Clinical Neurology and Neurosurgery 184 (2019) 105415

Contents lists available at ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

Surgery for spontaneous intracerebral hemorrhage – A comparative study with medical management in moderate to large sized hematomas

Ajay Hegde[a,b], Girish Menon[a], Vinod Kumar[a,*]

[a] Department of Neurosurgery, Kasturba Medical College, Manipal Academy of Higher education, Manipal, India
[b] Institute of Neurological Sciences, NHS Greater Glasgow and Clyde, Glasgow, Scotland, United kingdom

ARTICLE INFO

Keywords:
Intracerebral haemorrhage
Surgery for ICH
Conservative management
Stroke
Stroke outcome

ABSTRACT

Objectives: Intracerebral Hemorrhage (ICH) is a devastating form of stroke and accounts for 10–15% of all cases. The management of ICH has predominantly been directed towards medical management. Multiple trials have failed to prove the superiority of surgical evacuation over conservative methods. However, surgery in a carefully selected set of patients is beneficial in reducing mortality and limiting disability. In this article, we retrospectively analysed our ICH register to compare the outcomes of surgical and conservative management of patients < 70 years having a clot volume above 30 ml.

Patients and Methods: We retrospectively analysed patients with ICH admitted at our centre between January 2015 and December 2017. A total of 119/624 patients with supratentorial hematoma volume > 30 ml, GCS ≥ 5 and age less than 70 were included in this study.

Results: The group was dichotomised into two groups A & B based on the management. Seventy-two (60.5%) patients underwent surgical intervention in group A and the remaining 47 (39.5%) were managed by best possible conservative methods in group B. The mean age in Group A was 51.01 years and 55.89 years in group B (P = 0.012). The volume of hematoma in the surgical group was 46.5 ± 14.9 ml in comparison to 38.53 ± 10.84 ml in the medically managed group (p = 0.002). Mortality at 90 days was 27/47 (57.44%) in the medically managed group while 23/72 (31.9%) in the surgical group (p = 0.006). Median mRS at discharge and 90 days were nearly identical and there was no significant difference in the dichotomized outcome among the two different management cohorts (p > 0.05). Mortality was the highest in the 30–50 ml medically managed group and > 51 ml surgical group (p = 0.024). Age of the patient, GCS on presentation and medical management were independent predictors of mortality on logistic regression. The Cox Regression survival analysis of the two groups showed a clear survival advantage in the surgically managed group adjusting for age and GCS (p = 0.002) at 90 days.

Conclusion: Surgical Evacuation of spontaneous intracerebral haemorrhage has a survival advantage at 90 days in moderate to large sized hematomas. It, however, did not demonstrate any quantifiable improvement in functional outcome. Surgical evacuation of moderate-sized hematomas reduces mortality caused by delayed perihematomal oedema.

1. Introduction

Intracerebral haemorrhage (ICH) is the second leading cause of stroke, accounting for 10–15% and around 1 million cases every year worldwide [1]. It accounts for a high mortality of 30–50% and nearly 2/3rds remain disabled [1–3].

Management of ICH poses a considerable dilemma. There is no convincing evidence of benefit from any medical treatment, and the role of surgery remains controversial [4]. Surgery has been typically reserved for young patients with deteriorating GCS scores [5]. Logic and reasoning suggest that early evacuation through the shortest trajectory should reduce ICP and limit the harmful effects of haemoglobin breakdown byproducts [1,6,7]. It has been, however, observed that prompt clot evacuation and a clean post-operative scan does not translate into good clinical outcome. Deep hematomas are inaccessible, and it is believed that the surgical path to evacuate them might add to the existing damage. Therefore, most neurologists are more likely to adopt conservative treatment rather than surgically removing the deep hematoma. The only conclusive evidence for surgical evacuation remains for cerebellar hematomas > 3 cm [8] and lobar hematomas close

* Corresponding author.
E-mail addresses: dr.ajayhegde@gmail.com (A. Hegde), girish.menon@manipal.edu (G. Menon), vinodneuro@gmail.com (V. Kumar).

https://doi.org/10.1016/j.clineuro.2019.105415
Received 7 May 2019; Received in revised form 1 July 2019; Accepted 5 July 2019
Available online 11 July 2019

the (< 1 cm) the surface [9].

The first randomised trial was published in 1961 by McKissock [10] which concluded that surgery might worsen outcomes in ICH. Treatment of ICH has been based on the findings of this study for almost half a century. Later on Fernandes et al. in 2000 and a few others, observed benefits from surgery with a reduction in death and dependency by a factor of 0.63[11,12]. The landmark International Surgical Trial in Intracerebral Haemorrhage (STICH) in 2005, again had a negative effect on surgery. A decade after the STICH trial, the 2015 guidelines for the management of ICH formulated surgical guidelines largely based on the conclusions of the STICH trial [8].

