Decompressive Hemicraniectomy for pediatric closed head injury: How early should we open the box?

Samer K. Elbabaa, MD, FAANS, FACS
Reinert Chair in Pediatric Neurosurgery
Associate Professor of Neurological Surgery
Director, Division of Pediatric Neurosurgery

Saint Louis University School of Medicine
SSM Cardinal Glennon Children’s Medical Center
Saint Louis, MO
I have no financial disclosures related to this topic
Kocher 1901

‘If there is no CSF pressure but brain pressure exists, then pressure relief must be achieved by opening the skull’
**Monro-Kellie hypothesis**

The Monro-Kellie hypothesis states that the cranial compartment is incompressible, and the volume inside the cranium is a fixed volume. The cranium and its constituents (blood, CSF, and brain tissue) create a state of volume equilibrium, such that any increase in volume of one of the cranial constituents must be compensated by a decrease in volume of another.

How about when skull sutures are open?
In the news

U.S. House of Representatives
A photo of U.S. Rep. Gabrielle Giffords, who underwent a hemicraniectomy Saturday to relieve pressure on her brain as it swelled.

Rep. Giffords's treatment more common in last decade

Doctors removed nearly half of U.S. Rep. Gabrielle Giffords’s skull in order to relieve pressure on her brain as it swelled as a result of the injury she received in Saturday’s shooting. This and other top-notch care in the first few hours saved her life.
Case in point: 2 yr M s/p fall
Exam:
Intubated, od7nr os6nr +corneals
motor: UE-flexor posturing with LUE alternating with extension;
LE-minmal movement. GCS 5T
- Taken emergently for decompression
- 6 weeks later
- discharged from rehab
- Bone flap replaced 3 months later
- Intact neurologic exam
Guidelines for the Medical Management of Severe Traumatic Brain Injury in Infants, Children, and Adolescents for first-tier therapies (A) and second-tier therapies (B)
Guidelines for the Medical Management of Severe Traumatic Brain Injury in Infants, Children, and Adolescents for first-tier therapies (A) and second-tier therapies (B)
I. RECOMMENDATIONS

Strength of Recommendations: Weak.
Quality of Evidence: Low, from poor and moderate-quality class III studies.

A. Level I

There are insufficient data to support a level I recommendation for this topic.

B. Level II

There are insufficient data to support a level II recommendation for this topic.

C. Level III

Decompressive craniectomy (DC) with duraplasty, leaving the bone flap out, may be considered for pediatric patients with traumatic brain injury (TBI) who are showing early signs of neurologic deterioration or herniation or are developing intracranial hypertension refractory to medical management during the early stages of their treatment.
Chapter 12. Decompressive craniectomy for the treatment of intracranial hypertension

VII. SUMMARY

Eight small class III case series suggest that large decompressive surgeries with duraplasty may be effective in reversing early signs of neurologic deterioration or herniation, and in treating intracranial hypertension refractory to medical management, and that these effects may be correlated with improving outcomes in the critically ill pediatric patients who develop such indications.

Limited evidence suggests that duraplasties, when done, should be large, and consideration should be given to removing the bone rather than “floating” it in situ. There is insufficient evidence to allow defining the patient characteristics that either 1) optimize the beneficial effects of these procedures or 2) render them ineffective.

VIII. KEY ISSUES FOR FUTURE INVESTIGATION

* A primary focus on future research should be performing a randomized controlled trial on DC as a method of controlling increased ICP in pediatric patients with TBI.

* Given the infrequency with which pediatric patients with TBI are admitted to any individual center, it would be very useful to develop a prospective pediatric TBI database to facilitate class II investigations into many of the variables relevant to DC (such as timing, size and placement, and technique), which are unlikely to ever be subject to class I study.
Predictors of poor outcome of decompressive craniectomy in pediatric patients with severe traumatic brain injury

Khan SA1, Shailwani H, Shamim MS, Murtaza G, Enam SA, Qureshi RO, Tahir MZ.

OBJECTIVE:
This study aimed to determine the risk factors associated with poor outcome of decompressive craniectomy (DC) for severe traumatic brain injury (TBI) in pediatric patients.

