

SUBPERIOSTEAL DRAINAGE VERSUS SUBDURAL
DRAINAGE IN THE MANAGEMENT OF CHRONIC SUBDURAL
HEMATOMA
(A COMPARATIVE STUDY)

By
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Abstrak

Hematoma subdural kronik (CSDH) menjadi salah satu diagnosis yang paling kerap dalam amalan neurosurgeri. Dengan penuaan penduduk terutamanya di negara-negara yang maju dan membangun, kejadian CSDHs dijangka semakin meningkat. Kraniostomi “burr-hole”, irrigasi dan penempatan satu system saluran dalaman adalah pembedahan semasa disyorkan untuk CSDH. Tujuan kajian ini adalah untuk membuat satu perbandingan antara dua teknik pembedahan dalam rawatan CSDH, yang telah terbukti dalam kajian sebelum ini. Objektif utama kami adalah untuk membandingkan keberkesanan penempatan “subperiosteal drain” (SPD) dan “subdural drain” (SDD) berikutan burr-hole dan irrigasi, dan juga untuk mengkaji perbezaan yang signifikan dari segi komplikasi pembedahan, hasil fungsi pada 3 bulan dan kadar kematian. Kajian ini telah dijalankan di dua pusat neurosurgeri tempatan, di mana kumpulan SPD yang telah dijalankan di Hospital Umum Sarawak (HUS) dan kumpulan SDD yang telah dilakukan di Hospital Sultanah Aminah Johor Bahru. Kajian kami menjangkau tempoh 2 tahun dengan data 30 pesakit bagi kedua-dua kumpulan. Secara keseluruhannya, tidak terdapat perbezaan statistik yang signifikan dari segi ciri-ciri pesakit umum, gejala pra-pembedahan dan selepas pembedahan, gred Markwalder, baki isipadu hematoma selepas pembedahan dan berulang, kematian dan hasil fungsian selepas pembedahan dan pada 3 bulan susulan antara kedua-dua kumpulan pesakit. Walaupun tidak mencapai kepentingan statistik, kami memerhatikan kadar yang lebih rendah dari segi komplikasi pembedahan terutamanya dalam aspek pendarahan otak (intracranial hematoma) selepas pembedahan dengan penempatan sistem SPD. Kajian ini menyimpulkan bahawa rawatan dengan “burr-hole”, irrigasi dan penempatan sistem SPD adalah sama berkesan untuk sistem SDD dengan kadar yang lebih rendah secara keseluruhan dari segi komplikasi pembedahan untuk CSDHs.

Abstract

Symptomatic chronic subdural hematomas (CSDH) remain one of the most frequent diagnoses in current neurosurgical practice. With the aging population especially in the well-developed and developing countries, the incidence of CSDHs is expected to steadily witness an exponential rise. Burr-hole craniostomy with irrigation and placement of a close-system drainage is the current recommended surgery for symptomatic CSDH. The aim of this study is to perform a direct comparison between two surgical techniques in the treatment of symptomatic CSDH, which have been proven in previous studies to be efficient. Our main objective was to compare the efficacy of placement of a subperiosteal drain (SPD) and a subdural drain (SDD) following single burr-hole craniostomy and irrigation, and also to demonstrate any significant differences in terms of overall surgical complications, functional outcome at 3 months and mortality rate. The study was carried out in two well established local neurosurgical centres, whereby the SPD group was performed in Hospital Umum Sarawak (HUS) and the SDD group was performed in Hospital Sultanah Aminah Johor Bahru. Our study spanned over a duration of 2 years with data of 30 patients for both groups collected and analyzed. Overall, there were no statistically significant difference in terms of patient general characteristics, pre-operative and post-operative symptoms, Markwalder grades on admission and at discharge, post-operative hematoma volume and recurrence, mortality and functional outcome at discharge and at 3 month follow-up between both groups of patients. Although not achieving statistical significance, we observed a lower rate of surgical complication especially for post-operative intracranial hematoma with placement of the SPD system. This study concludes that treatment with single burr-hole craniostomy, irrigation and placement of SPD system is equally effective to the SDD system with a lower overall surgical complication rate for CSDHs.

SUPERIOSTEAL DRAINAGE VERSUS SUBDURAL DRAINAGE IN THE MANAGEMENT OF CHRONIC SUBDURAL HEMATOMA (A COMPARATIVE STUDY)

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Introduction: Symptomatic chronic subdural hematomas (CSDH) remain one of the most frequent diagnoses in current neurosurgical practice. Burr-hole craniostomy with irrigation and placement of close-system drainage is the current recommended surgery for symptomatic CSDH. The aim of this study is to perform a direct comparison between two surgical techniques in the treatment of symptomatic CSDH, which have been proven in previous studies to be efficient. Our main objective was to compare the efficacy of placement of a subperiosteal drain (SPD) and a subdural drain (SDD) following single burr-hole craniostomy and irrigation, and to demonstrate any significant differences in terms of overall surgical complications, functional outcome at 3 months and mortality rate.

Objectives: The aims of this study was to perform a direct comparison on the efficacy of placement of the subperiosteal drain and subdural drain in the treatment of

symptomatic CSDH, and to evaluate any differences in terms of overall surgical complications, functional outcome and mortality.

Materials and Methods: The study was carried out in two local neurosurgical centres. The SPD group was performed in Hospital Umum Sarawak (HUS) and the SDD group was performed in Hospital Sultanah Aminah Johor Bahru (HSAJB), from 1st January 2012 till 30th January 2014 with a total of 30 patients in both treatment groups.