The results of the STICH I trial has had such a detrimental impact that it led to a significant reduction in the hematoma evacuation surgeries in Newcastle from 32% in 2002 to 17% in 2007 [13]. However, in the United States, surgical evacuation rates have remained more or less constant throughout the decade [14]. There appear to be huge variations existing between different regions concerning hematoma evacuation surgeries, with evacuation rates as high as 74% in Lithuania and as low as 2% in Hungary [4]. The ethical issues and cost have further diminished the interest of clinicians to perform a prospective surgical randomised control trial. The Early Surgery versus Initial Conservative Treatment in Patients with Traumatic Intracerebral Hemorrhage (STITCH trauma) trial is a good failed example of this effort where the study did not recruit the said number of patients due to concerns over funding [15]. Most of the other studies, have been small case series and only 14 planned and systematic trials have been conducted and a total of fewer than 5000 patients have been studied as part of a trial so far on this rather common medical emergency [9–11,16–22]. Of late, there has also been a renewed interest in decompressive craniectomy for ICH on lines of its ischemic counterpart with an international multicentric trial, the Swiss Trial of Decompressive Craniectomy Versus Best Medical Treatment of Spontaneous Supratentorial Intracerebral Hemorrhage (SWITCH) in progress. (23)

However, several recent studies have renewed interest in surgery for ICH and have had a positive impact on surgery [22,24–28] This article is an attempt to retrospectively analyse our Spontaneous Intracerebral haemorrhage (SICH) register and compare the outcomes of surgical and conservative management of patients with ICH having a clot volume above 30 ml.

2. Materials and methods

This was a retrospective study conducted at Kasturba Medical College, Manipal between January 2015 and December 2017. A total of 624 patients were admitted with spontaneous intracerebral haemorrhage were treated during this period. All patient data and follow up details were recorded prospectively in an online SICH register maintained at our hospital. Patients with supratentorial hematoma volume > 30 ml, GCS ≥ 5 and age less than 70 were included in this study. Patients with haemorrhage secondary to vascular malformations, aneurysms, coagulation abnormalities and traumatic hematomas were excluded. A computed tomography (CT) of the brain was performed at the time of admission and 24 h in conservatively managed cases and postoperatively at 12 h in operated cases. Hematoma volume was calculated by the axbxc/2 method [29]. Surgical intervention was offered to all patients admitted within the above inclusion criteria as a part of our protocol to manage large supratentorial hematomas after explaining the risks, benefits and probable long term permanent disability. Surgery at our centre involved mini craniotomy or a large fronto temporo parietal decompressive craniectomy. Hematoma evacuation through the middle frontal gyrus through a small cortisectomy / trans – sulcal was the standard treatment in both techniques. Conservative management was continued for all patients who refused surgical evacuation of hematoma and best medical management prescribed by the 2015 AHA guidelines were followed [8]. This included blood pressure control with intravenous and oral anti-hypertensives with a target blood pressure of 140mmhg, intubation and ventilation of patients with GCS ≤ 8, intravenous sedation with midazolam and morphine; anti-edema measures intravenous 20% mannitol 2 g iv/day for three days in tapered dosing. Oedema when persisting after the third day, intravenous 3% hypertonic saline was administered for five days with regular monitoring of serum osmolality and sodium levels. Outcome was measured using the modified ranking score at discharge and 90 days. Patients who failed to attend the clinic were evaluated with a telephonic mRS [30]. Good outcome was defined as an mRS of 0–3 and poor outcome as 4–6 at 90 days.

A total of 119 patients fulfilled the above criteria and were included in our analysis. While 72 patients underwent surgical evacuation of hematoma, 47 patients were managed conservatively. Preoperative clinical, radiological and postoperative outcome were compared between the two groups. Descriptive statistics mean, median and standard deviation were reported for continuous variables. Student *t*-test applied for continuous variables and Chi-Square test was used for categorical data. A p value of < 0.05 was considered significant. Binary Logistic regression in step forward method was applied to determine the independent predictors of mortality in our cohort. Cox regression survival analysis was done to report any survival advantage among the two groups.

3. Results

Our study included 119 patients, with a mean age of 52.97 + 10.22 years, predominantly male dominated (98:21). The group was dichotomized into two groups A & B based on the management. Seventy-two (60.5%) patients underwent surgical intervention, 54 in the form of mini craniotomy and 18 decompressive craniectomies. There was no difference in the mortality or outcome concerning these two surgical techniques (p = 0.8). The remaining 47 (39.5%) were managed by the best possible conservative means described earlier. The mean age in Group A was 51.01 years and 55.89 years in group B (P = 0.012). The median GCS in the two groups were 9 and ten respectively. Other demographic and clinical parameters of the two groups are summarised in Table 1.