METHODS:
This retrospective study is conducted on pediatric population (age 1-15 years) presenting with TBI who underwent DC at our institute between January 2000 and 2010. Based on Glasgow outcome score (GOS) at a minimum follow-up of 5 months, patients were divided into two groups, namely poor outcome (GOS 1, 2, and 3) and good outcome (GOS 4 and 5). Records were reviewed and analyzed for preoperative and intraoperative predictors.

RESULTS:
We found 25 patients who were eligible as per selection criteria. Mean age at presentation was 6 ± 4 years and there was male preponderance (84%). Fall (60%) was the most common mechanism of injury followed by gunshots and road traffic accident. On univariate analysis, presenting GCS ≤5 (p value = 0.009), delay in presentation of more than 150 min (p value = 0.010), DC performed after more than 4 h of arrival in hospital (p value = 0.042), and intraoperative blood loss exceeding 300 ml (p value = 0.001) were significant predictors of poor outcome.

CONCLUSION:
Our study suggests that DC in children is not only a life-saving procedure, but also leads to a good functional outcome after severe injury. However, patient selection still remains an important aspect, and the above-mentioned factors should be considered while deciding for DC to improve survival. Further prospective studies on larger sample size are warranted to validate our results.
Pediatric traumatic brain injuries treated with decompressive craniectomy.
Patel N1, West M, Wurster J, Tillman C.

BACKGROUND:
Traumatic brain injury (TBI) occurs in an estimated 80% of all pediatric trauma patients and is the leading cause of death and disability in the pediatric population. Decompressive craniectomy is a procedure used to decrease intracranial pressure by allowing the brain room to swell and therefore increase cerebral perfusion to the brain.

METHODS:
This is a retrospective study done at St. Mary's Medical Center/Palm Beach Children's Hospital encompassing a 3 year 7 month period. All the pediatric patients who sustained a TBI and who were treated with a decompressive craniectomy were included. The patients' outcomes were monitored and scored according to the Rancho Los Amigos Score at the time of discharge from the hospital and 6 months postdischarge.

RESULTS:
A total of 379 pediatric patients with a diagnosis of TBI were admitted during this time. All these patients were treated according to the severity of their injury. A total of 49 pediatric patients required neurosurgical intervention and 7 of these patients met the criteria for a decompressive craniectomy. All seven patients returned home with favorable outcomes.

CONCLUSION:
This study supports the current literature that decompressive craniectomy is no longer an intervention used as a last resort but an effective first line treatment to be considered.

Weintraub D1, Williams BJ, Jane J Jr.

Abstract
BACKGROUND:
Pediatric traumatic brain injury accounts for approximately 37,000 hospitalizations and 2,685 deaths in the United States annually. The 2003 guidelines consolidated and summarized the body of literature on this subject. Among the material covered was the role of surgical management of elevated intracranial pressure. Here we review the guideline recommendations, recent literature on the topic, and important recent results in the adult population.

METHODS:
A Medline literature review was performed to identify studies published since 2000 addressing decompressive craniectomy in the pediatric and adult populations. Important articles included in the 2003 guidelines were also reviewed. All references were reviewed to identify additional relevant studies.

RESULTS:
There is little new data that addresses the key issues for investigation proposed in the 2003 pediatric guidelines. The only randomized trial in the pediatric population remains a 2001 study, which demonstrated a benefit of decompressive craniectomy. One recent randomized trial in adults demonstrated no benefit of the procedure and an additional randomized trial in adults is underway. No pediatric randomized trial is planned. Smaller, non-randomized series appear to support the practice.

CONCLUSION:
Based on the only randomized trial in children and the abundance of smaller studies, it is our belief that decompressive craniectomy does provide a benefit in terms of the management of intracranial hypertension and overall outcome in children.
Decompressive craniectomy in children: single-center series and systematic review.

Güresir E1, Schuss P, Seifert V, Vatter H.

BACKGROUND:
Decompressive craniectomy (DC) is performed as a life-saving procedure in patients with intractably increased intracranial pressure after traumatic brain injury, bleeding, cerebral infarction, or brain swelling of other causes. However, the application of DC is as controversial in the pediatric population as it is in adults.