Results: Overall, there were no statistically significant difference in terms of patient general characteristics, pre-operative and post-operative symptoms, Markwalder grades, post-operative hematoma volume and recurrence, mortality and functional outcome at discharge and at 3 month follow-up between both groups. Albeit not achieving statistical significance, we observed a lower rate of surgical complication especially for post-operative intracranial hematoma with placement of the SPD system.

Conclusion: Our study concludes that both treatment methods proved to be highly effective in the treatment of CSDH. However, with a lower overall surgical complication rate, treatment with single burr-hole craniostomy, irrigation and placement of the SPD system can be considered a treatment of choice for the management of symptomatic CSDH.

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CHAPTER 1

Introduction

Chronic subdural hematoma (CSDH) is defined as a slow growing encapsulated collection of blood and its breakdown product within the subdural layer of the dura mater. (Chen et al. 2000). The term chronic encompasses a period of 2 weeks or more, usually with most patients recalling some form of prior head injury which leads to traumatic tearing of bridging veins connecting the brain parenchymal surfaces with the dura mater.

Epidemiologically, CSDH is one of the most common forms of intracranial hemorrhage encountered in daily neurosurgical practice. At present, its incidence is on the rise due to the prolonged life expectancy of the general population in developing countries in recent years. On average, its incidence is estimated to be between 1 and 5 cases per 100,000 people (Kudo et. al 1992, Gazerri et. al 2007). CSDH is more common among the elderly, with reported incidences of up to 7.5 cases per 100,000 people, rising up to 58 per 100,000 people in patients above 65 years of age (Mellegard et al. 1996, van Havenbergh et. al 1996, Gazerri et. al 2007). These numbers are expected to double in the next two decades by the year 2030 as the general population continues to mature in age (Santarius et. al 2010). In a larger demographic study conducted by Baechli and colleagues in 2004, they reported a significantly higher prevalence of CSDH in patients older than 65 years (69% vs. 31%), and that men are more frequently affected women (64% vs. 33%). The higher incidence of CSDH in men is most likely a result of over-representation of head injury in the male counterparts. In addition, between 20-25% of the CSDH cases, patients present with bilateral lesions (Greenberg MS, 2010).

As mentioned earlier, the elderly population are at a higher risk of developing CSDH, whereby age related cerebral atrophy with a corresponding increase in subdural space predisposes the increasingly fragile bridging veins to stretching and tearing. This additional subdural space volume can be occupied by the hematoma before considerable rise in intracranial pressure occurs, hence the typical delayed presentation of usually 1-2 weeks later. Trivial head injuries or repeated falls prior to clinical presentation are a common antecedent event described in most elderly patients. In their study in 2004, Baechli et. al also noted that in 77% of the cases, the patient had a prior fall in the past and 41% of the patients had underlying medical co-morbid conditions requiring treatment with oral anti-coagulants or platelet aggregation inhibitors. The risk of developing a CSDH was at least 42.5 times higher in warfarinised patients and also increased for patients on aspirin (Rust et. al 2006). Other common risk factors associated with an increased risk of CSDH are chronic alcohol consumption, chronic liver and renal impairment, epilepsy, and diabetes mellitus. In a study from Helsinki, chronic alcohol consumption was reported in 50% of the patients with CSDH (Fogelholm R et. al 1975). This was related to factors such as alcohol-induced liver impairment, platelets dysfunction, and alcohol-related cerebral atrophy.

There has been an ongoing debate on the actual pathophysiology of CSDH, and consequently its evolution and recurrence, all of which has bearing in the general management of CSDH. The pathophysiology of CSDH was first theorized by Virchow back in 1857, when he coined the term “pachymeningitis hemorrhagica interna” which recognized the presence of dural inflammation and hemorrhagic elements. By the early 20th century, the traumatic nature of CSDH was established and widely accepted and with the advent of ultra-structural study of subdural membranes, the complex pathophysiology of CSDH since been put forth. Current evidence suggests that the formation and evolution of CSDH is

multifactorial. Many theories have been reported, which includes the “micro-bleed” theory, the “inflammatory and growth factor” theory, and the “anti-coagulant and profibrinolytic” theory.