Majority of the hematomas were located in the basal ganglia region (84.03%). The side of the hematoma did not influence our choice of management (p = 0.957) (Table 2). Larger hematomas > 40 ml were predominantly managed surgically. The volume of hematoma in the surgical group was 46.5 ± 14.9 ml in comparison to 38.53 ± 10.84 ml in the medically managed group (p = 0.002). Intraventricular extension was noted in 44 patients in the surgical group and 27 in the medically managed group (p = 0.69). Median mRS at discharge and 90 days were nearly identical, and there was no significant difference in the dichotomised outcome among the two

Table 1
Demographic, risk factors and clinical presentation of our group.

	Surgery (72)	Conservative (47)	P
Age in years (mean)	51.01	55.89	0.012
< 50 years	36 (69.2%)	16 (30.8%)	0.086
> 50 years	36 (53.7%)	31 (46.3%)	
Sex			
Male	62 (63.2%)	36 (37.7%)	0.183
Female	10 (45.4%)	11 (54.6%)	
Hypertension	44 (65.6%)	23 (34.4%)	0.191
Diabetes Mellitus	12 (46.1%)	14 (53.9%)	0.09
Ecospirin	5 (62.5%)	3 (37.5%)	0.889
Systolic Blood Pressure (mmHg)	180.97	182.97	0.806
Diastolic Blood Pressure (mmHg)	102.64	102.34	0.908
GCS	9 (47.3%)	10 (52.7%)	0.095
GCS < 8	35 (71.4%)	14 (28.6%)	0.04
Blood Glucose on admission (mg/dL)	176.49	167.65	0.759

Table 2
Radiological parameters of our dichotomised cohort.

	Surgery (72)	Conservative (47)	P
Side			0.957
Right	41 (60.3%)	27(39.7%)	
Left	31 (60.8%)	20 (39.2%)	
Volume of hematoma(ml)	46.5	38.53	0.002
30–40 ml	35 (49.3%)	36 (50.7%)	0.013
41–50 ml	15 (71.4%)	7 (28.6%)	
51–80ml	20 (83.3%)	4 (16.6%)	
> 81ml	2 (100%)	0	
Intraventricular extension	44 (62%)	27 (38%)	0.69
Growth	6 (75%)	2 (25%)	0.363
Hydrocephalus	14 (48.3%)	15 (51.7%)	0.121
External ventricular drain	1 (20%)	4 (80%)	0.05
Location			0.201
Lobar	9 (47.4%)	10 (52.6%)	
Basal Ganglia	63 (63%)	37 (37%)	

Table 3
Outcome parameters.

	Surgery (72)	Conservative (47)	P
mRS at Discharge	5	5	0.805
mRs at 3 months	4	6	0.371
Alive	49 (71%)	20 (29%)	0.006
Dead at 3 months	23 (46%)	27 (54%)	
Good Outcome	19 (61.3%)	12 (38.7%)	
Bad Outcome	53 (60.2%)	35 (39.8%)	0.917

different management cohorts ($p > 0.05$) (Table 3).

Mortality at 90 days was 27/47 (57.44%) in the medically managed group while 23/72 (31.9%) in the surgical group ($p = 0.006$). Among the dead patients, the mean age was 53 and 59 years ($p = 0.054$), median GCS on admission was 7 and 9 ($p = 0.13$), and hematoma volume was 50.47 ml and 41.59 ml ($p = 0.039$) in the two groups respectively. On further stratification of GCS, 14/27 (51.85%) patients with GCS > 8 died in the medically managed group, while only 5/23 (8.6%) died in the surgical group (0.029). In the medically managed group, 18 deaths were in patients with hematoma volume 30–50 comprising of 66.6% of deaths in this group. Mortality was the highest in the 30–50 ml medically managed group 23/27, and > 51 ml surgical group ($p = 0.024$). Location of Hematoma, survival in days following ictus, IVE and ICH score among the two groups were similar not reaching statistical significance. Admission blood glucose was significantly higher at 201.39 ± 41.24 mg/dl in the surgical group compared to 164.54 ± 56.01 mg/dl in the medically managed group. (Table 4). It was also observed that patients with medically managed smaller hematomas (31–40 ml) had a mean survival of 20.05 days in comparison to a mean hospital stay of 13.05days. Binary logistic regression was performed to assesses independent predictors of mortality in our cohort. Age of the patient, GCS on presentation and medical management were independent predictors of mortality, while the volume of hematoma and intraventricular extension failed to reach statistical significance. Medical management had the highest odds of death at 4.67 (Table 5). The accuracy of this model was 73.1% with a sensitivity of 82.6% and specificity of 60%. Cox Regression analysis for survival at 90 days adjusted for age and GCS showed a survival advantage in the surgical group (Fig. 1).