OBJECTIVE:
To find factors influencing the outcome in pediatric patients who underwent DC because of sustained high intracranial pressure.

METHODS:
Between April 2000 and December 2009, 34 pediatric patients (age 0-18 years) underwent DC. Patients were stratified according to the indication for DC. Outcome was assessed according to the modified Rankin Scale score at 6 months. MEDLINE was searched for published studies or reports of DC in pediatric patients to gain a larger population. Two reviewers independently extracted data.

RESULTS:
Literature data, including the current series, revealed a total of 172 pediatric patients. Overall, a favorable outcome was achieved in 106 of 172 patients (62%). A favorable outcome was achieved in 25 of 36 patients without traumatic brain injury vs 81 of 136 patients with traumatic brain injury (69% vs 60%). Patients without signs of cerebral herniation had a better outcome than patients with unilateral or bilateral dilated pupils (73% vs 60% vs 45%, respectively).

CONCLUSION:
The current data indicate that DC in children with traumatic or nontraumatic brain swelling might be warranted, regardless of the underlying cause. Despite mydriasis, a favorable outcome might be achieved in a significant number of pediatric patients. Nevertheless, careful individual decision making is needed for each patient, especially when signs of cerebral herniation have persisted for a long time.
Decompressive craniectomy in 14 children with severe head injury: clinical results with long-term follow-up and review of the literature.
Pérez Suárez E1, Serrano González A, Pérez Díaz C, García Salido A, Martínez de Azagra Garde A, Casado Flores J.

BACKGROUND: Decompressive craniectomy (DC) is a controversial therapeutic measure used in patients with intractable intracranial hypertension after severe head injury. This study describes the morbidity and mortality of DC in 14 children with a mean follow-up of 3.2 years. We review published evidence from the past 10 years on the indications for DC in pediatric brain trauma. We also examine timing, surgical technique, and the results of this procedure.

METHOD: We retrospectively reviewed patients who underwent DC from 2002 to 2010. Clinical data were collected at admission, as were data on the indication for craniectomy, timing, and surgical technique. Perioperative intracranial pressure (ICP), complications of craniectomy, and Glasgow Outcome Scale score at 2 years were recorded as outcome variables.

RESULTS: Fourteen craniectomies were performed. The median presenting Glasgow Coma Scale score was 6.5 (range, 4-15). Ten patients were presented with anisocoria. In 13 patients, craniectomy initially decreased ICP to <25 mm Hg. Two patients (14%) had a poor prognosis on admission and died. The most frequent complications were hygroma (8 patients) and infections (3 patients). The mean Glasgow Outcome Scale score at the 2-year follow-up visit was 4.4 (range, 4-5). Behavioral and psychiatric abnormalities and poor academic performance were frequent (82%).

CONCLUSIONS: DC reduces ICP in pediatric patients with traumatic brain injury. The mortality rate is low and long-term prognosis in survivors is good. Complications related to surgery are frequent. Wide craniectomy with duraplasty seems to be the most common technique. Defining the most appropriate indications and timing for DC in pediatric patients should be the objective of future prospective studies.
OBJECT:
The impact of intracranial pressure (ICP), decompressive craniectomy (DC), extent of ICP therapy, and extracranial complications on long-term outcome in a single-center pediatric patient population with severe traumatic brain injury (TBI) is examined.

METHODS:
Data of pediatric (≤16 years) TBI patients were retrospectively reviewed using a prospectively acquired database on neurosurgical interventions between April 1996 and March 2007 at the Charité Berlin. The patients' records, neuroimages, admission Glasgow Coma Scale (GCS) score, the time to craniectomy for hematoma evacuation/DC, and the extent of ICP therapy were reviewed. Twelve-month and long-term outcome was evaluated (Glasgow Outcome Scale).

