Intracranial Hypertension in Subarachnoid Hamorrhage: Outcome After Decompressive Craniectomy

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Absrtact Intracranial hypertension can occur following aneurysmal subarachnoid haemorrhage (SAH). It can be treated with decompressive craniectomy (DC) with the aim of reducing intracranial pressure, increasing cerebral perfusion and reducing further morbidity and mortality. We studied the outcome of patients undergoing DC following SAH at our institution, to ascertain whether the use of this treatment can be rationalized.

Keywords Subarachnoid hemorrhage • Intracranial hypertension • Decompressive craniectomy

Introduction

Raised intracranial pressure can occur following subarachnoid hemorrhage for a number of different reasons and at variable times after the ictus. Surgical treatment strategies to manage this problem include hematoma evacuation, CSF drainage and, in cases of refractory intracranial hypertension, DC (unilateral or bifrontal) can be considered. While outcome with this treatment has been, and still is, the subject of prospective randomized trials in trauma and also in ischaemia, less is known about its associated outcome following aneurysmal subarachnoid hemorrhage [1–3]. The aetiology of the raised pressure can determine the most appropriate treatment(s). We sought to identify whether the time from ictus or the aetiology of the raised pressure had an effect on outcome, with the aim of providing guidance for when to consider the use of DC in this patient group.

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Materials and Methods

Our database of patients admitted with SAH and our operating theater records were examined to determine which patients had undergone a decompressive craniectomy. Those included were diagnosed with SAH using computed tomography (CT) or lumbar puncture and had aneurysms confirmed with the use of either CT and/or digital subtraction angiography (DSA). The electronic patient records system was used to retrieve medical records for clinical information, including outcome assessment, and the Picture Archiving and Communications System (PACS) to review patients' scan images and reports.

It was determined that those undergoing DC had raised intracranial pressure (ICP), either by intra-operative assessment by the surgeon at the time of microsurgical clipping, or using intra-parenchymal monitoring in the intensive care unit (either Codman ICP Monitoring System, Codman & Shurtleff, Inc, USA or Raumedic NEUROVENT-P-TEMP Monitor, Raumedic AG, Germany).

Patients undergoing DC have been subdivided into those with and those without a hematoma requiring evacuation as part of the procedure.

Results

During the four-year period from January 2007 to December 2010, 665 patients were admitted with aneurysmal SAH, of whom 607 underwent treatment for their aneurysm(s). Of these 607 patients, 117 (19.3 %) underwent microsurgical clipping and 490 (80.7 %) underwent endovascular coiling. Decompressive hemi-craniectomies were performed in 20 patients, with two of them undergoing bifrontal decompressive craniectomies following SAH. The pathway to decompression varied within the group, with some undergoing decompression at the time of aneurysm treatment, others prior to it, and some in a delayed fashion.

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Table 1 Patient characteristics and treatment method

		All patients	Hematoma evacuated	No Hematoma evacuated
Number		22	13	9
Age (median)		43.1	50.6	40.3
Sex (F:M)		14:8	9:4	5:4
WFNS grade N (%)	1	2 (9)	0	2 (22)
	2	1 (5)	1 (8)	0
	3	1 (5)	1 (8)	0
	4	8 (36)	6 (46)	2 (22)
	5	10 (45)	5 (38)	5 (56)
Aneurysm treatment N (%)	Clip	11 (50)	8 (61.5)	3 (33)
	Coil	9 (41)	4 (30.8)	5 (56)
	None	2 (9)	1 (7.7)	1 (11)

Table 2 Outcome following SAH and decompressive craniectomy

	All patients	Hematoma evacuated	No hematoma evacuated
GOS	N (%)	N (%)	N (%)
1	11 (50)	6 (46.2)	5 (56)
2	0	0	0
3	4 (18)	3 (23.1)	1 (11)
4	2 (9)	2 (15.4)	0
5	5 (23)	2 (15.4)	3 (33)

Table 1 shows the patients' characteristics subdivided into those with and those without a hematoma evacuated at the time of DC. There was a median age of 43.1 and a preponderance of females. The majority who underwent a DC were admitted with a poor WFNS grade. This is not an unexpected finding given that this measure is usually utilized in those with a life-threatening hematoma or uncontrollable ICP, which are more likely to be observed in those admitted with a worse clinical grade. A higher proportion of those undergoing hematoma evacuation in addition to decompression had their aneurysms clipped rather than coiled, which was the reverse of the group with no hematoma evacuated.

