Hemorrhagic complications after decompressive craniectomy

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ABSTRACT

Background: Decompressive craniectomy (DC) is the preferred surgical management option for lowering refractory intracranial pressure in cases of traumatic brain injury (TBI). A number of randomized controlled trials have demonstrated decreased mortality but increased morbidity following DC for TBI patients. Here, we reviewed the frequency of postoperative hemorrhagic complications following DC correlating with poor outcomes.

Methods: We retrospectively reviewed the medical records of patients who presented with TBI and underwent DC during the years 2015–2017. The frequency and characteristics of hemorrhagic complications were correlated with the patients' outcomes.

Results: There were 74 patients with TBI included in the study who underwent DC. Of these, 31 patients developed expansion of existing hemorrhagic lesions, 13 had new contusions, three developed new extradural hemorrhages, two developed new subdural hematomas, and one patient developed an intraventricular hemorrhage. Those who developed expansion of existing hemorrhagic lesions following DC had longer ICU stays and poorer outcomes (Glasgow outcome scale).

Conclusion: After 74 DC performed in TBI patients, 67% developed new hemorrhagic lesions or expansion of previously existing hemorrhages. This finding negatively impacted clinical outcomes, including mortality.

Keywords: Decompressive craniectomy, Glasgow coma scale, Revised trauma score, Traumatic brain injury

INTRODUCTION

Decompressive craniectomy (DC) is increasingly utilized in traumatic brain injury (TBI) patients to control raised ICP refractory to best medical management.[⁵,⁶] Despite the mention of DC in TBI management guidelines, there is still disagreement regarding its indications, optimal timing, and impact on clinical outcomes. Further, DC results in a varied incidence of postoperative complications not fully evaluated in the literature.[⁵,⁶]

Here, we report a single-center experience with DC in patients with TBI by estimating the frequency, type, and clinical outcomes of hemorrhagic complications observed following the performance of DC.
MATERIALS AND METHODS

This was a retrospective review and analysis of 74 patients undergoing DC for raised ICP secondary to severe TBI from 2015 to 2017 at our tertiary care referral hospital [Table 1].

Definitions and scales

We utilized the Rotterdam score to describe and standardize CT studies in these 74 patients following DC,[7] Clinical outcomes were assessed using the Glasgow outcome scale (GOS). For the purpose of differentiation, contusions were defined as hemorrhage when blood constituted more than half the volume of a contusion.

Analysis

Pearson’s correlation was used to test for a correlation between RCTS at presentation and postresuscitation GCS, length of stay, and GOS. Data were analyzed using SPSS version 20 (IBM Inc, Armonk, NY, USA).

RESULTS

Patients demographics and clinical characteristics

A total of 74 patients undergoing DC were included in the study [Table 2]. Patients averaged 31.3 (±18) years of age, and 87.8% (n = 65) were male. TBIs were attributed in 63.5% of patients to motor vehicle accidents, while 17.6% were due to falls. The median postresuscitation GCS score at presentation was 7 (range: 3–15). The median revised trauma score was 10 (range: 6–12). Notably, 46% (n = 34) of patients had pupillary abnormalities at the time of presentation.

Preoperative studies showed contusions in 37.8% (n = 28) of patients, subdural hematomas in 28.4% (n = 21) of patients, while 20.3% (n = 15) of patients had both [Table 3].

Surgical procedures

Surgery included in 21.6% (n = 16) bifrontal DC, in 41.9% (n = 31) unilateral DC, and in 36.5% (n = 27) DC with clot evacuation [Table 3].

Postoperative new CT findings in 74 TBI patients

The postoperative CT scans performed during the index hospitalization revealed following new postoperative findings not documented on preoperative CT scans; 41.9% (n = 31) showed expansion of the previously existing contusion/hemorrhages, 17.6% (n = 13) showed contusions that were not present on the preoperative scans, 4.1% (n = 3) developed new extradural hematomas, 2.7% (n = 2) exhibited new acute subdural hemorrhages, and 1.3% (n = 1) showed a new-onset intraventricular hemorrhage [Table 3].

Length of hospital stay (LOS)

The overall mean floor and special care unit stay were 4.33 days (±4.40) for the no expansion/flare-up group versus 6.04 days (±6.23) for those who developed expansion/flare of the original TBI; there was no significant difference.