4. Discussion

Multiple trials and studies have tried to address the role of surgery in primary ICH, the most notable among them being the STICH trials [9,11,17,19,22,31,32]. A fair summary of STICH I trial is that except for possibly those with superficial ICHs, craniotomy at one day or longer after onset is not better than standard medical management with

Table 4
Subgroup analysis of deceased patients in both the groups.

	Surgical Group (n = 23)	Medical Group (n = 27)	P
Age			
Mean (years)	53	59	0.054
30–40 years	2 (66.7%)	1 (33.3%)	0.449
41–50 years	8 (57.1%)	6 (42.9%)	
51–60 years	6 (50%)	6 (50%)	
> 61 years	7 (33.3%)	14 (66.7%)	
Glasgow Coma Scale			
Mean	7	9	0.13
GCS 4–8	18(58.1%)	13 (41.9%)	0.029
GCS 9–15	5(26.3%)	14 (73.7%)	
Side			
Right	13 (46.4%)	15(53.6%)	0.945
Left	10(45.5%)	12(54.5%)	
Hematoma Volume			
Mean (ml)	50.47	41.59	0.039
30–50	13(36.1%)	23(63.9%)	0.024
> 51	10(71.4%)	4(28.6%)	
Location			
Deep Hemorrhage	22(48.9%)	23(51.1%)	0.219
Lobar Hemorrhage	1(20%)	4(80%)	
Intraventricular Extension	18(47.4%)	20(52.65%)	0.73
ICH Score (mean)	2.7	2.5	0.205
Survival Days	18.34	14.81	0.047
Blood Glucose	201.39	164.54	0.013
Mortality			
At Discharge	9 (42.9%)	12 (57.1%)	
After Discharge	14 (48.2%)	15 (51.8%)	

Table 5
Logistic Regression analysis of factors influencing mortality.

Parameter	OR	p	95%CI
Glasgow coma score	0.658	< 0.001	0.545–0.793
Age	1.074	0.003	1.025–1.125
Medical Management	4.679	0.003	1.715–12.765

delayed surgery if necessary [9]. STICH I and the subsequent STICH II trials were subjected to widespread criticisms especially with regards to the timing of surgery, large crossovers from medical arm to surgical arm and the fact that minimally invasive techniques were hardly used. A Cochrane review by Prasad et al. which included ten trials concluded

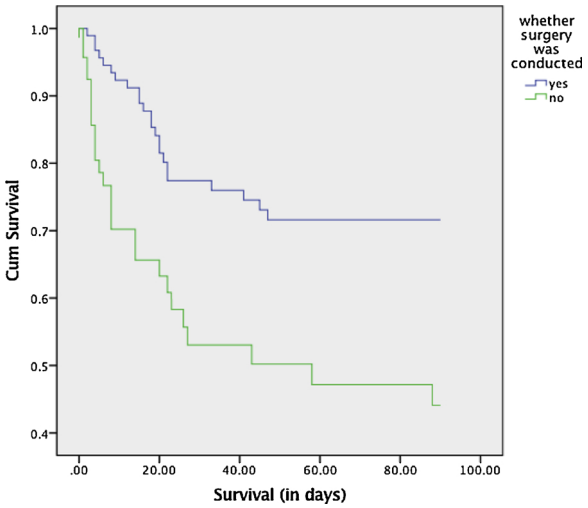

Fig. 1. Cox Regression analysis for conservative and surgical management adjusted for age and GCS on presentation.

that surgery added to medical management reduces the odds of being dead or dependent compared with medical management alone (OR = 0.71, 95% confidence interval (CI) 0.58 to 0.88; p = 0.001). [33].

Age, GCS on presentation, the volume of hematoma, are well-established predictors of poor outcome in ICH [34,35]. Our logistic regression model determined Age, GCS and medical management as predictors of mortality. In our study, we retrospectively analysed patients < 70 years with hematoma volumes > 30 ml and GCS > 5. Patients above 70 years and GCS of ≤4 are known to have a poor outcome and were excluded from this study cohort [36]. A subgroup analysis of the STICH data was attempted by Gregson et al. to pool all available original data from all available surgical trials to carry out an individual patient data meta-analysis [37]. The meta-analysis concluded that the outcome is better if surgery is done within 8 h of ictus (p = 0.003), volume of the haematoma is 20–50 ml. (p = 0.004), GCS is between 9 and 12 (p = 0.0009), patient is aged between 50 and 69 (p = 0.01) and the hematoma is superficial with no IVH (p = 0.09). In our study, median GCS of patients who were operated was nine while those managed conservatively was 10 (P = 0.09). 35/49 (71.4%) of the patients with GCS < 8 were taken up for surgery while the remaining 14/49 were managed conservatively. In spite of this disparity medically managed group accounted for 73.7% (14/19) of the mortality in patients with GCS 9–15.