Table 2 shows the Glasgow Outcome Scale (GOS) for those patients who underwent a DC, including the breakdown by whether the surgery included hematoma evacuation. This demonstrates a wide variability in outcome in the two subgroups in addition to the total patient group. There was no statistical significance in outcome between the two subgroups ($p=0.63$). The outcome (GOS 1–3 = poor and 4–5 = good) when measured against the time from ictus to decompression, as seen in Fig. 1, also did not show a statistical significance ($p=0.762$).

The median follow-up was 1 year (range 6.5–16.3 months) in survivors. All deaths occurred within 30 days (median of 7 days, range 1–90) except for one, which occurred 3 months after the subarachnoid hemorrhage.

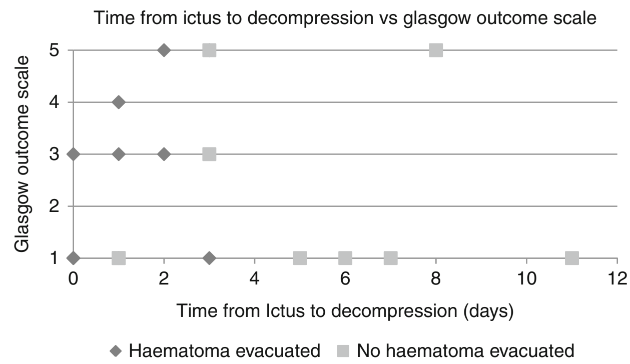

Fig. 1 Scatter graph demonstrating outcome for the two subgroups

The size of the craniectomy performed varied, with the maximum diameter being larger than 12 cm in 10 of 22 patients, smaller than 12 cm in 9, and unknown in 3. There was no significant difference in outcome based upon the whether the bone flap was larger or smaller than 12 cm ($p=0.78$).

A relationship was identified whereby worse WFNS grades were associated with poorer outcomes ($p=0.04$). However, patient age did not have a significant association with outcome in this series ($p=0.61$).

Discussion

This group of 22 patients with SAH and undergoing DC demonstrates a wide variance in outcome. No significant difference was observed in either of the two subsets with and without hematoma evacuation, or with time of ictus to decompression. However, there was an association between WFNS grade and outcome. There have been a number of other case groups of patients undergoing DC after SAH that have identified other significant variables affecting outcome.

A study of 16 patients by Clemens et al. showed a significant difference in outcome for those undergoing early DC (<48 h after ictus) with 6 of 8 patients having a good outcome, compared to only 1 of 8 in whom late decompressions were performed [4]. However, the larger case series of 79 patients undergoing decompressive craniectomies after SAH, by Guresir et al., found that it was the time from ICP becoming elevated to decompression rather than from the ictus that provided a significant difference in outcome [5]. In this paper, no significant difference was observed between those undergoing primary versus secondary decompression, and those with brain swelling alone versus bleeding or infarction.

This was in contrast to the group of Dorfer et al., which consisted of 66 patients undergoing DC following SAH. This study found that timing was not a significant factor in predicting outcome, but that there was a difference in outcome depending on the pathology necessitating DC. There was a significantly better neurological outcome in those with a hematoma compared to those with ischaemia [6].

Timing was a significant factor related to outcome in the trials on DC for malignant MCA infarction [3]. The difference in aetiology amongst those undergoing DC following SAH (hematoma, early swelling, delayed ischaemia) may explain why the studies on DC after SAH have not consistently had the same findings. The subset undergoing DC after SAH for ischaemia do not usually have a clear point in time when the ischaemia begins, unlike those in the trials for DC after malignant infarction, which again makes comparisons inappropriate.