Table 1: The inclusion criteria and some important variables that we studied.

| Inclusion criteria                  | n (%)/(range) |
|-------------------------------------|---------------|
| Age >18 years                       |               |
| Isolated TBI                        |               |
| Unilateral or bilateral DC          |               |
| Data collection                     |               |
| PreDC                               |               |
| Demographics                        |               |
| Preoperative Glasgow coma score      |               |
| Preoperative revised trauma score    |               |
| Laboratory investigations           |               |
| Pupillary response                  |               |
| Rotterdam CT score                  |               |
| Marshall CT score                   |               |
| Hospital course                     |               |
| Total length of hospital stay       |               |
| Surgical procedure                  |               |
| Days in intensive care unit         |               |
| Duration of surgery                 |               |
| Estimated blood loss                |               |
| Intraoperative use of blood products|               |
| PostDC complications on postoperative CT scans |          |
| Clinical outcomes                   |               |
| Glasgow Outcomes Score              |               |

Table 2: Patients’ clinical and surgical characteristics.

| Patient characteristics               | n (%)/(range) |
|---------------------------------------|---------------|
| Age                                   | 31.32±17.94   |
| Gender: female                        | 9 (12.2%)     |
| Comorbidity                           |               |
| Diabetes mellitus                     | 6 (8.1%)      |
| Hypertension                          | 4 (5.4%)      |
| Ischemic heart disease                | 4 (5.4%)      |
| Mechanism of injury                   |               |
| Road traffic accident (motor bike)    | 33 (44.6%)    |
| Road traffic accident (pedestrian)    | 14 (18.9%)    |
| Fall                                  | 13 (17.6%)    |
| GCS at presentation**                 | 7 (3-15)      |
| Revised trauma score**                | 10 (6-12)     |
| Pupils                                |               |
| BERL                                  | 32 (43.2%)    |
| Anisocoric                            | 30 (40.5%)    |
| Fixed and dilated                     | 4 (5.4%)      |

*Mean±standard deviation. **Median (range). GCS: Glasgow coma scale, BERL: Bilaterally equal and reactive to light
between these two groups [Table 4]. The mean intensive care unit (ICU) stay for those demonstrating expansion, however, was longer versus those without expansion (6.32 vs. 3.16 days, \(P = 0.029\)).

### Patient outcomes

Out of the cohort of 74 patients, 37.8% \((n = 28)\) had GOS of 5 with a mortality rate of 32.4% \((n = 24)\) over the mean follow-up duration of 10.88 (±14.88) months [Table 4]. Patients who had no expansion were more likely to have undergone DC and clot evacuation (25.68% vs. 10.81%), which were more likely to have had longer operative times (2.99 vs. 2.10 h, \(P = 0.007\)), shorter lengths of ICU stays (6.32 vs. 3.16, \(P = 0.029\)), and overall better outcomes including mortality (20.9% vs. 48.4%, \(P = 0.013\)); these results were statistically significant.

### DISCUSSION

#### Incidence of CT-documented contusion expansion following TBI

In this study, the decision for DC decompression was based on the CT scan findings and the patients’ clinical status; 50% of patients in groups RCTS 5 or 6 developed worsening of their primary lesions. Flint et al. reported contusion expansion in 80% of their patients with initial RCTS of 5–6.\(^1\)

#### LOS

In the literature, the LOS for moderate-to-severe TBI patients ranged from 5.9 to 17.5 days and is proportional to the severity of the injuries.\(^2,^3\) Here, there was no difference in the average

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**Table 3:** Brain CT findings.

| Characteristic                                      | \(n\) (%)          |
|----------------------------------------------------|--------------------|
| Preoperative CT findings (at presentations)        |                    |
| Cisterns                                           |                    |
| Normal                                             | 8 (10.8)           |
| Compressed                                         | 23 (31.1)          |
| Absent                                             | 20 (27.0)          |
| Midline shift                                      |                    |
| \(<5\) mm                                           | 17 (23.0)          |
| \(>5\) mm                                          | 34 (45.9)          |
| ASDH                                               | 21 (28.4)          |
| Contusion                                          | 28 (37.8)          |
| SDH and contusion                                  | 15 (20.3)          |
| Lesion side                                        |                    |
| Right                                              | 21 (28.4)          |
| Left                                               | 33 (44.6)          |
| Bilateral                                          | 17 (23.0)          |
| Rotterdam CT score of TBI*                          | 4 (4.16±1.24)      |
| Marshall CT score of TBI*                           | 4 (4.30±1.36)      |
| Postoperative CT findings and clinical outcomes     |                    |
| Worsening of existing contusion or hemorrhage      | 31 (41.9)          |
| New findings, other than worsening contusion or hemorrhage |          |
| New contusion                                      | 13 (17.6)          |
| Acute extradural hematoma                           | 3 (4.1)            |
| Acute subdural hematoma                             | 2 (2.7)            |
| Intraventricular hemorrhage                         | 1 (1.4)            |
| GOS=5                                              | 28 (37.8)          |
| Mortality (GOS=1)                                  | 24 (32.4)          |

\*Median (mean±standard deviation)

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**Table 4:** Hospital stay, surgical characteristics, and postsurgical outcomes.