Volume of hematoma is also an important predictor of mortality in ICH. [38,39] However, in our study, it failed to be an independent predictor of mortality as our study comprised of patients with hematoma volume > 30 ml. In this cohort, smaller hematomas had a higher probability of being managed conservatively (46.5 ml vs 38.5 ml, p = 0.002). This bias could be explained by the fact that smaller hematomas present with better GCS on presentation and family members often refuse surgical intervention and opt-in for conservative management after considering the risk/benefit ratio of surgery. Our study had a total of 71 patients with hematoma volume 30–40 ml. Of these, 35 were managed surgically and 36 were managed conservatively. Mortality was 9/35 (25.7%) in the surgical group and 18/36 (50%) in the medically managed group. These patients tend to have a higher mortality than their surgical counterparts. Similarly, in the 41–50 ml sub group, 4/15 (26.6%) patients in the surgical group and 5/7 (71.4%) in the medical cohort succumbed at 90 days. Larger hematomas were predominantly managed surgically with more mortality in the surgical group. Although smaller hematomas were managed conservatively larger number of deaths were reported in this group. In our group of 27 medically managed patients who died, 18 were with volume 30–40 and nine were with volume > 41 ml. The mean duration of survival in these two groups were 22.94 + 22.94 days and 4.33 + 4.44 days. In addition to the above analysis, we noticed medically managed (between 30–40 ml) patients who succumbed to the illness, survived for an average of seven days following their discharge.

We could presume that the higher rates of mortality in conservatively managed smaller hematomas could be secondary to perihematomal oedema [40,41] which increases rapidly in the first 48 h and reaches its peak at two weeks following haemorrhage [42]. Surgery remains at the forefront in combating oedema by clot evacuation as mentioned by several authors [43,44]. It improves CBF on the ipsilateral side as shown in a single-photon-emission computed tomography (SPECT) study [45]. Hematoma growth is another important cause of deterioration in patients with small hematomas but more common within the first few hours [8,46]. A total of 8 patients had hematoma expansion and two of these were in the medically managed group. While 2/2 (100%) of these patients managed conservatively died, 6/6 (100%) survived following surgery.

Previous studies have shown that the SICH patients with intraventricular extension were more likely to have a poor outcome in previous studies [47]. In our study, IVE was seen in 44/72 (61.1%) patients in the surgically managed group and 27/47 (57.44%) in the medical treatment arm. It also did not have any association with mortality (P = 0.73). Similarly, blood glucose has been a poor outcome predictor in several studies [48–50]. Blood glucose in our dead subgroup of surgical patients was higher than the medically managed group. This is following the author's article that higher glucose levels are a consequence of the severity of SICH [51].

In spite of the difference in numbers in the two groups, surgery offered a definite survival advantage over the medically managed group. (49/72, 68.05% in the surgical group vs 20/47, 42.55% in the medical group, p = 0.006). However, functional outcome measured by the mRS score did not show any statistical significance at 90 days (Good Outcome 19 vs 12, Poor Outcome 53 vs 35) in the two dichotomised groups. Medically managed patients with smaller hematomas and better GCS had higher rates of mortality.

Limitations :

This is a retrospective observational study from an ICH register and is bound to have flaws. Patients with smaller hematomas and better GCS were managed conservatively in comparison to their surgical cohort. mRS was measured at 90 days, which is a short duration to assess functional outcome in ICH after surgery. Perihematoma oedema could not be measured volumetrically.

5. Conclusion

Surgical Evacuation of spontaneous intracerebral haemorrhage has a definite survival advantage at 90 days. It failed to demonstrate and quantifiable improvement in functional outcome. It helps reduce mortality in moderate-sized hematomas (30–50 ml) by combating delayed perihematomal oedema. Well-designed large volume randomised control trials focussing on newly developed minimally invasive surgical techniques are essential to re-establish the supremacy of meticulous surgical evacuation in improving survival and functional outcome in ICH.

Data availability

The data used to support the findings of this study are available from the corresponding author upon request.

Funding statement

The authors did not receive any funding for this study.

