Decompressive Craniectomy and Lumbar Drainage in Adults

Austin R. T. Colohan
Loma Linda University
June 6, 2009

Road to Recovery

April 22, 2006
June 13, 2006

"Skull Crackers"

March, 2007

TBI – "The Signature Injury of the Iraq War"

"We can save you, but you might not be what you were"

Clinical Neurosurgery, Volume 52, 2005
Decompressive Craniectomy

- Has a history spanning 100 years
- Remains controversial
- No adequate randomized trials
- We have all done them, and know that DC controls ICP and some patients do reasonably well.

Decompressive Craniectomy History

- Early trephines
- Kocher (1901)
- Cushing (1905)
- Kjellberg & Prieto (1971)
- Venes & Collins (1975)
- Pereira (1977)

Escalating Cycle of Brain Swelling

Brain Swelling
- Energy failure
- Increase in brain injury and poor outcome
- Decrease in O2 delivery
- Increase in ICP
- Decrease in CBF

Decompressive Craniectomy

- University of Virginia
- Bilateral decompressive craniectomy on 35 patients with malignant post-traumatic ICP
- Compared to historical controls of Traumatic Coma Data Bank (TCDB)

Overall rate of good recovery and moderate disability was 37%, vs. 16% for TCDB
- Mortality rate was 23%
- Patients whose ICP did not exceed 40 mmHg and underwent surgery within 48 hours of injury had a 60% favorable outcome

Early surgery in salvageable patients was beneficial.

Whitfield PC, BritJnsurg 2001; 88(6)
Decompressive Craniectomy

- 27 head injury patients with GCS 3 or 4 and ICP > 30 mm Hg:
  
  - Favorable recovery: 43%
  - Mortality: 40%

Csokay A. Neuroriltes 2002, 24

Decompressive Craniectomy

- 40 patients out of a series of 816 with severe TBI underwent decompressive craniectomy
  
  - 37 patients had unilateral craniectomy, only 3 had bilateral decompression
  - 34 patients had temporal (R 24, L9) lobectomy
  - 25% of patients had social rehabilitation at 1 year

Albanese J, CritCareMed 2003, 31(10)

Decompressive Craniectomy

- 27 underwent decompressive craniectomy “early” at the time of evacuation of mass lesions with good outcome in only 19%
  
- 13 underwent “late” craniectomy after medical management with good outcome in 38%

Albanese J, CritCareMed 2003, 31(10)

“Decompressive craniectomy was associated with a better-than-expected functional outcome in patients with medically uncontrollable ICP and/or brain herniation, compared with outcomes in other control cohorts reported in the literature”

April 2006

Do Long-Term Results Justify DC After Severe TBI?

- 33 patients at University of Tuebingen, Germany

- Criteria for surgical intervention:
  
  - ICP > 30 mm Hg despite medical management
  - TCD revealed only systolic flow pattern or peaks
  - no other major injuries
  - age < 60 (mean age 36.3)


Morgalla A et al. JNS;2008;109:685–690
Do Long-Term Results Justify DC After Severe TBI?

<table>
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<th>Outcome</th>
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<tr>
<td>vegetative</td>
<td>20</td>
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<td>mild deficit</td>
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Morgalla A et al. JNS; 2008; 109: 685-690

Decompressive Craniectomy/TBI: Prospectively Designed Studies (Class II data)

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<td>100</td>
<td>69.96</td>
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2/3 of survivors

March, 2006

DC - Logical Foundation

- Aggressive treatment of elevated ICP is associated with better outcome following severe TBI.
- Decompressive craniectomy when performed properly and in a timely manner is associated with good control of elevated ICP.

ERGO....? Logical conclusion or leap of faith

March, 2006
Decompressive Craniectomy in TBI

- At present, there is no Class I evidence (prospectively controlled, randomized trials) that decompressive craniectomy improves outcome in an unselected group of patients with TBI.
- Most studies based on retrospectively analyzed data (class III data).

Cochrane Report, 2006


The authors of the review conclude that there is no evidence to support the routine use of DC to improve mortality and quality of life in brain injured adults with high ICP.

Critics

- Does craniectomy control ICP?
- Does brain herniating through the defect escalate the problem?
- Do the results justify the treatment? (shift outcome from mortality to persistent vegetative state and severe disability)
- Will the operation be performed in good prognosis patients who are destined to have a good outcome without decompressive craniectomy?