It has been previously shown that a larger craniectomy is significantly related to a decrease in intracranial pressure and better outcome [7]. This was not demonstrated in our patient group but the sample may have been subject to selection bias. Some patients underwent surgery for a planned DC following failure of all other treatment modalities to control ICP, whereas others had it performed due to swelling encountered at the time of aneurysm clipping early in their admission. The different operative approach may have influenced the size of the craniectomy performed. A retrospective analysis of 525 decompressive craniectomes performed in seven neurosurgical centres found that only 43 % had bone flaps >12 cm removed. This again, may have been due to a large number in this study undergoing primary decompressions associated with hematoma evacuations. In this study it was found that there was a better outcome in those under the age of 65 undergoing DC with a bone flap >12 cm, although this included other causes, in addition to SAH, for the intracranial hypertension [8].

Our study has demonstrated that some patients can have a good outcome despite their poor clinical state prior to DC. DC following SAH is used rarely used (22 of 665 cases (3.3 %) of SAH over a four year period), which makes analysis of its outcome and associated factors difficult due to the large number of patient variables. While it is clear that a good outcome can be achieved, the majority were not so fortunate, with 50 % of our cohort dying and 18 % being left with a severe disability. There has been variability in the findings from other groups, which may be due to the relatively small numbers and varying indications for DC within this patient group.

Conclusion

A number of different factors have been shown to influence outcome following DC after SAH (WFNS grade, aetiology of intracranial hypertension, timing of surgery). However, study findings have not consistently been replicated. Some patients do appear to benefit from DC following SAH but it would still be difficult, using the studies published so far, to predict outcome accurately enough to determine whether the treatment should be recommended.

Conflict of Intrerest We declare that we have no conflict of interest.

References

1. Cooper DJ, Rosenfeld JV, Murray L, Arabi YM, Davies AR, D'Urso P et al (2011) Decompressive craniectomy in diffuse traumatic brain injury. N Engl J Med 364:1493–1502
2. Hutchinson PJ, Corteen E, Czosnyka M, Mendelow AD, Menon DK, Mitchell P, Murray G, Pickard JD, Rickels E, Sahuquillo J, Servadei F, Teasdale GM, Timofeev I, Unterberg A, Kirkpatrick PJ et al (2006) Decompressive craniectomy in traumatic brain injury: the randomized multicenter RESCUEicp study (www.RESCUEicp.com). Acta Neurochir Suppl 96:17–20
3. Vahedi K, Hofmeijer J, Juettler E, Vicaut E, George B et al (2007) Early decompressive surgery in malignant infarction of the middle cerebral artery: a pooled analysis of three randomised controlled trials. Lancet Neurol 6:215–222
4. Schirmer CM, Hoit DA, Malek AM (2007) Decompressive craniectomy for the treatment of intractable intracranial hypertension after aneurysmal subarachnoid haemorrhage. Stroke 38:987–992
5. Guresir E, Schuss P, Vatter H, Raabe A, Seifert V, Beck J (2009) Decompressive craniectomy in subarachnoid hemorrhage. Neurosurg Focus 26(6):E4
6. Dorfer C, Frick A, Knosp E, Gruber A (2010) Decompressive hemicraniectomy after aneurysmal subarachnoid hemorrhage. World Neurosurg 74:465–471
7. Jiang JY, Xu W, Li WP, Xu WH, Zhang J, Bao YH, Ying YH, Luo QZ (2005) Efficacy of standard trauma craniectomy for refractory intracranial hypertension with severe traumatic brain injury: a multicenter, prospective, randomized controlled study. J Neurotrauma 22:623–628
8. Tagliaferri F, Zani G, Iaccarino C, Ferro S, Ridolfi L, Basaglia N, Hutchinson P, Servadei F (2012) Decompressive craniectomies, facts and fiction: a retrospective analysis of 526 cases. Acta Neurochir 154:919–926