References

[1] A.I. Qureshi, A.D. Mendelow, D.F. Hanley, Intracerebral haemorrhage, Lancet 373 (May 9675) (2009) 1632–1644 Elsevier.
[2] J.P. Broderick, T. Brott, T. Tomsick, R. Miller, G. Huster, Intracerebral hemorrhage more than twice as common as subarachnoid hemorrhage, J. Neurosurg. 78 (February 2) (1993) 188–191 Journal of Neurosurgery Publishing Group.
[3] R. Fogelholm, K. Murros, A. Rissanen, S. Avikainen, Long term survival after primary intracerebral haemorrhage: a retrospective population based study, J. Neurol. Neurosurg. Psychiatr. 76 (November 11) (2005) 1534–1538 BMJ Publishing Group Ltd.
[4] B.A. Gregson, A.D. Mendelow, STICH Investigators. International variations in surgical practice for spontaneous intracerebral hemorrhage, Stroke 34 (November 11) (2003) 2593–2597. American Heart Association, Inc.
[5] J. Broderick, S. Connolly, E. Feldmann, D. Hanley, C. Kase, D. Krieger, et al., Guidelines for the management of spontaneous intracerebral hemorrhage in adults: 2007 update: a guideline from the american heart Association/American stroke association stroke council, high blood pressure research council, and the quality of care and outcomes in research interdisciplinary working group: the american academy of neurology affirms the value of this guideline as an educational tool for neurologists, Stroke 38 (May 6) (2007) 2001–2023. American Heart Association, Inc.
[6] M.N. Carvi y Nievas, Why, when, and how spontaneous intracerebral hematomas should be operated, Med. Sci. Monit. 11 (January 1) (2005) RA24–31 International Scientific Information, Inc.
[7] R. Thiex, S.E. Tsirka, Brain edema after intracerebral hemorrhage: mechanisms, treatment options, management strategies, and operative indications, Neurosurg. Focus. Am. Assoc. Neurol. Surg. 22 (May 5) (2007) 1–7.
[8] J.C. Hemphill, S.M. Greenberg, C.S. Anderson, K. Becker, B.R. Bendok, M. Cushman,