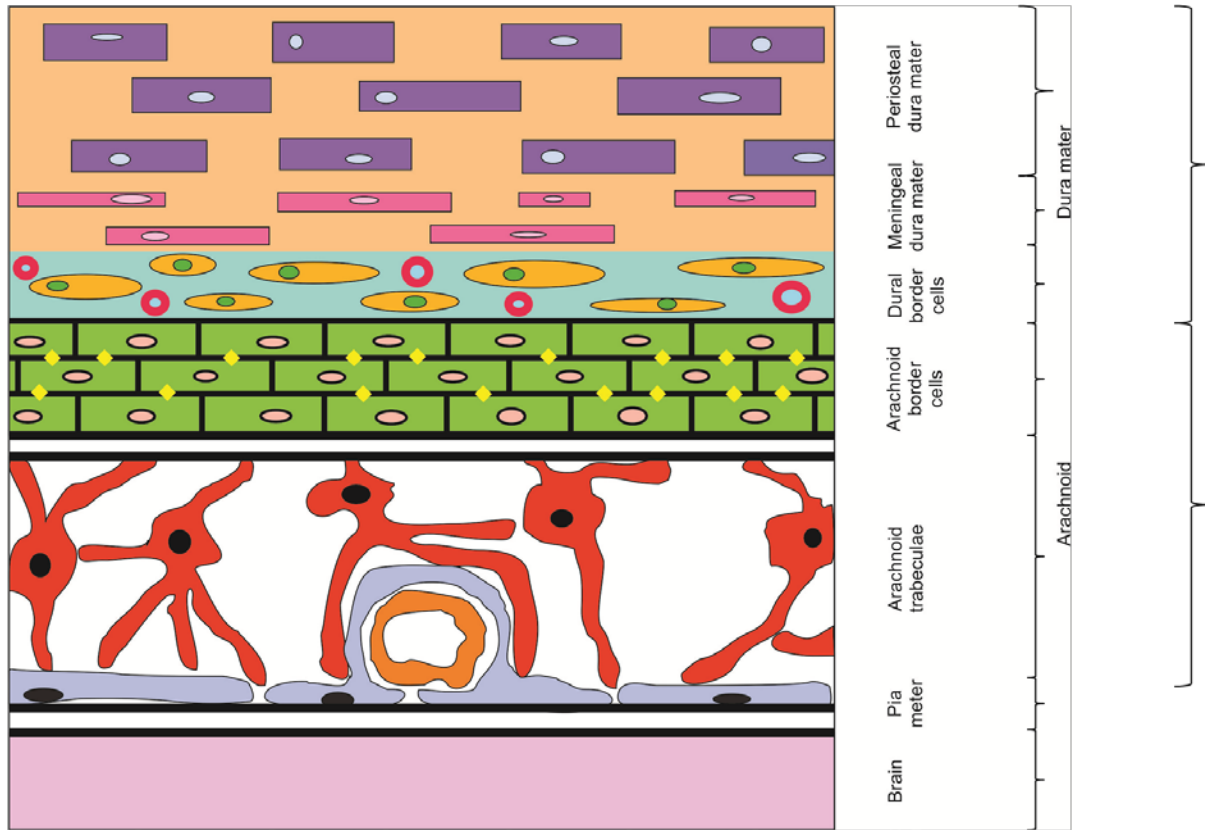


Figure 1.0 Diagram depicting the ultra-structural architect of the meninges (adapted from Santarius et al. 2010). The dura mater is largely composed of fibroblast and collagen. The arachnoid layer is supported by a basement membrane held together with numerous tight junctions (red diamonds). The dural border cells (green layer) are composed of fibroblasts without tight junctions and are a relatively loose layer in between the firm dura mater and arachnoid mater. Therefore, the subdural space is indeed a potential space that can form within the dural border cell layer (green). The bridging veins (blue round spheres) act as a potential source of bleeding within this layer.

As depicted in Figure 1.0, the layer of dural border cells is comprised of cells devoid of tight junctions and enlarged extracellular space containing amorphous material (Santarius et al 2010). It is this layer of dura border cells that tethers the dura and arachnoid layer together, which makes the subdural space virtually non-existent in healthy individuals. With age and the increasing cerebral atrophy along with it, the arachnoid layer is gradually stretched away from the dural layer, which remains adhered to the skull bone. The resultant force pulls the dural border cell layer and stretches the traversing bridging veins. Hence, any additional force can result in tearing of these veins with subsequent bleeding into the dural border cell, thus creating a relatively minor acute subdural hematoma. Today, it is widely accepted that the initial trauma and development of the CSDH occurs as a result of a cascade of inflammatory process triggered by the presence of blood. After approximately 2 weeks, an inner (pial) and outer (dural) neo-membrane is formed inside the dural border cell layer through collagen synthesis and fibroblast spread (Ducreut et. al 2012, Drapkin 1991). The subsequent neovascularization and formation of fragile capillaries into the neo-membranes of the hematoma capsule lead to further micro-bleeds within the subdural space. This was due to the lack of muscle layer in these neo-capillaries, making them fragile and susceptible to repeated micro-bleeding and consequent CSDH expansion (Ducreut et. al 2012). In a report by Weigel R et. al in 2001, they theorized that the ongoing inflammation causes high levels of vascular endothelial growth factors (VEGF) within the CSDH. This leads to enhanced angiogenesis and hyperpermeability of the neo-capillaries which directly contributes to hematoma expansion. The neomembranes of the CSDH capsule also demonstrate high concentrations of profibrinolytic and anticoagulation factors, which prevent hemostasis and enhance further expansion of the hematoma (Labadie et. al 1975). In addition, the presence of high levels of tissue plasminogen activator (TPA) and high fibrin degradation products within the CSDH also negates hemostasis and contributes to hematoma growth (Katano et. al 2006).

The clinical presentation of CSDH varies widely without any pathognomonic symptoms or signs. Furthermore, the development of these symptoms is usually slow and progressive over time in the majority of patients as the preceding head injury tends to be trivial without any accompanying severe brain injury. With slow accumulation of blood and under relatively low pressure, the time from onset to presentation can range from weeks to months. Therefore, patients with CSDH can be asymptomatic, present with subtle symptoms such as headache, altered sensorium, vomiting and giddiness or present with more severe life threatening symptoms secondary to increasing intracranial pressure such as seizures, hemiparesis or coma. As such, a clinical grading system was devised by Markwalder in 1981, to aid in the objective assessment of patients presenting CSDH. It is as shown in Table 1.0 below. This grading system is used pre- and post-operatively to assess the clinical course of the patient.

Table 1.0: Markwalder grading scale for CSDH

Grade 0	No neurological symptoms or signs
Grade 1	Headache, Asymmetrical reflexes
Grade 2	Altered mental status, Hemiparesis
Grade 3	Stupor but responsive, Hemiplegia
Grade 4	Coma, Decerebrate/Decorticate posturing

Clinically, CSDH is defined as a hematoma that has persisted more than 21 days after trauma, giving rise to an appearance of dark red liquefied blood surrounded by a thin capsular membrane observed intraoperatively. Other descriptive terms of the CSDH consistency is of the classic “crankcase-oil” appearance upon surgical evacuation. The older classification of subdural hematomas is based on the density appearance on computed tomography (CT) scans. However, this previous CT characterization of acute SDH as hyperdense, subacute SDH as isodense and chronic SDH being hypodense is no longer of clinical significance. Until recently, Nakaguchi et. al in 2001 described a newer radiological classification of CSDH which provided a significant influence on the risk of recurrence in the post-operative period. They classified radiological appearance of CSDH into 4 main types: homogenous, laminar, and separated and trabeculated, based on the internal architecture and natural history of CSDH.