RESULTS:
Fifty-three pediatric TBI patients [mean age 8.41 (0-16) years] were studied. Patients were categorized into two groups, with DC (n = 14) and without DC (n = 39). DC was performed 3 ± 3.98 median, quartiles 2 (0-3.75) days post-trauma. In the majority of children (n = 9; 64%), surgical decompression was performed early within 2 days post-trauma. (0.8 ± 0.9 days). The DC group tended to be older (median age 12 vs. 7 years, p = 0.052), had a lower GCS (3 vs. 6.5, p < 0.01), and had a 3-fold longer stay on the ICU (20 vs. 6.5 days, p < 0.03) compared to the conservatively treated group. Mean follow-up duration (n = 30) was 5.2 ± 2.4 years (range 1-10.5). At the most recent follow-up examination, 92% of survivors had returned to school.

CONCLUSION:
Though initial GCS was worse in pediatric TBI patients who underwent decompressive craniectomy compared to the conservatively treated patients, long-term outcome was comparable.

In children, decompressive craniectomy might be favored early in the management of uncontrollable ICP.
Pediatric outcomes (2007): UVA


OBJECT:
The authors examine the indications for and outcomes following decompressive craniectomy in a single-center pediatric patient population with traumatic brain injury (TBI).

METHODS:
A retrospective review of data was performed using a prospectively acquired database of patients who underwent decompressive craniectomy at the authors' institution between January 1995 and April 2006. The patients' neuroimages were examined to evaluate the extent of intracranial injury, and the patients' records were reviewed to determine the admission Glasgow Coma Scale (GCS) score, the extent of systemic injuries, the time to craniectomy, and the indications for craniectomy. Long-term functional outcome and independence levels were evaluated using the Glasgow Outcome Scale (GOS) and a Likert patient quality-of-life rating scale. Twenty-three craniectomies were performed in children during the study period. The mean patient age at craniectomy was 11.9 years (range 2-19 years). In all patients, the computed tomography scans obtained at presentation revealed pathological findings, with diffuse axonal injury and traumatic contusions being the most common abnormalities. The median presenting GCS score was 4.6 (range 3-9). Nineteen patients (83%) suffered from other systemic injuries. One patient (4%) died intraoperatively and six patients (26%) died postoperatively. Postoperative intracranial pressure (ICP) control was obtained in 19 patients (83%); an ICP greater than 20 mm Hg was found to have the strongest correlation with subsequent brain death (p = 0.001). The mean follow-up duration was 63 months (range 11-126 months, median 49 months). The mean GOS score at the 2-year follow-up examination was 4.2 (median 5). At the most recent follow-up examination, 13 (81%) of 16 survivors had returned to school and only three survivors (18%) were dependent on caregivers.

CONCLUSIONS:
Although the mortality rate for children with severe TBI remains high, decompressive craniectomy is effective in reducing ICP and is associated with good outcomes in surviving patients.
Early decompression? (2012)

Childs Nerv Syst. 2012 Mar;28(3):441-4

The importance of very early decompressive craniectomy as a prevention to avoid the sudden increase of intracranial pressure in children with severe traumatic brain swelling (retrospective case series).

Csókay A1, Emelifeonwu JA, Fügedi L, Valálik I, Láng J.

PURPOSE:
The purpose of the retrospective case series of eight consecutive patients is to call our attention to the optimal timing of decompressive craniectomy (DC) in children.

METHOD:
We report the outcomes of eight children under the age of 12 with severe head injuries. DC was performed at different intracranial pressure (ICP; 20 and 25 mmHg) levels.

RESULTS:
Our results suggest that above 20 mmHg, very fast progression of ICP (within 15 min) can occur, which may limit the time available to plan and perform DC with a successful patient outcome.

CONCLUSION:
Considering the anamnestic data, it could be useful to perform DC at 20-22 mmHg ICP in young patients in order to prevent the potential of very fast brain swelling if there is no possibility to perform durotomy within 20 min after the onset of raising the ICP. It is especially considerable in poor countries where the emergency route could be less organized because of locations of building and extreme load of the staff. Further controlled trials are necessary to evaluate the indication and standardization of early decompressive craniectomy as a standard preventive therapy in pediatric severe traumatic brain swelling.
Epidemiology

- 1.5 million CHI in children yearly in the US
- 300,000 hospitalizations - 5% are hospitalized and 1-3% require intervention
- 70-90% of injury-related deaths in peds
- M:F 2:1
- MVA, falls; football most common sports-related cause
- Injury can be bimodal - first insult at time of event; second insult 1-5 days later (usually from hypotension or hypoxemia)
Pediatric TBI

