0.78; p=0.36).4 A retrospective review of consecutive mini-craniotomies for CSDH patients by Van Der Veken and colleagues highlighted its technical superiority over BHC.29 Mahmood et al in their study of mini-craniotomy under local anesthesia noticed overall significantly lower recurrence rate (2.86%) compared with international data on BHC (4.6–16%) and other surgical options (14.6%).30 Author concludes craniotomy should be reserved for cases with recurrence or large septated haematomata due to its association with high mortality and morbidity.
Postoperative posture:
Nakajima et al compared flat head position versus elevated head position in postoperative period. They reported that percentage of patients with reformation of subdural collection was higher in the patients with flat head position. Similar findings were noted by Ishaq and colleagues. Abourazi et al reported increased incidence of re-accumulation of subdural collections among patients with flat head position. Teles et al in their meta-analysis demonstrated that there is no statistically significant difference between two post-operative patient positions regarding recurrence after BHC for CSDH. Author concludes that elevated head position has better outcome in term of recurrence.

Embolization of middle meningeal artery:
Embollization of middle meningeal artery (EMMA) with or without trephination is new effective method. Meta-analysis and systematic review by Aditya et al found significantly lower recurrence rate in embolized group compared with conventional group, i.e., 2.1% vs 4.4% (OR, 0.087; 95% CI, 0.026-0.292; p<0.001; I²=0%) [35]. EMMA interrupts blood supply to the membrane and prevents haematoma enlargement however it ceases to prevent recurrence. Jummah et al meta-analysis concluded that EMMA has high success rates in patients with refractory or chronic SDH, with minimal complication rate. It showed treatment failure to be 2.8% (95% CI, 0.5%--5.2%; I²= 0%), need for surgical rescue 2.7% (95% CI, 0.4%--5%; I²=0%), and embolization-related complications 1.2% (95% CI, 0.4%--2.7%; I²=0%) in comparison to non-embolized group. Kim et al in their study noticed decrease in recurrence (OR, 0.04; 95% CI, 0.01-0.27) and complication rate (OR, 0.15; 95% CI, 0.01-2.53) in group of patients treated by EMMA alongside surgery compared to the group with surgery alone. Similar findings were noticed by Shotar et al: recurrence rate (OR, 0.29; 95% CI, 0.10-0.88) and complication rate (OR, 0.68; 95% CI, 0.24-1.95). Ban et al noticed decrease in recurrence rate (OR, 0.10, 95% CI, 0.01-0.88) in group with EMMA but on the other hand these patients had higher complication rate(OR, 1.50; 95% CI, 0.36-6.95). Ng et al noticed better results in group treated with surgery alone compared to patients treated with EMMA: recurrence rate (OR, 1.17; 95% CI, 0.07-20.02).

Author concludes EMMA as a promising treatment option which needs large sample size, multicenter randomized control trails.
CONCLUSION

Surgical treatment options for CSDH range from minimally invasive to open procedure like craniotomy. Twist-drill and burr-hole craniostomy are both efficacious in treating CSDH. Drainage placement improves outcome and lower the recurrence rate. Postoperative posture; elevated head lowers the risk of recurrence. Craniotomy is a major procedure largely reserved for recurrent cases or cases with large septate haematoma. EMMA is a new and promising treatment option but it needs further evaluation.

REFERENCES

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