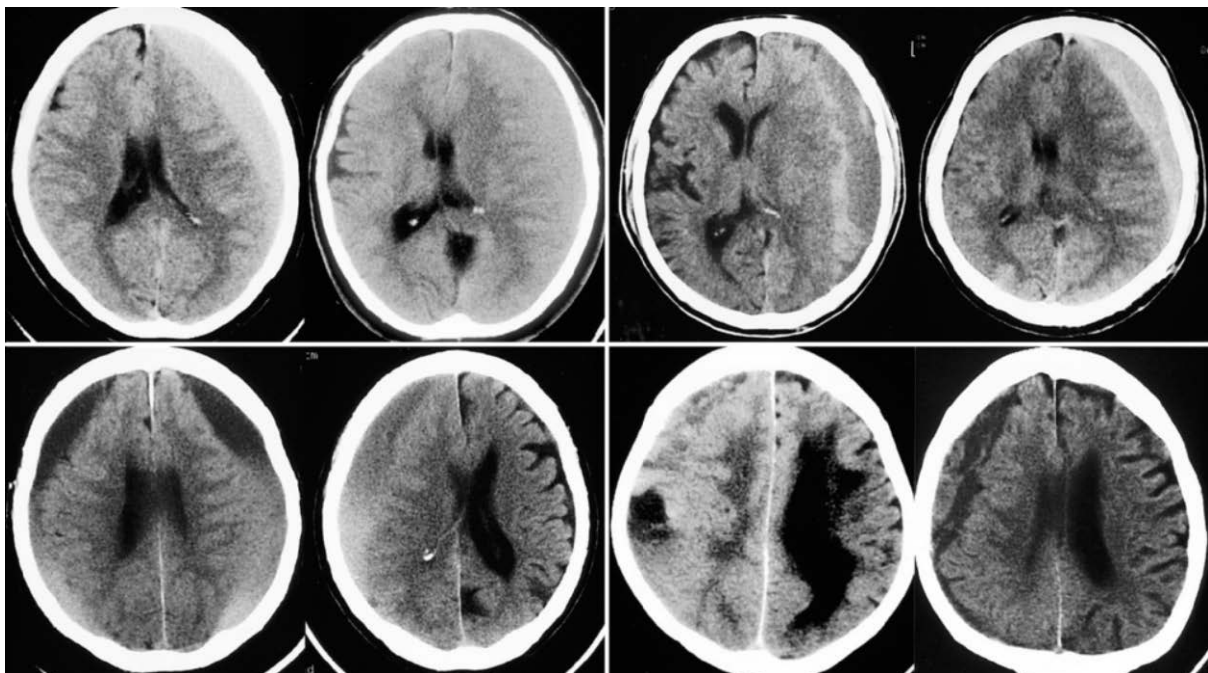


Figure 2.0 Non-contrast computed tomography (NCCT) scans showing classification of CSDH according to their internal architectures (adapted from Nakaguchi et.al 2001). *Upper left:* Homogenous type. *Upper right:* Laminar type. *Bottom left:* Separated type. *Bottom right:* Trabeculated type.

The Nakaguchi classification serves as an independent predictor of recurrence in patients with CSDH based on the internal architectural appearance on NCCT scans, as shown in Table 2.0. Both the homogenous and trabeculated type showed lower risk of post-operative recurrence rate as compared with the laminar and separated types.

Table 2.0 Post-operative risk of recurrence based on the Nakaguchi classification of CSDH

Hematoma type	Risk of Post-operative Recurrence (%)
Homogenous stage	10-15%
Laminar stage	20%
Separated stage	40%
Trabeculated	0%

Therapeutic options for patients with CSDH include non-surgical or surgical management by means of burr-hole craniostomy, twist drill craniostomy or craniotomy. Asymptomatic patients without radiological evidence of mass effect are usually managed expectantly with serial follow-ups and repeat NCCT scans. There is no recommended cut-off size of the CSDH seen on NCCT scans to determine surgery for patients. Furthermore, spontaneous resolution of CSDH have been reported in elderly patients (>70 years) who are asymptomatic (Parlato et. al 2000, Goksu et. al 2009). However, Naganuma and colleagues in 1986 reported that spontaneous resolution rarely occurs in CSDH patients and advocate surgical evacuation.

The decision for surgical evacuation of a CSDH is also influenced by both the clinical presentation of the patient as well as the radiographic appearance of the lesion. Surgery is indicated for any patient who demonstrates neurological symptoms (Baechli H et. al 2004, Camel M et. al 1986). The technique of both a single or double burr-hole followed by a closed drainage system has been proven to be safe, cost-effective, and associated with reduced morbidity and mortality (Belkhair et. al 2013, Han et. al 2009, Hamilton et. al 1993, Kansal et. al 2010, Lee et. al 2009, Santarius T et. al 2009). In a meta-analysis by Smith MD et. al in 2012, they reported that performing either a single or double burr-hole craniostomy did not provide significant differences in patient outcome improvement. In addition, many adjunct techniques and approaches have also been described including intra-operative irrigation with warm saline, frontal placement of a subdural drain, and post-operative patient positioning, all with the aim of reducing post-operative recurrence of CDSH (Abouzar et. al 2007, Nakaguchi et. al 2000, Nakaima et, al 2002). At present, these are only class (II) evidences and no class (I) evidence reported in the literature on the surgical treatment of symptomatic CSDH as published in a meta-analysis by Weigel and colleagues in 2003.