- 81% mild
- 8% moderate
- 6% severe
- 5% fatal
Injury Severity

- Mild – unconscious <15 min; GCS 13-15
- Moderate – unconscious >15 min; GCS 9-12
- Severe – unconscious >6hr; GCS 3-8
Pediatric Glasgow Coma Scale

- **Best eye response: (E)**
  - Eyes opening spontaneously - 4 points
  - Eye opening to speech - 3 points
  - Eye opening to pain - 2 points
  - No eye opening - 1 point

- **Best verbal response: (V)**
  - Smiles, oriented to sounds, follows objects, interacts - 5 points
  - Cries but consolable, inappropriate interactions - 4 points
  - Inconsistently inconsolable, moaning - 3 points
  - Inconsolable, agitated - 2 points
  - No verbal response - 1 point

- **Best motor responses: (M)**
  - Infant moves spontaneously or purposefully - 6 points
  - Infant withdraws from touch - 5 points
  - Infant withdraws from pain - 4 points
  - Abnormal flexion to pain for an infant (*decorticate response*) - 3 points
  - Extension to pain (*decrebrate response*) - 2 points
  - No motor response - 1 point
Anatomy of the Skull
Layers of the scalp and meninges
Pathophysiology

- Children are more vulnerable to injury from head trauma

  - Relatively large (10% of body weight) means increased momentum with accel/decel and tend to land on head with falls

  - Elastic, underdeveloped cervical ligaments and muscles are less protective

  - Soft calvarium (transfers energy to brain)

  - Large subarachnoid space (veins at increased risk of tearing)
Traumatic Head Injury

Coup

Contrecoup

Primary Impact

Secondary Impact

Epidural and Subdural Hematoma
Neurons

Diffuse Axonal Injury

- Shearing injury of axons
  Deep cerebral cortex, thalamus, basal ganglia

- Punctate hemorrhage and paranchymal edema
Aims of Decompressive Craniectomy

- Reduce ICP
- Improve blood flow
- Reduce damage to surrounding brain tissue
- i.e. reduce secondary brain injury
Types of decompression

Primary
- Performed after evacuation of a hematoma

Secondary
- Performed for intracranial hypertension refractory to medical treatment
When to do it?

Currently generally used a last resort

More logical to do earlier??
AIMS IN THE MANAGEMENT OF HEAD INJURY

• Prevention of secondary insult
• Maintain adequate Cerebral perfusion pressure
• Prevent rise in intracranial pressure
• ? Early neurosurgical intervention
ANATOMICAL CONSIDERATIONS  
ADULT vs CHILD

• OPEN SUTURES – more prone to injury, allow for greater amount of intracranial expansion, delayed onset of herniation

• Brain tissue LESS MYELINATED vs to adult – predisposed to greater shearing forces

• SECONDARY INSULTS – result in more profound secondary brain injury – worse outcomes vs adults
PATHOPHYSIOLOGY OF SECONDARY BRAIN INJURY
Management is much simpler than we think, if we do it on time for the appropriate indication!
NEURO-INTENSIVE CARE

• INTRACRANIAL PRESSURE DIRECTED vs CEREBRAL PERFUSION PRESSURE DIRECTED

• Indications for ICP monitoring:
• Severe TBI with GCS<8, and abnormal CT Brain changes ...
  (Haemotoma, cerebral contusion, cerebral oedema, compressed basal cisterns)

• Aim to keep ICP<20cm H20
Intracranial Pressure (ICP)

CPP = MAP – ICP

Normal CPP > 50 mm Hg

Autoregulatory mechanisms maintain CBF at CPP’s down to 40 mm Hg
Circulatory Support:
Maintain Cerebral Perfusion Pressure

Number of Hypotensive Episodes

- 0.0
- 1.5
- 3.0
- 4.5
- 6.0

Outcome:
- Good
- Moderate
- Severe
- Vegetative
- Dead

Kokoska et al. (1998), *Journal of Pediatric Surgery*, 33(2)
Intracranial Pressure (ICP)

- In head injury, ICP > 20-25 mm Hg may be more detrimental than low CPP (increasing CPP may not afford protection from intracranial hypertension).