Decompressive Craniectomy, ICP and CPP


ICP Therapy

1st Tier Therapies
- CS<8

2nd Tier Therapies
- Hypothermia
- Barbiturate Therapy
- Controlled Hyperventilation
- Mannitol
- Hyperosmolar Therapy
- Mild Hyperventilation
- Ventricular Drainage
- Sedation & Paralysis

AANS Guidelines for Severe Head Injury

Acta Neurochir 2002, 144:791-796
**Indications for Decompressive Craniectomy**

- Age < 50 years
- Initial post-resuscitation GCS > 3
- Brain swelling on CT
- No fatal primary brain injury with irreversible brainstem signs

**Indications for Decompressive Craniectomy**

- ICP > 30 resistant to medical therapy, CPP < 50
- Intracranial hypertension with deterioration in clinical status
- Surgical intervention to be performed before irreversible brainstem damage

**Decompressive Craniectomy Contraindications**

- Bleeding diathesis
- Initial and persistent GCS 3 (despite resuscitation) and/or bilaterally fixed pupils

**DC - Comparison to other Secondary Tier Therapy**

- Side effects of barbiturates and hypothermia
- CBF and hyperventilation
- ARDS & "flowering" of contusions with pressor therapy

**Decompressive Craniectomy**

- **Early:** Unilateral, with hematoma removal
- **Late:** Unilateral for control of ICP and reduction of shift (with/without removal of hematoma, contusion or edematous brain), Bilateral for reduction of global intracranial hypertension

**Unilateral or Bilateral**

- Unilateral edema/swelling treated by fronto/temporo/parieto/occipital craniectomy
- Bilateral diffuse edema/swelling treated by bifrontal craniectomy
DC - Surgical Technique

- Use ICP guided parameters during procedure
- Trauma flap or bicoronal flap - attention to blood loss
- Bone flap must be at least 14 cms in diameter
- Removal of significantly contused areas of brain, especially in temporal or frontal regions

DC - Surgical Technique

**Duraplasty** is mandatory, preference of materials

- Natural - e.g., temporalis fascia, pericranium, fascia lata, cadaveric grafts, bovine (however, not often practical in large decompressive procedures)
- Artificial - less desirable for early reconstruction

DC - Surgical Technique

**Closure:**

- Attention to hemostasis, subgaleal drain, single layer skin closure
- Be careful of dressing & post-op positioning

Decompressive Craniectomy

**ICP and Tissue PO₂**

Jaeger, M. JNNP 2003;74:513-515

*Drill across pterion*

1 or 2 burr holes

*Midline*

Unilateral decompression
Bilateral Decompression

- Single burr hole in midline
- Bilateral burr holes
- Drill across pterion
- No burr hole usually necessary
In Situ Hinge Craniotomy


2nd Operation

DC - Complications

- Increased incidence of infection
- Major surgical procedure
- Cortical infarction
- Infections related to replacement of bone flap (4%)
- Re-absorption of flap (4%)
- Increased hydrocephalus requiring shunting (35%)

Timing of Cranioplasty

- Gaab: 6 weeks to 3 months.
- Polin: 3 to 6 months.
- Coplin: 3 to 6 months.

DC - Early Cranioplasty

- Can safely be performed
- Would prevent complications associated with a large cranial defect
- May be associated with neurological improvement
- Perform cranioplasty within weeks, not months, after injury

WHAT NEXT?

- Ventriculostomy
- Hyperosmolar agents
- Pressors
- Barbiturates
- Intermittent hyperventilation

35 year old, GCS 6

Ventriculostomy
Hyperosmolar agents
Pressors
Barbiturates
Intermittent hyperventilation
Unilateral Decompression with R frontal ICH removal

One Month Later

May 13, 2003, GCS <8

May 14, 2003

What would you do with this patient?

10 days later, no surgery!
Indications for Decompressive Craniectomy in TBI

- Age < 50 years
- Initial post-resuscitation GCS > 3
- Brain swelling on CT
- No fatal primary brain injury with irreversible brainstem signs
- ICP > 30 resistant to medical therapy, CPP < 50
- Intracranial hypertension with deterioration in clinical status

DC - Need for Randomized Study

- Procedure is undergoing a rebirth
- ABIC proposals have been turned down twice by NIH due to design flaws
- Best hope may be EBIC Study

Rationale for Class I Study of Decompressive Craniectomy

- Severe head injury is common
- Severe disability and persistent vegetative state have profound social and economic consequences

Rationale for Class I Study of Decompressive Craniectomy

- Centers not performing decompressive craniectomy will be provided with class I evidence
- Will help determine which patient subgroups are most likely to benefit
- Will establish the incidence of complications (hematoma, infection, hydrocephalus etc)


European Trial

- Effectiveness of Controlled Lumbar CSF Drainage in Medically Refractory Increased Intracranial Pressure

Ali Murad, MD; Samer Ghostine, MD; Austin R.T. Coakham, MD

Room 30 AB
4:16-4:30
# 650

 Dept. of Neurosurgery
AANS, May 4, 2009

DECRA(N) Trial

- Australian study of early decompressive craniectomy in severe head injury
- No further information available on web

Lumbar CSF Drainage for Refractory Intra-cranial Hypertension in adults
N=15

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<th>EVD placed</th>
<th>duration</th>
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Lumbar Drain ICP (mm Hg)

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<td>3 hr</td>
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*** \( P < 0.01 \) * \( P < 0.05 \)
Must have a functioning ventriculostomy draining at same level as lumbar drain!