Following surgical intervention, the majority of patients (72-90%) with CSDH will recover their pre-morbid functional status (Weigel et. al 2003, Borger et. al 2003,). Younger age patients were associated with significantly better outcomes (Ramachandran et. al 2007). In their retrospective analysis of outcome in 322 patients over the age of 65 years treated surgically for CSDH, Borger et. al in 2012 reported higher morbidity and mortality rates in patients between 75-95 years of age. Among the post-operative complications associated with CSDH surgery include tension pneumocephalus, infection of subdural space with development of subdural empyema, intracerebral hematoma, and seizures (Gelabert-Gonzalez et. al 2005). As reported in previous studies, the overall surgical morbidity with worsening

neurology post-operatively ranges between 4-5% (Diaz et. al 2003, Ramachandran et. al 2007). The mortality rates in different series have been varying between 0-8% and about 10% of patients will have a permanent residual neurological deficit (Diaz et. al 2003, Rohde et. al 2002).

Many risk factors contributing to the recurrence of CSDH following surgical evacuation have been extensively studied over the last decades. Reported post-operative recurrence of CSDH usually varies between 5-30% (Mori et. al 2001, Nakaguchi et. al 2000). Besides the radiological Nakaguchi classification of CSDH (which is an independent predictor of recurrence), other risk factors associated with re-accumulation of CSDH includes advance age >70yrs, poor consciousness on admission, bleeding tendencies (anti-coagulant or anti-platelet use), cerebral atrophy, chronic alcohol consumption, septum or multiple membranes within the hematoma cavity, post-operative brain re-expansion and subdural air collection, and bilateral CSDH (Abouzari et. al 2007, Chon et. al 2012, Delgado et. al 2000, Ohba et. al 2013, Torihashi et. al 2008, Yamamoto et. al 2003). The only proven factor with Class I evidence yielding lower recurrence rate was reported by Santarius and colleagues in 2009, which was the placement of a closed drainage system following burr-hole craniostomy, twist-drill craniostomy or craniotomy. Recurrence of CSDH was usually found between 1-8 weeks after the first surgery (Mori et. al 2001). Therefore it is recommended that patients with CSDH be follow up for at least 2 months post-operatively to assess for possible hematoma recollection. The Glasgow Outcome Score is commonly used as a follow-up assessment tool to clinically evaluate patients post-operatively (Jennet et. al 1975).

CHAPTER 2

LITERATURE REVIEW

2.1 Surgical methods in the treatment of CSDH

2.1.1 Burr-hole craniostomy and comparison of other techniques

To date, there has been no standardized approach to the treatment of CSDH (Weigel et. al 2003). The three most well described surgical techniques for the treatment of CSDH are burr-hole craniostomy, twist drill craniostomy and craniotomy. The size of craniostomy differentiates between twist drill craniostomy (up to 5mm diameter) from burr-hole craniostomy (5-30mm diameter). In the mid-1920s, Putnam and Cushing reported comprehensively on the treatment of CSDH via craniotomy with total removal of the hematoma and outer neo-membranes, and recommended this as the surgical procedure of choice. Hence, craniotomy was advocated as the treatment of choice until the mid-1960s. In 1964, a series with a direct comparison between craniotomy and burr-hole craniostomy showed better clinical outcomes and lower recurrence rate for patients in the burr-hole craniostomy treatment arm (Svien et. al 1964). In a separate study by Tabaddor and Shulman in 1977 comparing all three aforementioned techniques, they published that patients in the craniotomy group had the highest mortality rate and poorest outcome in comparison to those in the burr-hole and twist drill craniostomy groups. Two other meta-analyses comparing the three techniques also yield similar results, with patients in the craniotomy group demonstrating poorer functional outcomes (Weigel et. al 2003, Lega et. al 2010). Furthermore, Weigel and colleagues also concluded that burr-hole craniostomy have lower recurrence rate of hematoma than twist drill craniostomy.

Therefore, despite the lack of class I evidence, it is widely accepted that the treatment of choice for CSDH was burr-hole craniostomy as it balances a low recurrence rate against morbidity and mortality better than twist drill craniostomy and craniotomy (Ducruet et. al 2012, Lega et. al 2010, Weigel et. al 2003). Twist drill craniostomy is recommended for surgically high-risk patients as a bedside procedure under local anaesthesia whereas craniotomy is reserved for CSDH with significant neo-membranes (Ducruet et. al 2012).

2.1.2 Number of burr-holes (single versus double)

At present, the number of burr holes required to optimally drain CSDH remains a subject of debate. There is no conclusive evidence to date to favour a single or double burr-hole craniostomy. In a study comparing number of burr holes as an independent predictor of post-operative recurrence in CSDH, the authors found that patients treated with a single burr-hole have significantly higher rate of recurrence, prolonged hospitalization, and a higher rate of surgical site infection (Taussky et. al 2008). Contrastingly, two other studies did not demonstrate any significant difference in complications, recurrence rate, mortality or outcome when comparing the number of burr-holes for CSDH (Han et. al 2009, Kansal et. al 2010). In a more recent meta-analysis on 5 retrospective cohorts regarding single versus double burr-hole placement, it was stated that single burr-hole craniostomy was comparable to double burr-hole craniostomy in the treatment of CSDH. The authors also found a negative correlation between the number of burr-holes and the rate of recurrence as reported previously (Belkhair et. al 2013).