- Aggressive attempts to maintain CPP > 70 should be avoided due to ARDS (Level II)

- CPP < 50 should be avoided (Level III)
Mechanisms of Traumatic Brain Injury

- **Impact injury**
  - Cerebral or brainstem contusions
  - Cerebral lacerations
  - Diffuse axonal injury (DAI)

- **Secondary injury**
  - Intracranial hematoma
  - Edema
  - Ischemia
Nonoperative Management

- Frequent neuro checks!
- Frequent neuro checks!!
- Frequent neuro checks!!! (It means: avoid chemical sedation as much as possible!)
- ICP monitoring
Secondary Brain Injury

- Altered cerebral blood flow
- Altered cerebral perfusion
- Altered oxygen metabolism (reactive oxygen species)
- Inflammation (cytokines, prostaglandins)
- Hormonal dysfunction (adrenal insufficiency)
INDICATIONS FOR ICP MONITORING IN PEDIATRIC PATIENTS WITH SEVERE TBI

• ↑ICP ≡↓Outcome; Aggressive Tx ≡↑Outcome

• Intra-cranial pressure monitoring (ICP) is appropriate in infants and children with severe traumatic brain injury (TBI) (Glasgow Coma [GCS] score ≤8) (O).

• The presence of open fontanel and/or sutures in an infant with severe TBI does not preclude the development of intracranial hypertension or negate the utility of ICP monitoring.
Hemicraniectomy
Decompressive Craniectomy

- Part of 3rd tier, or even 2nd tier..
- One hemisphere more severely affected with shift
- Subdural hematoma which does not account for degree of shift
- Wide duraplasty
- Often helpful for patients GCS 5-8
Decompressive Craniectomy
Decompressive Craniectomy
Decompressive Craniectomy
Decompressive Craniectomy
Decompressive Craniectomy
Decompressive Craniectomy
Decompressive Craniectomy
Bilateral Hemicraniectomy in Non-Penetrating Traumatic Brain Injury

Brian P. Walcott, Brian V. Nahed, Sameer A. Sheth, Vijay Yanamadala, James R. Caracci, and Wael F. Asaad

Abstract

Traumatic brain injury is a heterogeneous entity that encompasses both surgical and non-surgical conditions. Surgery may be indicated with traumatic lesions such as hemorrhage, fractures, or malignant cerebral edema. However, the neurological exam may be clouded by the effects of medications administered in the field, systemic injuries, and inaccuracies in hyperacute prognostication. Typically, neurological injury is considered irreversible if diffuse loss of grey/white matter differentiation or if brainstem hemorrhage (Duret hemorrhage) exists. We aim to characterize a cohort of patients undergoing bilateral hemicraniectomy for severe traumatic brain injury. A retrospective consecutive cohort of adult patients undergoing craniectomy for trauma was established between the dates of January 2008 and November 2011. The primary outcome of the study was in-hospital mortality. Secondary outcomes were ICU length of stay, surgical complications, and Glasgow Outcome Score at most recent follow-up. During the study period, 210 patients undergoing craniectomy for traumatic mass-occupying lesion (epidural hematoma, subdural hematoma, or parenchymal contusion) were analyzed. Of those, 9 met study criteria. In-hospital mortality was 67% (6 of 9 patients). The average ICU length of stay was 12 days. The GOS score was 3 in surviving patients. Bilateral hemicraniectomy is a heroic intervention for patients with severe TBI, but can be a life-saving procedure.
FIG. 2. Post-operative head computed tomography (CT) scan reconstruction. Three-dimensional reconstruction of axial-acquired non-contrast head CT scan demonstrates large fronto-temporal-parietal craniectomies.
Bilateral Hemicraniectomy: How far can we go??

FIG. 3. Intra-operative photograph. In this photograph, the patient is positioned supine with the anterior superior aspect of their cranium at the top of the image. Large bilateral craniectomies were performed with the peri-sagittal dural leaflets tacked to each other over a strip of bone that covers the superior sagittal sinus.
Now, let’s put the bone back in..
Risks

Autologous bone flap cranioplasty following decompressive craniectomy is combined with a high complication rate in pediatric traumatic brain injury patients.