et al., Guidelines for the management of spontaneous intracerebral hemorrhage: a guideline for healthcare professionals from the american heart Association/ American stroke association, Stroke 46 (2015) 2032–2060. American Heart Association, Inc;.
[9] A.D. Mendelow, B.A. Gregson, E.N. Rowan, G.D. Murray, A. Gholkar, P.M. Mitchell, Early surgery versus initial conservative treatment in patients with spontaneous supratentorial lobar intracerebral haematomas (STICH II): a randomised trial, Lancet 382 (August 9890) (2013) 397–408 Elsevier.
[10] W. Mckissock, A. Richardson, L. Walsh, Primary intracerebral hæmorrhage results of surgical treatment in 244 consecutive cases, Lancet 274 (October 7105) (1959) 683–686.
[11] H.M. Fernandes, B. Gregson, S. Siddique, A.D. Mendelow, Surgery in intracerebral hemorrhage, Stroke 31 (October 10) (2000) 2511–2516. American Heart Association, Inc.
[12] K. Minematsu, Evacuation of intracerebral hematoma is likely to Be beneficial, Stroke 34 (June 6) (2003) 1567–1568. American Heart Association, Inc.
[13] M.A. Kirkman, W. Mahattanakul, B.A. Gregson, A.D. Mendelow, The effect of the results of the STICH trial on the management of spontaneous supratentorial intracerebral haemorrhage in Newcastle, Br. J. Neurosurg. 22 (July 6) (2009) 739–746. Taylor & Francis.
[14] O. Adeoye, A. Ringer, R. Hornung, P. Khatri, M. Zuccarello, D. Kleindorfer, Trends in surgical management and mortality of intracerebral hemorrhage in the United States before and after the STICH trial, Neurocrit. Care 13 (August 1) (2010) 82–86 Humana Press Inc.
[15] A.D. Mendelow, B.A. Gregson, E.N. Rowan, R. Francis, E. McColl, P. McNamee, et al., Early surgery versus initial conservative treatment in patients with traumatic intracerebral hemorrhage (STITCH[Trauma]): the first randomized trial, J. Neurotrauma 32 (September 17) (2015) 1312–1323 Mary Ann Liebert, Inc. 140 Huguenot Street, 3rd Floor New Rochelle, NY 10801 USA.
[16] A.M. Naidech, R.A. Bernstein, S.L. Bassin, R.K. Garg, S. Liebling, B.R. Bendok, et al., How patients die after intracerebral hemorrhage, Neurocrit. Care 11 (February 1) (2009) 45–49 Humana Press Inc.
[17] A.D. Mendelow, B.A. Gregson, H.M. Fernandes, G.D. Murray, G.M. Teasdale, D.T. Hope, et al., Early surgery versus initial conservative treatment in patients with spontaneous supratentorial intracerebral haematomas in the International Surgical Trial in Intracerebral Haemorrhage (STICH): a randomised trial, Lancet 365 (January 9457) (2005) 387–397 Elsevier.
[18] M. Zuccarello, T. Brott, L. Derex, R. Kothari, L. Sauerbeck, J. Tew, et al., Early surgical treatment for supratentorial intracerebral hemorrhage: a randomized feasibility study, Stroke. 30 (September 9) (1999) 1833–1839.
[19] O.P.M. Teernstra, Evers SMAA, J. Lodder, P. Leffers, C.L. Franke, G. Blaauw, Stereotactic treatment of intracerebral hematoma by means of a plasminogen activator, Stroke 34 (April 4) (2003) 968–974. American Heart Association, Inc.
[20] G. Pantazis, P. Tsitsopoulos, C. Mihas, V. Katsiva, V. Stavrianos, S. Zymaris, Early surgical treatment vs conservative management for spontaneous supratentorial intracerebral hematomas: a prospective randomized study, Surg. Neurol. 66 (November 5) (2006) 492–501 discussion501–2.
[21] N. Hattori, Y. Katayama, Y. Maya, A. Gatherer, Impact of stereotactic hematoma evacuation on activities of daily living during the chronic period following spontaneous putaminal hemorrhage: a randomized study, J. Neurosurg. J. Neurosurg. Publ. Group 101 (September 3) (2004) 417–420.
[22] J. Zheng, H. Li, H.-X. Zhao, R. Guo, S. Lin, W. Dong, et al., Surgery for patients with spontaneous deep supratentorial intracerebral hemorrhage: a retrospective case-control study using propensity score matching, Bull. Sch. Med. Md 95 (March 11) (2016) e3024.
[23] J. Beck, C. Fung, Swiss Trial of Decompressive Craniectomy Versus Best Medical Treatment of Spontaneous Supratentorial Intracerebral Hemorrhage (SWITCH): a Randomized …. (2014).
[24] Y.T. Lo, A.A.Q. See, N.K.K. King, Decompressive craniectomy in spontaneous intracerebral hemorrhage: a case-control study, World Neurosurg. 103 (July) (2017) 815–820 e2.
[25] A.R. Satter, M.R. Islam, M.R. Haque, E. Mahmood, M.Z. Rahman, N. Barman, et al., Comparison between Decompressive Craniectomy with Durotomy and conservative treatment in spontaneous supratentorial intracerebral hemorrhage, Mymensingh Med. J. 25 (April 2) (2016) 316–325.
[26] H.-T. Kim, J.-M. Lee, E.-J. Koh, H.-Y. Choi, Surgery versus conservative treatment for spontaneous supratentorial intracerebral hemorrhage in spot sign positive patients, J. Korean Neurosurg. Soc. 58 (October 4) (2015) 309–315.
[27] M.K. Bhaskar, R. Kumar, B. Ojha, S.K. Singh, N. Verma, R. Verma, et al., A randomized controlled study of operative versus nonoperative treatment for large spontaneous supratentorial intracerebral hemorrhage, Neurol. India 65 (July 4) (2017) 752–758.
[28] P. Mandava, S.B. Murthy, N. Shah, Y. Samson, M. Kimmel, T.A. Kent, Pooled analysis suggests benefit of catheter-based hematoma removal for intracerebral hemorrhage, Neurology 92 (April 15) (2019) e1688–97.