2.1.3 Intra-operative irrigation

The purpose of intra-operative irrigation of the CSDH cavity with warm saline was to dilute its contents and aid in the evacuation of the hematoma. However, the role of irrigation remains unclear and only a few papers were found to study the comparison of patients treated with and without intra-operative irrigation. The role of burr-hole craniostomy and irrigation was reported in four class III and one class II evidence publications.

There was no significant difference in relation to hematoma recollection reported in 3 of those studies when intra-operative irrigation was performed (Kuroki et. al 1994, Suzuki et. al 1998, Matsumoto et. al 1999). In 1993, Ram and colleagues were able to demonstrate a non-significant reduction in hematoma recurrence in the irrigation group. A separate report by Hennig et. al in 1999 found a lower rate of recurrence in patients treated with intra-operative inflow and outflow drainage. In twist drill craniostomy however, irrigation did yield in a significant decrease in hematoma recurrence (Aoki et. al 1984). The use of intra-operative irrigation was not related to any increase in morbidity or mortality when burr-hole or twist drill craniostomy was performed (Aoki et. al 1984, Hennig et. al 1999).

In a local study by Adam et.al which was reported in 2006, the use of intra-operative irrigation with warm saline as an adjunct to burr-hole craniostomy did not yield any significant difference in terms of clinical outcome and hematoma recurrence when compared with burr-hole drainage alone. However, in a recent meta-analysis by Almenawar et.al published in 2014, the results were contrasting when the authors revealed that irrigation of the hematoma cavity resulted in a significant decrease in hematoma recurrences. This finding was also reiterated in another meta-analysis by Liu and colleagues in September 2014, when they reported that intraoperative irrigation may lead to a better outcome in patients.

2.1.4 Closed-system drainage

The utility of a closed drainage system following burr-hole or twist drill craniostomy was the most convincing data with regards to the surgical adjuncts in treating CSDH. This was initially reported by Wakai et. al in 1990, when the authors noted that usage of a drain after burr-hole craniostomy resulted in significantly reduced rate of hematoma recurrences. In an earlier study, Markwalder et. al reported faster rate of recovery in patients treated with a closed-system drainage. The most significant change in practice came about with the level 1 evidence publication by Santarius et. al in 2009. In their randomized controlled trial, they reported a significant benefit in recurrence, mortality and clinical outcome at discharge for patients treated with a subdural drain placement in double burr-hole craniostomy. This was also the only study to recommend the placement of closed-system drainage as a standard in the surgical management of CSDH with burr-hole craniostomy (Type A recommendation). A recent meta-analysis conducted by Almenawar et.al which was published in 2014 further enhances the role of closed-system drain placement, which was found to significantly decrease the rate of hematoma recurrence.

2.1.5 Drain placement

The placement of the drain forms the basis of this study. Much has been published on the placement of a closed-system drainage following a burr-hole craniostomy for the treatment of CSDH. The insertion of a subdural drain has been deemed safe but potential complications from its close proximity to the cortical brain surface such as traumatic contusion or hematoma with consequently worsening neurological symptoms, seizures, infection and subdural empyema have been reported. Therefore, a less invasive technique of placing a subperiosteal (subgaleal) drain was advocated by a few authors in recent years. This novel technique was reported in studies by Gazerri et. al and Zumofen et. al, both of which

yielded similar rates of recurrence and complications when compared with placement of subdural drain. In a separate study, the authors performed a retrospective direct comparison of subperiosteal and subdural drainage and found no significant difference in recurrence or complication rates, albeit a trend towards fewer surgical complications in the subperiosteal group, and fewer recurrences were reported in the subdural group (Bellut et. al 2012). A single center prospective randomized study by Kaliaperumal et. al in 2012, which compared the outcomes of subdural and subperiosteal drain concluded that there was no recurrence of CSDH utilizing the subdural drain or subperiosteal drain following burr-hole craniostomy. In addition, the authors also found a statistically significant modified Rankin Score (mRS) measurements, with better outcomes in the subperiosteal group at 3 and 6 month follow-up.

2.1.6 Anti-coagulation and anti-platelet treatment

There are no class I evidence comparing the outcome of patients who undergo surgery for the treatment of CSDH with and without reversal of oral anti-coagulants. Due to the increased risk of intra- and post-operative bleeding with hematoma expansion, the general consensus remains that of urgent reversal of oral anti-coagulants prior to surgical evacuation of CSDH (Ducruet et. al 2012). Rapid reversal of oral anti-coagulants is usually achieved with the fresh frozen plasma (FFP), recombinant Factor VIIa (rFVIIa), or prothrombin complex concentrate (PCC) transfusion (Lin et. al 2003, Mayer et. al 2005, Lankiewicz et. al 2006). Intravenous vitamin K is also given as an adjuvant to FFP, PCC and rFVIIa to prevent a rebound change in the international normalized ratio (INR). Transfusions of these products have a certain degree of complications. FFP transfusion can give rise to complications such as transfusion related lung injury (TRALI), and also precipitate fluid overload in patients with renal or cardiac failure. The risk of thrombosis with consequent deep vein thrombosis and pulmonary embolism are related to both PCC and rFVIIa transfusion. In terms of costs, both