Martin KD1, Franz B, Kirsch M, Polanski W, von der Hagen M, Schackert G, Sobottka SB.

Abstract

OBJECTIVE: Decompressive craniectomy (DC) is a last treatment option of refractory intracranial hypertension in traumatic brain injury (TBI) patients. Replacement of the autologous bone flap is the preferred method to cover the cranial defect after brain swelling has subsided. Long term outcomes and complications after replacement of the autologous bone flap in pediatric patients were studied in comparison to young, healthy adults.

METHODS: Medical records of 27 pediatric patients who underwent DC and subsequent replacement of the bone flap between 1998 and 2011 were reviewed retrospectively. Patients were divided into two age groups (group 1: 18 children < 15 years; group 2: 9 adolescents 15-18 years). For comparative reasons, a young adult control group of 39 patients between 18 and 30 years was additionally evaluated.

RESULTS: With 81.8 % resorption of the bone flap, this was the major complication in young children. In up to 54.4 % of patients, a surgical revision of the osteolytic bone flap became necessary. However, in some pediatric patients, the osteolysis resolved spontaneously and further operations were not required. Probable enabling factors for bone flap resorption were young age (0-7 years), size of craniectomy, permanent shunt placement, and extent of dural opening/duraplasty. Other complications were bone flap infections, loosening of the re-inserted bone flap, and postoperative hematomas.

CONCLUSION: There is an unacceptably high complication rate after reimplantation of the autologous bone following DC in pediatric TBI patients, especially in young children up to seven years of age. Artificial or synthetic cranioplasties may be considered as alternatives to initial bone flap reimplantation in the growing child. Despite the fact that DC is an effective treatment in TBI with persistent intracranial hypertension, it is important to realize that DC is not only combined with replacement of the autologous bone flap but also with a high rate of additional complications especially in pediatric patients.
Analysis of bone flap replacement risks


Outcomes of cranioplasty following decompressive craniectomy in the pediatric population.
Rocque BG1, Amancherla K, Lew SM, Lam S.

Abstract
Cranioplasty is routinely performed following decompressive craniectomy in both adult and pediatric populations. In adults, this procedure is associated with higher rates of complications than is elective cranial surgery. This study is a review of the literature describing risk factors for complications after cranioplasty surgery in pediatric patients. A systematic search of PubMed, Cochrane, and SCOPUS databases was undertaken. Articles were selected based on their titles and abstracts. Only studies that focused on a pediatric population were included; case reports were excluded. Studies in which the authors assessed bone flap storage method, timing of cranioplasty, material used (synthetic vs autogenous), skull defect size, and/or complication rates (bone resorption and surgical site infection) were selected for further analysis. Eleven studies that included a total of 441 cranioplasties performed in the pediatric population are included in this review. The findings are as follows: 1) Based on analysis of pooled data, using cryopreserved bone flaps during cranioplasty may lead to a higher rate of bone resorption and lower rate of infection than using bone flaps stored at room temperature. 2) In 3 of 4 articles describing the effect of time between craniectomy and cranioplasty on complication rate, the authors found no significant effect, while in 1 the authors found that the incidence of bone resorption was significantly lower in children who had undergone early cranioplasty. Pooling of data was not possible for this analysis. 3) There are insufficient data to assess the effect of cranioplasty material on complication rate when considering only cranioplasties performed to repair decompressive craniectomy defects. However, when considering cranioplasties performed for any indication, those in which freshly harvested autograft is used may have a lower rate of resorption than those in which stored autograft is used. 4) There is no appreciable effect of craniectomy defect size or patient age on complication rate.

There is a paucity of articles describing outcomes and complications following cranioplasty in children and adolescents. However, based on the studies examined in this systematic review, there are reasons to suspect that method of flap preservation, timing of surgery, and material used may be significant. Larger prospective and retrospective studies are needed to shed more light on this important issue.
Timing of bone flap replacement


Optimal timing of autologous cranioplasty after decompressive craniectomy in children.
Piedra MP1, Thompson EM, Selden NR, Ragel BT, Guillaume DJ.

