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

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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.[1] 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 wassearched 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 cranostomy is opening of the skull up to a diameter of 5mm.[1]

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=0.021*and* p<0.001respectively). While recurrence and reoperation rates in patients from the two groups didn't differ significantly (p=0.566and p<0.715). Duration of hospital stay in patients who underwent TDC was significantly shorter comparison 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 systemic 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;I^2=70%; p=0.15),morbidity (RR,0.45;95% CI,0.98-1.11; I^2=63%; p=0.05),mortality (RR,0.69; 95%CI,0.46-1.05; I^2=0%; p=0.09), recurrence rate (RR,1;95%CI,0.66-1.52; I^2=49%; p=0.99) between TDCand 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.

Author	Year	Objective	Conclusion	OR (95%CI)
Wang *et al*	2016	To compare twist-drill craniostomy and burr-hole craniostomy	Recurrence and reoperation rates in both groups were similar. Rates of complication and pneumocrania in patients who underwent the modified TDC were significantly lower Than BHC group.	p=0.566 and p=0.715, respectively. p=0.021 and p<0.001respectively.
Weigel *et al*	2003	To evaluate the results of surgical treatment options for chronic subdural haematoma in contemporary neurosurgery according to evidence-based criteria.	Recurrence rate of TDC was greater than BHC or craniotomy	OR,3.6;95%C:I,2.8-4.5; p<0.001
Almenawer *et al*	2014	To compare the efficacy and safety of multiple treatment modalities for the management of CSDH patients.	No statistical difference in cure, morbidity,mortality or recurrence.	1.05(0.98-1.11) *p=0.15,0.45(0.2-1.01)* *p=0.05*,0.69 (0.461.05) *p=0.09*, 1(0.66-1.52) *p=0.99*
Teles *et al*	2015	To assess the effects of different surgical techniques and postoperative care on recurrence of CSDH.	No statistically significant difference in recurrence rate of TDC vs BHC.	OR,0.99; CI95%,0.53; p=0.97

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 systemic 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] On contrary 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; I^2 =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; CI95%,0.92; p=0.07). DBHC was not associated with increased complication rate (OR:0.74, CI95%: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.

Author	Year	Objective	Conclusion	OR(95%CI)
Taussky *et al*	2007	To analyze the use of one vs. two burr holes in respect to recurrence rates and complications.	Single burr hole is associated with significantly higher recurrence rate, complication rate and longer duration of hospital stay	***p*<0.05** Recurrence rate: 29%vs5% Complication rate: 9%vs0% Duration of hospital stay: 11 vs 9 days
Teles *et al*	2015	To assess the effects of different surgical techniques and postoperative care on recurrence of CSDH.	Double BHC slightly superior to single.	OR,0.58;95% CI,0.37; ***p*=0.01**
Belkhair S	2013	To compare the revision rates after SBHC vs DBHC.	SBHC is as effective as DBHC	OR,0.62;95% CI,0.26-1.46.
Almenawer *et al*	2014	To compare the efficacy and safety of multiple treatment modalities for the management of CSDH patients.	No difference in recurrence rates related to number of burr holes.	RR,1.15;95%CI,0.941.37; I^2=88.2%; *p*=0.62.
Wan *et al*	2019	To investigate whether DBHC is associated with increased risks of recurrence,complications and mortality compared with SBHC in patients with CSDH.	No significant differences in recurrence rate,complications rate and morbidity between SBHC and DBHC.	OR,1.28;95%CI,0.92; *p*=0.07. OR,0.74;95%CI,0.20; *p*=0.11 OR,0.74;95%CI,0.55; *p=0.58*

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).[13] Suzuki and associates found no significant difference in recurrence rate (OR,1.13; 95% CI,0.20).[14] 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).[15] 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).[4] Xu *et al* concluded that irrigation is not necessary for all patients (OR,1.17; 95% CI,0.61–2.25).[16] Weigel *et al* have type C recommendations regarding irrigation.[1]

Author concludes that irrigation has no statistically significant effect regarding recurrence rate.

Author	Year	Objective	Conclusion	OR (95%CI)
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.[1] Wakai *et al* had significantly fewer recurrences with drainage (5% v 33%).[17] Markwalder *et al* in their series of 21 patients noticed progressive improvement in those with drains compared to those without drains.[18] 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.[19] 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; I^2=34%; *p*=0.002).[3] 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).[4] Peng *et al* in their meta-analysis noticed significant reduction in recurrence risk with use of subdural drains.[2].Liu et al meta-analysis favours use of post-operative drainage system (OR,0.36; 95%CI,0.21-0.60).[13] 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).[21]

Author concludes that use of drainage reduces recurrence risk.

Author	Year	Objective	Conclusion	OR(95%CI)
Almenawer *et al*	2014	To compare the efficacy and safety of multiple treatment modalities for the management of CSDH patients.	The use of drains following CSDH drainage resulted in significant decrease in recurrence.	RR,0.46; 95%CI,0.27-0.76; I^2=34%; p=0.002
Teles *et al*	2016	To assess the effects of different surgical techniques and postoperative care on recurrence of CSDH.	The use of drains reduces the risk of recurrence.	OR,0.41;95%CI,0.23-0.74; p=0.003
Peng *et al*	2016	To assess the effects and safety of use of external drains versus no drains after burr-hole evacuation for the treatment of CSDH	Significant reduction in the risk of recurrence with subdural drains	OR,0.45; 95%CI,0.32-0.61
Liu *et al*	2014	To systematically evaluate the results of different surgical procedures for chronic subdural hematoma	Use of drain is favoured	OR,0.36; 95%CI,0.21-0.60
Alcala-Cerra *et al*	2014	To determine the effect of a subdural drain after burr-hole evacuation on symptomatic recurrence, reoperation, poor functional outcome, mortality and post-operative complications	Statistically significant reduction in the risk of symptomatic recurrence, reoperation and poor functional outcome.	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)

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 <72hours, 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;I^2 =0%;p=0.003).[3] Tanikawa *et al* reported craniotomy an effective treatment option for CSDH with multiplemembranes.[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-craniotomiesfor 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 haematoma due to its association with high mortality and morbidity.