PCC and rFVIIa are considerably more expensive than FFP (Woo et. al 2012). In this study, due to the unavailability of rFVIIa and the high cost of PCC, FFP and vitamin K was selected as the reversal agents for patients on anti-coagulants. A definitive recommendation on the timing of resumption of oral anti-coagulant treatment in patients post-operatively has not been clearly defined. In general, the risk of thromboembolic events due to prolonged discontinuation of anticoagulation has to be balanced against the increased risk of bleeding due to early commencement of treatment post-operatively. In three separate studies yielding class (III) recommendations, the respective authors found that reinstating oral anti-coagulant after 72 hours of surgery was deemed safe and did not lead to a higher risk of intracranial bleeding post-operatively (Kawamata et. al 1995, Yeon et. al 2012, Chari et. al 2013). Similarly, there is no definite recommendation on the method of reversal of anti-platelet therapy in patients with CSDH. The most effective way is by discontinuing the drug for a week, which is the period of the platelet lifespan required to replace the existing dysfunctional platelets (Mascarenhas et. al 2012). For patients requiring urgent clot evacuation, the reversal of anti-platelets therapy can be done with transfusion of platelet concentrates or intravenous desmopressin (Rannucci et. al 2007). In our study, patients on anti-platelet treatment and require emergent burr-hole craniostomy, platelets were transfused peri-operatively.

2.1.7 Anti-convulsant treatment

The overall reported rate of seizures in patients treated surgically for CSDH ranges between 2.3% to 15% (Ohno et. al 1993, Ducruet et. al 2012, Ratilal et. al 2013). A higher post-operative seizure rate was noted in patients with unilateral and mixed-density CSDH, and hence AED prophylaxis was proposed in these patients (Chen et. al 2000). Two separate studies reported no significant difference in rate of seizures with prophylactic administration of anti-epileptic drugs (AEDs), and concluded that the morbidity with AEDs far outweighs the benefits (Rubin et. al 1993, Ohno et. al 1993). In 1995, Sabo et. al reported a significant increase in morbidity and mortality in patients with CSDH presenting with new onset seizures, and therefore recommended the administration of AEDs for a period of six months following the initial presentation. In addition, another group of authors found that AED prophylaxis reduced the incidence of post-operative seizures in patients treated for CSDH (Grobelny et. al 2009). At present, recommendation for the administration of AED is for those presenting with seizures, while prophylactic AED is reserved for patients at high risk for seizures such as chronic alcohol consumption (Ducruet et. al 2012). For this study, AED was given only as a treatment for those presenting with seizures and not as a prophylaxis.

2.1.8 Volume estimation of chronic subdural hematoma

A simple method for the estimation of intracerebral and extradural hematoma, known as the XYZ/2 or ABC/2 method had been widely described previously. In 1999, Kasner et. al demonstrated that this method was also applicable for the calculation of acute subdural hematoma volume. However, the validity of this method was questionable when applied in the estimation of CSDH. This is due to the fact that CSDH are not always symmetric crescents and because of their complex neo-membrane formations, the hematoma may assume asymmetrical shapes such as comma, or lens on axial CT scan slices. Hence, a study on the value of XYZ/2 technique compared with computer-assisted volumetric analysis was performed by Hassan et. al in 2005. The authors defined the parameters as X; indicates the depth of hematoma, Y1; maximum length of hematoma on any slice, and Z1; maximum width of hematoma on any slice. Depth of hematoma (X value), was determined by multiplying the number of slices in which the hematoma was visible by the slice thickness. The linear distance between each corner of subdural crescent represented the length of hematoma (Y). When compared to the gold standard (computer-assisted volumetric analysis), this formula demonstrated excellent correlation, thus providing the validity of XYZ/2 formula in the estimation of CSDH volume (Hassan et. al 2005).

CHAPTER 3

STUDY PROCEDURE

3.1 Problem statement

In recent years, there has been an observed steady rise in the incidence of patients presenting with symptomatic CSDH, as a result of prolonged life expectancy especially in developing countries (Baechli et. al 2004, Gelabert-Gonzalez et. al 2005). It is also mainly a diagnosis mainly found in elderly patients with accompanying medical conditions which may contribute to its development simultaneously. To date, there are only a few class (II) evidence publications in the literature on the treatment of CSDH. As a general consensus, the standard surgical method of choice for symptomatic CSDH is burr-hole craniostomy combined with irrigation and placement of closed-drainage system (Lee et. al 2009, Weigel et. al 2003). In a randomized controlled trial by Santarius et. al in 2009, the authors concluded that placement of a subdural drain after burr-hole evacuation of CSDH was associated with reduced recurrence and mortality. More recent studies have been reported on a considerably less invasive method by placing a subperiosteal drain instead of the conventional subdural drain (Gazzeri et. al 2007, Zumofen et. al 2009, Bellut et. al 2012). This is due to the fact that placement of the subdural drain on the cortical brain surface could potentially give rise to complications such as hematoma, seizures, and surgical site infection (e.g. empyema). With a clear tendency towards less mortality and complications, the placement of a subperiosteal drain is recommended for patients with a predictable high risk of complications especially in patients above 80 years of age (Bellut et. al 2012).

3.2 Importance and Validity of Research

In this study, we aimed to perform a direct comparison of subdural and subperiosteal drainage placement for the treatment of CSDH in our local setting, to further analyze the recurrence rates and the overall outcomes in terms of surgical complications and mortality of patients. The previous study by Bellut et. al in 2012 was a retrospective analysis comparing the placement of subdural drainage versus subperiosteal drainage. In that study however, the lower rate of serious complications, mortality and post-operative seizures could not be shown to be statistically significant. Therefore, with a prospective study design we intended to collect a sample size of 30 patients in each group (power of 80%) to demonstrate the difference in overall outcomes and rate of hematoma recurrence ($\alpha < 0.05$). The only local tertiary centre with neurosurgery services to practice placement of a subperiosteal drain following single burr-hole craniostomy is in Sarawak General Hospital. The other hospitals in the country practiced the standard surgical technique of a single burr-hole craniostomy and subdural drain placement. At present, there has been no comparative study locally, to analyze the overall outcome and the recurrence rate of CSDH between both surgical techniques as well.