OBJECT:
The object of this study was to determine if early cranioplasty after decompressive craniectomy for elevated intracranial pressure in children reduces complications.

METHODS:
Sixty-one consecutive cases involving pediatric patients who underwent autologous cranioplasty after decompressive craniectomy for raised intracranial pressure at a single academic children's hospital over 15 years were studied retrospectively.

RESULTS:
Sixty-one patients were divided into early (< 6 weeks; 28 patients) and late (≥ 6 weeks; 33 patients) cranioplasty cohorts. The cohorts were similar except for slightly lower age in the early (8.03 years) than the late (10.8 years) cranioplasty cohort (p < 0.05). Bone resorption after cranioplasty was significantly more common in the late (42%) than the early (14%) cranioplasty cohort (p < 0.05; OR 5.4). No other complication differed in incidence between the cohorts.

CONCLUSIONS:
After decompressive craniectomy for raised intracranial pressure in children, early (< 6 weeks) cranioplasty reduces the occurrence of reoperation for bone resorption, without altering the incidence of other complications.
Complications of delayed cranial repair after decompressive craniectomy in children less than 1 year old.

Frassanito P1, Massimi L, Caldarelli M, Tamburrini G, Di Rocco C.

Abstract

BACKGROUND:
Decompressive craniectomy is an effective treatment option in case of refractory intracranial hypertension after severe head injury. The incidence of complications following cranial repair after decompressive craniectomy for traumatic brain injury is not negligible, particularly in infants and young toddlers. However, only a few dedicated papers can be found in the literature.

METHOD:
We describe the complications observed in two boys and one girl under 1 year of age that were treated in the last decade by hemicranial decompressive craniotomy and enlarging hemispheric duraplasty, and subsequent cranial repair by means of autologous bone-flap replacement.

FINDINGS:
Despite good clinical and neurological outcome, the postoperative clinical course was complicated in all cases by early or late evidence of subdural fluid collections associated to the occurrence of hydrocephalus and causing recurrent dislocation and progressive resorption of the autologous bone flap.

CONCLUSIONS:
Infants less than 1 year old, undergoing decompressive craniectomy after traumatic brain injury, experience a high rate of complications following subsequent cranial repair. Subdural collections and resorption of the autologous bone flap are to be considered as extremely common complications.

Jacob AT1, Heuer GG, Grant R, Georgoff P, Danish SF, Storm PB, Stein SC

AIMS:
The impact of decompressive hemicraniectomy (DCH) on the overall outcome of pediatric brain injury patients has not been fully determined. In this paper, the authors performed a systematic review of patient outcome based on quality of life following DCH in a pediatric population.

METHODS:
We describe our experience with decompressive craniectomy in pediatric patients and perform a literature review and pooled outcomes analysis to supplement these findings. A total of 13 children underwent DCH for intractable intracranial pressure in our institution from 2000 to 2008. Follow-up was available in 11 patients with 1 death (9%) and 7 survivors (70%) obtaining a favorable outcome (Glasgow Outcome Scale, GOS, scores = 4-5).

RESULTS:
A literature review to determine the usefulness of DCH identified 17 articles that, when combined with our series, resulted in 186 pediatric DCH cases. Pooled outcomes found 42 deaths and 112 patients who had favorable outcomes at 6 months. The average 6-month mortality was 21.1%, and the pooled mean quality of life among survivors 0.75 (0.68-0.82), midway between moderate disability and good outcome.

CONCLUSIONS:
Based on our findings, DCH results in a majority of pediatric patients having a good outcome based on the GOS score.
Associated vascular injury: Be aggressive!

» 10 yr M fell off a go cart
Left transverse sinus injury!
Excellent clinical outcome
Summary

• 2 mechanisms of brain injury
  • Impact injury
  • Secondary injury

• Hemicraniectomy maybe an excellent choice GCS 5-8

• Operative and nonoperative strategies are generally aimed at reducing mass effect and, therefore, reducing ICP

• If DH crosses your mind, its very likely a good time to do it!

• Nothing beats a neuro exam!
Thank you

» selbaba@slu.edu