Author	Year	Objective	Conclusion	OR(95%CI)
Almenawer *et al*	2014	To compare the efficacy and safety of multiple treatment modalities for the management of CSDH.	Craniotomy is associated with higher complication rates if considered initially.	RR,0.22;95%CI,0.05-0.85; I^2=0%; ***p*=0.003**
Weigel *et al*	2003	To evaluate the results of surgical treatment options for chronic subdural haematoma in contemporary neurosurgery according to evidence based criteria.	Craniotomy has higher mortality and morbidity compared to TDC and BHC.	OR,1.6;95%CI,0.6-1.9 OR,1.7;95%CI,0.7-0.4 OR,4.6;95%CI,1.9-10.9 OR,3.5;95%CI,1.9-6.4
Teles *et al*	2016	To assess the effects of different surgical techniques and postoperative care on recurrence of CSDH	No statistical difference in recurrence rate when compared craniotomy and BHC	OR,1.23;95%CI,0.78; *p*=0.36

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.[31] Similar findings were noted by Ishafq and colleagues.[32] Abourazi *et al* reported increased incidence of re-accumulation of subdural collections among patients with flat head position.[33] 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.[4]

Author concludes that elevated head position has better outcome in term of recurrence.

Author	Year	Objective	Conclusion	OR(95%CI)
Nakajima	2002	To assess the role of postoperative patient posture in the recurrence of chronic subdural haematoma	Favours elevated head position.	OR,1.14;95%CI,0.23-5.80
Ishafq	2009	To assess the effect of head positioning on outcome after burr hole craniostomy for chronic subdural haematoma	Favours elevated head position.	OR,1.38; 95%CI,0.28-6.80
Abouzari	2007	To assess the role of postoperative patient posture in the recurrence of traumatic chronic subdural hematoma after burr-hole surgery	Favours flat head position.	OR,0.33; 95%CI,0.01-8.22
Teles *et al*	2016	To assess the effects of different surgical techniques and postoperative care on recurrence of CSDH.	No statistically significant difference noted.	OR,1.06; 95%CI,0.37-3.01; I^2=0%; *p*=0.92

Emolization of middle meningeal artery:

Embolization of middle meningeal artery (EMMA) with or without trephination is new effective method.[34] 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; $p<0.001$; $I^2=0\%$)[35]. EMMA interrupts blood supply to the membrane and prevents haematoma enlargement however it ceases to prevent recurrence.[36] 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%; I^2= 0%), need for surgical rescue 2.7% (95%CI,0.4%–5%; I^2=0%), and embolization-related complications 1.2% (95%CI,0.4%–2.7%; I^2=0%) in comparison to non-embolized group.[37] 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.[38] 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).[39] 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).[40] 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).[41]

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

Author	Year	Objective	Conclusion	OR(95%CI)
Aditya *et al*	2019	To present meta-analysis and systemic review of this topic.	EMMA is a promising treatment for CSDH.	OR,0.087; 95%CI,0.026-0.292; $p<0.001$; $I^2=0\%$
Jummah *et al*	2020	To assess the efficacy and safety of middle meningeal artery embolization in the management of refractory or chronic subdural hematomas.	EMMA appears to be a promising treatment for refractory or CSDH. Definitive conclusions remain limited by paucity of data and small sample sizes. Multicenter, randomized, prospective trials are needed.	Treatment failure: 2.8% (95%CI,0.5%–5.2%; $I^2=0\%$) Surgical rescue: 2.7% (95%CI,0.4%–5%; $I^2= 0\%$) Embolization-related complications: 1.2% (95%CI,0.4%–2.7%;$I^2 = 0\%$)
Kim *et al*	2017	To assess the safety and efficacy of embolization treatment of the middle meningeal artery (MMA) for patients with intractable chronic subdural hematoma (CSDH)	Perioperative MMA embolization could be offered as the least invasive and most effectual means of treatment for resistant patients of CSDHs with one or more recurrences.	Recurrence rate: (OR,0.04; 95%CI,0.01-0.27) Complication rate: (OR,0.15;95%CI,0.01-2.53)
Shotar *et al*	2020	To evaluate the impact on recurrence rate of postsurgical embolization of CSDH in patients with a higher-than-average risk of recurrence	Postsurgical embolization of the MMA may reduce the recurrence rate of CSDH with a risk factor of recurrence.	Recurrence rate: (OR,0.29;95%CI,0.10-0.88) Complication rate: (OR,0.68; 95%CI,0.24-1.95)
Ban *et al*	2017	To evaluate the effect of middle meningeal artery (MMA) embolization on chronic subdural hematoma (CSDH) and compare the treatment outcomes of MMA embolization and conventional treatment.	MMA embolization has a positive therapeutic effect on CSDH and is more effective than conventional treatment.	Recurrence rate: (OR,0.10; 95%CI,0.01-0.88) Complication rate: (OR,1.50; 95%CI,0.36-6.95)
Ng *et al*	2019	To investigate the effect of MMA embolization on hematoma volume resorption (HVR) after surgery in symptomatic patients	The addition of MMA embolization to surgery led to an increase in CSDH resorption at 3 months	Recurrence rate: (OR, 1.17;95%CI,0.07-20.02)

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.

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