|                         | All patients | Expansionflare-up | \(P\)-value |
|-------------------------|--------------|-------------------|-------------|
|                         | Yes          | No                |             |
| Total length of hospital stay (days) | 17.26±10.54 | 17.35±13.04 | 17.19±8.47 | 0.946 |
| Ward stay (days)        | 4.33±4.40    | 4.25±5.15         | 4.43±3.55  | 0.914 |
| Special care unit stay (days) | 6.04±6.23   | 5.96±6.94         | 6.10±5.67  | 0.934 |
| Intensive care unit stay (days) | 4.57±5.42   | 6.32±7.05         | 3.16±3.09  | 0.029 |
| Surgical procedure*     |              |                   | 0.057      |
| Bifrontal decompressive craniectomy                   | 16 (21.6%)  | 5 (6.76%)         | 11 (14.86%)| |
| Unilateral decompressive craniectomy                   | 31 (41.9%)  | 18 (24.32%)       | 13 (17.57%)| |
| Decompressive craniotomy and clot evacuation           | 27 (36.5%)  | 8 (10.81%)        | 19 (25.68%)| |
| Duration of surgical procedure (h)                    | 2.53±0.89   | 2.10±0.74         | 2.99±0.83  | 0.007 |
| Intraoperative blood loss (ml)                         | 903.70±806.1| 1042.86±1008.1   | 753.85±510.1| 0.362 |
| Number of intraoperative packed RBC transfused        | 1.30±1.44   | 1.57±1.60         | 1.00±1.23  | 0.311 |
| Number of intraoperativeFFPs transfused               | 1.22±2.68   | 1.29±2.27         | 1.15±3.16  | 0.901 |
| Number of intraoperative platelets transfused         | 0.70±1.84   | 1.21±2.42         | 0.15±0.56  | 0.136 |
| Glasgow outcomes scale                                | 2.89±1.74   | 2.42±1.67         | 3.53±1.65  | 0.006 |
| Mortality                                            | 24 (32.4%)  | 15 (48.4%)        | 9 (20.9%)  | 0.013 |

\*Number (%)
LOS on the hospital floor or special care unit for patients with or without expansion of their primary lesions. However, the ICU stay for those with expanding lesions was significantly longer versus those without expansion (6.32 vs. 3.16 days, \( P = 0.029 \)).

CT-documented complications of DC

The literature documents multiple complications of DC; primary contusion expansion, the formation of subdural hematoma subdural hygroma, and plus others.\(^6\) Here, our most common complication was hemorrhagic expansion of the primary contusion (\( n = 31, 41.9\% \)), followed by new contusions (\( n = 13, 17.6\% \)), new extradural hematomas (\( n = 3, 4.1\% \)), new subdural hematomas (\( n = 2, 2.7\% \)), and one postoperative intraventricular hemorrhage (\( n = 1, 1.4\% \)). Interestingly, 44.6\% (\( n = 33 \)) of our patients showed favorable outcome with GOS of \( \geq 4 \), a finding consistent with that reported in other studies.\(^9\)

Most RCTS on DC remain inconclusive in terms of meaningful neurological and functional benefits of DC in patients with severe TBI. One repeated argument against DC is that the expansion of the brain causes damage to white matter tracts and allows the contusions to expand, the latter shown in our series in two-thirds of cases. Although these patients had poorer outcomes in our study, our methodology has limitations (retrospective data collection, lack of functional outcomes, lack of randomization, etc.), and it is, therefore, beyond the scope of this paper to discuss whether our findings can be extrapolated to comment on the benefits or lack thereof, of DC for hemorrhagic contusions.

CONCLUSION

In our series of 74 TBI patients, the expansion of hemorrhagic contusions was seen in 67\% of patients after DC. Patients who had no expansion were more likely to have undergone clot evacuation along with DC, which were more likely to have had longer operative time, shorter length of ICU stay, and overall better outcomes including mortality.

Declaration of patient consent

Patient’s consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Flint AC, Manley GT, Gean AD, Hemphill JC, Rosenthal G. Post-operative expansion of hemorrhagic contusions after unilateral decompressive hemicraniectomy in severe traumatic brain injury. J Neurotrauma 2008;25:503-12.
2. Kurland DB, Khaladj-Ghom A, Stokum JA, Carusillo B, Karimy JK, Gerzanich V, et al. Complications associated with decompressive craniectomy: A systematic review. Neurocrit Care 2015;23:292-304.
3. Lagbas C, Bazargan-Hejazi S, Shaheen M, Kermah D, Pan D. Traumatic brain injury related hospitalization and mortality in California. Biomed Res Int 2013;2013:143092.
4. McGarry LJ, Thompson D, Millham FH, Cowell L, Snyder PJ, Lenderking WR, et al. Outcomes and costs of acute treatment of traumatic brain injury. J Trauma 2002;53:1152-9.
5. Myburgh JA, Cooper DJ, Finner SR, Venkatesh B, Jones D, Higgins A, et al. Epidemiology and 12-month outcomes from traumatic brain injury in Australia and New Zealand. J Trauma 2008;64:854-62.
6. Stiver SI. Complications of decompressive craniectomy for traumatic brain injury. Neurosurg Focus 2009;26:E7.
7. Waqas M, Shamim MS, Enam SF, Qadeer M, Bakhshi SK, Patoli I, et al. Predicting outcomes of decompressive craniectomy: Use of rotterdam computed tomography classification and marshall classification. Br J Neurosurg 2016;30:258-63.

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