The surgical technique practiced in this study was a single burr-hole craniostomy, followed with irrigation and placement of the closed drainage system. As mentioned, due to the better outcome to complication ratio in most patients, this technique is in line with the standard surgical treatment of choice (Santarius et. al 2009). Single burr-hole craniostomy has been proven to be just as good as a double burr-hole craniostomy and is not associated with a higher recurrence rate of CSDH (Han et. al 2009, Kansal et. al 2010, Belkhair et. al 2013). Similarly, intraoperative irrigation is used as an adjunct to reduce the recurrence rate and was not associated with any increase in morbidity or mortality (Ram et. al 1993, Hennig et. al 1999).

3.3 General Objectives

The main purpose of the study was to perform a direct comparison on the efficacy of placement of the subperiosteal drain and subdural drain, and to evaluate any differences in terms of surgical complications, functional outcome and mortality for the treatment of symptomatic CSDH.

3.4 Specific Objectives

1. To assess the general demographic characteristics of patients presenting with CSDH.
2. To compare the pre-operative and post-operative symptoms within both groups.
3. To compare the clinical neurological outcome of patients on admission and upon discharge based on the Markwalder grad within both groups.
4. To compare the post-operative hematoma size/volume based on CT scans between the two groups.
5. To compare the overall surgical complications between the two study groups.
6. To compare the functional outcome of patients based on the Glasgow Outcome Score at discharge and at 3 months follow-up between the two study groups.
7. To compare the mortality rate between the two study groups.

3.5 Research Questions

- 1.** Is there a significant difference in terms of pre-operative and post-operative symptoms within both groups?
- 2.** Is there a significant difference in the Markwalder grade of patients within both groups on admission and upon discharge?
- 3.** Is there a significant difference in the pre-operative and post-operative hematoma size and volume between the two groups?
- 4.** Is there a significant difference in the surgical complications between the subperiosteal and subdural drain groups?
- 5.** Is there a significant difference in the functional outcome, based on the Glasgow Outcome Score of patients upon discharge and during 3 month follow-up between the two groups?
- 6.** Is there a significant difference in terms of mortality between the two groups?

CHAPTER 4

MATERIALS AND METHODS

4.1 Research Design

This was an interventional prospective comparative study in a double centre to evaluate the efficacy of the subperiosteal drain placement compared with subdural drain placement and to demonstrate any differences in terms of overall surgical complications, outcome and mortality. The study was approved by the Malaysian Medical Research and Ethics Committee (MREC). It was carried out at two different tertiary hospitals with well established neurosurgery services, which were Hospital Umum Sarawak (HUS) and Hospital Sultanah Aminah Johor Bahru (HSAJB).

4.2 Research Location and Duration

This study was performed at two different tertiary hospitals with well established neurosurgery services, which were Hospital Umum Kuching Sarawak (HUS) and Hospital Sultanah Aminah Johor Bahru (HSAJB). The duration of study was over a total of 2 years, spanning from January 2012 till January 2014.

4.3 Surgical Techniques

Prior to the surgery, a proper informed consent will be taken from the patient or their immediate family members or caregivers, explaining in detail regarding the indications and risks of the study procedure. Peri-operatively, anti-coagulants and anti-platelet medications will be withheld before surgery, and 4 units of FFP with 10mg of intravenous (IV) vitamin K administered to establish normal clotting parameters. Anti-epileptic medications will only be given to patients who present with seizures on admission.

In that instance, IV Phenytoin 15-20mg/kg loading dose will be administered followed with an IV maintenance dose of 300mg daily. These peri-operative measures were standardized for both groups of patients on both of the study centres.

The standardized surgical steps involved are as described below:-

- I. The patient was given general anaesthesia during surgery.
- II. The patient was placed in a supine position with their head stabilized on a rubber horse-shoe ring without Mayfield head clamp fixation.
- III. The area of incision was marked and cleaned with povidone iodine and covered with sterile surgical drapes.
- IV. A single shot of antibiotic prophylaxis with 1.5 g of IV Cefuroxime (Zinacef; GlaxoSmithKline MY) and local anaesthetic agent (IV Marcain + Adrenaline) was administered to all patients directly before skin incision.
- V. A single burr-hole was made at the point of maximal clot thickness, with the burr-hole craniostomy size (measuring at least 10mm x 10mm in diameter) standardized.
- VI. The dura mater was coagulated and opened widely to the size of the burr-hole.
- VII. Intra-operative subdural irrigation was performed with body-tempered normal saline solution until the effluent was noted to be fairly clear and not totally removed.
- VIII. Placement of the closed-system drainage was done as practiced in each designated centre (subdural drain in HSAJB and subperiosteal drain in HUS).
- IX. In case of the placement of SPD system, a passive corrugated Radivac catheter was placed across the burr-hole beneath the galea.
- X. In case of the placement of SDD system, a Jacques catheter was negotiated through the burr-hole and gently placed in the subdural space.

- XI. Either drain was pulled through a small skin incision posterolateral to the burr-hole and connected to a collecting system (which is passive without any suction force applied).
- XII. The subdural space was filled with body-tempered saline before closing the skin incision to minimize intracranial air collection.
- XIII. The drainage system was placed below the level of the head.
- XIV. A repeat CT brain was performed within 24 hours post-operatively
- XV. Removal of drain was done also for all patients after the repeat CT brain within 24 hours.