Average ICP Before and After Lumbar Drain Placement (n=15)

Administration of Hypertonic Saline / Mannitol

Administration of Sedatives / Paralytics

25 yr male, involved in MVA
GCS 3
tSAH, cerebral edema

Journal of Neurosurgery - this month

Clinical evaluation of the safety and efficacy of lumbar cerebrospinal fluid drainage for the treatment of refractory increased intracranial pressure

Clinical article

Clinical evaluation of the safety and efficacy of lumbar cerebrospinal fluid drainage for the treatment of refractory increased intracranial pressure

- 100 patients with either severe TBI or SAH
- Successful reduction of ICP on average with improved CPP
- 6% herniation rate with lethal outcome due to lumbar drainage
Thank you

June 6, 2009

Decompressive Craniectomy and Acute Care Surgery

- 40 patients underwent DC (head AIS of 4 - 5)
- 55% mortality
- 30% good outcome

"In the era of acute care surgery we urge all our residents to scrub with the neurosurgeons and to learn these procedures. I'm not a neurosurgeon, but it looks like a pretty straightforward procedure to me."

Howard J Cipolle M et al. J Trauma 2008;65:380-386

Age and Outcome

- Generally has been accepted that decompressive craniectomy works best for patients under age 40-50.

- However, most studies have excluded older patients, making statistical comparisons difficult

Decompressive Craniectomy for Traumatic Brain Injury, Patient Age and Outcome

- Older patients were not excluded for "ethical and cultural reasons"
- 55 patients underwent DC regardless of age (21 w/o focal lesions and 34 following removal of mass lesion)

Case Study-J.M.

- MVC(Motorcycle) 9/1, GCS 3 → 6T
- Parenchymal & Bony Decompression for refractory ICP 9/1
- V.P. Shunt 9/10
- Awake, following commands 9/16
- Several shunt revisions
- To rehab 10/18

Case Study-J.M.

- Shunt revision 11/2
- Discharge 11/14 with right hemiparesis and mild to moderate dysphasia
- Return 11/18 with increase in weakness and worsening of speech - CT & EEG - O.K.
- Several Shunt Revisions eventually converted to VA Shunt 3/1

Case Study-J.M.

- Stable neurologically until 6/5 – cranioplasty
- Within 48hrs had marked improvement in both speech and motor function
- Seen last 7/15, ambulates independently, very mildly dysphasic, has begun vocational rehabilitation
Grant (1939) described the occurrence of delayed neurological, cognitive, and psychological symptoms following craniectomy.

**Reversible Monoparesis Following DC for TBI**

- Direct effects of atmospheric pressure on brain
- Alterations in CSF dynamics
- Changes in CBF
- Metabolic disturbances
- EEG phenomena


**Reversible Monoparesis Following DC for TBI**

- 38 patients with long-term follow-up after unilateral DC for TBI
- 26% experienced delayed contralateral upper extremity weakness, beginning 4.9 ± 0.4 months after DC
- Motor deficits improved markedly < 72 hours after cranioplasty
- All patients recovered full motor function


**Reversible Monoparesis Following DC for TBI**

- Ipsilateral contusions
- Abnormal CSF circulation
- Longer intervals to cranioplasty repair


**Conclusion:**

"Close follow-up of motor strength with early cranioplasty may prevent delayed motor complications of DC"
Malignant Cerebral Infarction

- Constitute 7% of all strokes
- Mortality rates are highest when lesions involve the trunk of one or more of the major cerebral vessels.
- Occlusion of either the distal ICA or proximal MCA trunk have been characterized as malignant in both clinical and animal studies.

Hacke et al found a 78% mortality in this subset of patients, with death occurring within the first four to five days.

Transtentorial herniation has been cited as the probable cause of death in many of these cases.

Decompressive craniectomy has been shown to reduce mortality from 80% to 34% or if initiated early, even to as low as 16%.

Schwab S et al, Stroke 9(29), 1998

Malignant CVA- Clinical Course

- Presenting symptoms include hemiplegia, homonymous hemianopsia, forced eye and head deviation toward the lesion side, aphasia with dominant hemisphere CVA
- Precipitous coma and pupillary dilatation usually occur together, followed by death if there is no further intervention.

Decompressive Craniectomy for Stroke

- Experimental findings suggest that early surgical decompression may limit the extension of the infarction and reduce morbidity
  1. Forsting M et al, Stroke 26, 1995
  2. Dourfler A et al, J Neurosurg 85, 1996
- Schwab and colleagues showed that patients undergoing decompressive craniectomy on average 21 hours after ictus did better than those who underwent surgery on average 39 hours after ictus.
  Schwab A et al, Cerebrovasc Dis 6, 1996
Neuroimaging

CT scan showing hypodensity in > 50% of the MCA territory is highly predictive of a progressive clinical course.

Does Side Count?

- In the past, it was felt that surviving with aphasia and a paralyzed dominant hand was not a satisfactory outcome.
- Recent studies show no difference in functional outcome after left or right-sided decompressive craniectomy.


Decompressive Craniectomy in Stroke

- Major MCA, ICA strokes, either hemisphere
- Younger (<50 years)
- Not neurologically devastated (posturing)
- Patients with dominant hemisphere strokes undergoing decompressive craniectomy have been shown to do as well as those with non-dominant strokes.