[29] R.U. Kothari, T. Brott, J.P. Broderick, W.G. Barsan, L.R. Sauerbeck, M. Zuccarello, et al., The ABCs of measuring intracerebral hemorrhage volumes, Stroke 27 (August 8) (1996) 1304–1305.
[30] A. Bruno, B. Close, J.A. Switzer, D.C. Hess, H. Gross, F.T. Nichols, et al., Simplified modified Rankin Scale questionnaire correlates with stroke severity, Clin. Rehabil. 27 (August 8) (2013) 724–727.
[31] L.M. Auer, W. Deinsberger, K. Niederkorn, G. Gell, R. Kleinert, G. Schneider, et al., Endoscopic surgery versus medical treatment for spontaneous intracerebral hematoma: a randomized study, J. Neurosurg. Publ. Group 70 (April (4)) (1989) 530–535 http://dxdoiorg/103171/jns19897040530.
[32] Seppo Juvela, Olli Heiskanen, Antti Poranen, Simo Valtonen, Timo Kuurne, Markku Kaste, et al., The treatment of spontaneous intracerebral hemorrhage, J. Neurosurg. Publ. Group 70 (May 5) (2009) 755–758 http://dxdoiorg/103171/jns19897050755.
[33] K. Prasad, A.D. Mendelow, B. Gregson, K. Prasad (Ed.), Surgery for Primary Supratentorial Intracerebral Haemorrhage, John Wiley & Sons, Ltd, Chichester, UK, 2008.
[34] S. Sacco, C. Marini, D. Toni, L. Olivieri, A. Carolei, Incidence and 10-year survival of intracerebral hemorrhage in a population-based registry, Stroke 40 (February 2) (2009) 394–399. American Heart Association, Inc.
[35] R.T.F. Cheung, L.Y. Zou, Use of the original, modified, or new intracerebral hemorrhage score to predict mortality and morbidity after intracerebral hemorrhage, Stroke 34 (July 7) (2003) 1717–1722.
[36] A. Hegde, G. Menon, Modifying the intracerebral hemorrhage score to suit the needs of the developing world, Ann. Indian Acad. Neurol. 21 (October 4) (2018) 270 Medknow Publications.
[37] B.A. Gregson, J.P. Broderick, L.M. Auer, H. Batjer, X.-C. Chen, S. Juvela, et al., Individual patient data subgroup meta-analysis of surgery for spontaneous supratentorial intracerebral hemorrhage, Stroke 43 (June 6) (2012) 1496–1504. American Heart Association, Inc.
[38] G. Bilbao, J. Garibi, I. Pomposo, J.I. Pijoan, A. Carrasco, G. Catalán, et al., A prospective study of a series of 356 patients with supratentorial spontaneous intracerebral haematomas treated in a Neurosurgical Department, Acta Neurochir. (Wien) 147 (August 8) (2005) 823–829 Springer-Verlag.
[39] J.C. Hemphill, D.C. Bonovich, L. Besmertis, G.T. Manley, S.C. Johnston, The ICH score, Stroke 32 (April 4) (2001) 891–897. American Heart Association, Inc.
[40] S.B. Murthy, Y. Moradiya, J. Dawson, K.R. Lees, D.F. Hanley, W.C. Ziai, et al., Perihematomal edema and functional outcomes in intracerebral hemorrhage: influence of hematoma volume and location, Stroke 46 (November 11) (2015) 3088–3092 Lippincott Williams & Wilkins Hagerstown, MD.
[41] G. Appelboom, S.S. Bruce, Z.L. Hickman, B.E. Zacharia, A.M. Carpenter, K.A. Vaughan, et al., Volume-dependent effect of perihaematomal oedema on outcome for spontaneous intracerebral haemorrhages, J. Neurol. Neurosurg. Psychiatr. 84 (April 5) (2013) 488–493.
[42] C. Venkatasubramanian, M. Mlynash, A. Finley-Caulfield, I. Eyngorn, R. Kalimuthu, R.W. Snider, et al., Natural history of perihematomal edema after intracerebral hemorrhage measured by serial magnetic resonance imaging, Stroke 42 (January 1) (2011) 73–80 Lippincott Williams & Wilkins Hagerstown, MD.
[43] M.K. Mittal, A. LacKamp, Intracerebral hemorrhage: perihemorrhagic edema and secondary hematoma expansion: from bench work to ongoing controversies, Front. Neurol. 7 (Suppl 1) (2016) 210.
[44] B. Orakcioglu, K. Becker, O.W. Sakowitz, C. Herweh, M. Köhrmann, H.B. Huttner, et al., MRI of the Perihemorrhagic Zone in a rat ICH model: effect of hematoma evacuation, Neurocrit. Care 8 (January 3) (2008) 448–455 Humana Press Inc.
[45] M.S. Siddique, H.M. Fernandes, N.U. Arene, T.D. Wooldridge, J.D. Fenwick, A.D. Mendelow, Changes in cerebral blood flow as measured by HMPAO SPECT in patients following spontaneous intracerebral haemorrhage, Acta Neurochir. Suppl. (Wien) 76 (2000) 517–520.
[46] H.B. Brouwers, Y. Chang, G.J. Falcone, X. Cai, A.M. Ayres, T.W.K. Battey, et al., Predicting hematoma expansion after primary intracerebral hemorrhage, JAMA Neurol. Am. Med. Assoc. 71 (February 2) (2014) 158–164.
[47] D.F. Hanley, Intraventricular hemorrhage, Stroke 40 (April 4) (2009) 1533–1538. American Heart Association, Inc.
[48] S. Sun, Y. Pan, X. Zhao, L. Liu, H. Li, Y. He, et al., Prognostic value of admission blood glucose in diabetic and non-diabetic patients with intracerebral hemorrhage, Sci. Rep. 6 (August 1) (2016) 32342 Nature Publishing Group.
[49] E.-C. Song, K. Chu, S.-W. Jeong, K.-H. Jung, S.-H. Kim, M. Kim, et al., Hyperglycemia exacerbates brain edema and perihematomal cell death after intracerebral hemorrhage, Stroke. Am. Heart Assoc., Inc 34 (September 9) (2003) 2215–2220.
[50] D.A. Godoy, G.R. Piñero, S. Svampa, F. Papa, M. Di Napoli, Hyperglycemia and short-term outcome in patients with spontaneous intracerebral hemorrhage, Neurocrit. Care 9 (February 2) (2008) 217–229 Humana Press Inc.
[51] L.I. Kongwad, A. Hegde, G. Menon, R. Nair, Influence of admission blood glucose in predicting outcome in patients with spontaneous intracerebral hematoma, Front Neurol. Frontiers 9 (August) (2018).