DECOMPRESSIVE CRANIECTOMY IN NEUROSURGERY: CURRENT STATUS AND REVIEW OF LITERATURE

Presenter : Gaurav Jaiswal

Moderators: Dr Rajender Kumar

Dr Deepak Gupta

History

- Decompressive craniotomy first described by Annandale in 1894
- Almost always performed as a palliative procedure in inoperable brain tumours
- Cushing reports subtemporal and suboccipital decompression to alleviate high ICP in 1905

CUSHING, H. (1905). The establishment of cerebral hernia as a decompressive measure for inaccessible brain tumor; with the description of intramuscular methods of making the bone defect in temporal and occipital regions. Surg. Gynecol. Obstet. **1**, 297–314.

INTROUCTION

- Management of raised ICP is common clinical scenario in Neurosurgery
- None remains more controversial than Decompressive Craniectomy

INTROUCTION

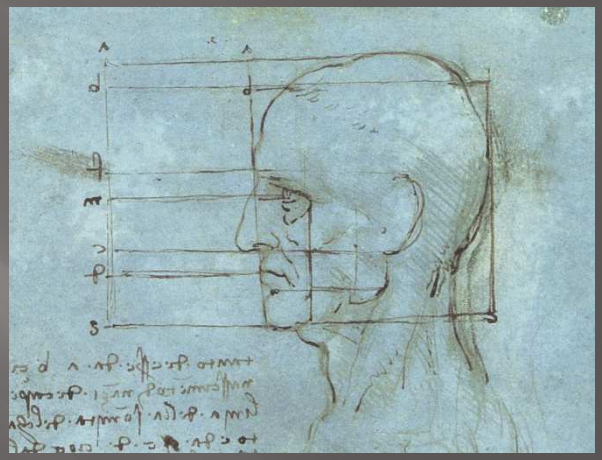
- Traumatic brain injury
- Cerebral Infarction
- Aneurysmal SAH
- Central Venous thrombosis
- Encephalitis
- Intracerebral hematoma
- Metabolic Encephalopathies

ICP determines Cerebral Oxygenation

- ICP: Pressure within cranial vault
- CPP = MAP – ICP
- Increased ICP results in cerebral ischemia
- Ischemia involves dilatation of cerebral vasculature
- Systemic hypertension is required to maintain cerebral perfusion

Monro-Kellie Doctrine

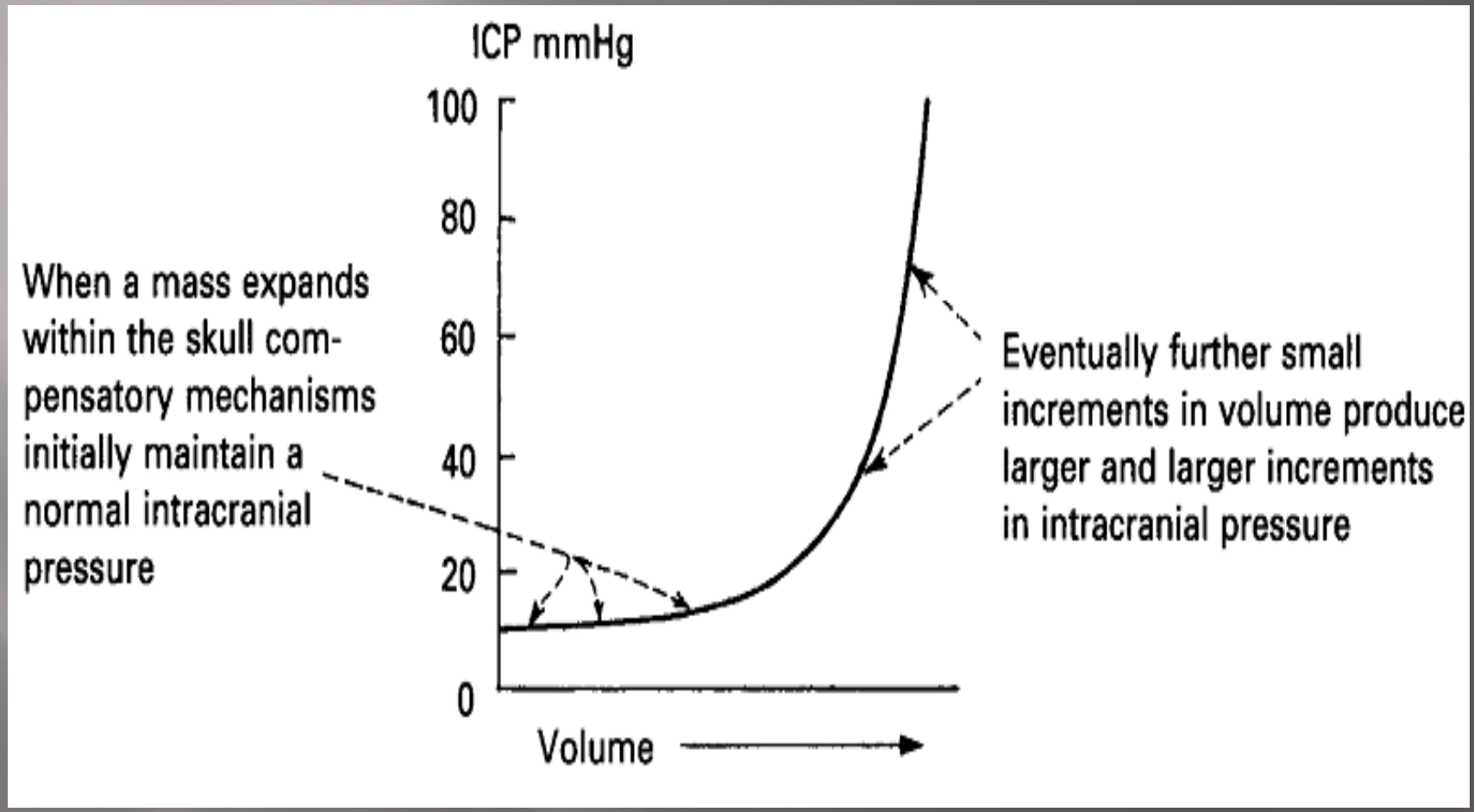
- Mature Cranial Vault is rigid structure
  - Brain Parenchyma
  - CSF
  - Blood



$V_{intracranial\ vault} = V_{brain} + V_{blood} + V_{csf}$

- Expansion in any of these increases ICP

Monro-Kellie Doctrine



Pathophysiology of Intracranial Hypertension

- Compromised Cerebral perfusion
- Disruption of osmotic differential across cellular membrane
- Intracellular edema further elevates ICP
- Feed-forward cycle for IC-HTN
- Herniation occurs in centrifugal manner
- Venous hypertension and arterial insufficiency
- Obstruction of CSF flow

Management of IC-HTN

- To reduce volume of intracranial compartments

-Head Positioning

-Hemodynamic optimization

-Hyperventilation

-CSF Drainage

-Mannitol/Diuretics

- Remove mechanical constraint of vault

-Large Craniectomies with durotomies

Management of IC-HTN

- ICP reduction correlates with size of craniectomy (Ranges from 15% to 85%)
- Durotomy further enhance ICP reduction
- Early Clinical experience with DC were limited to severe TBI that present in extremis
- Interest in Dc waned off
- Modern surgical techniques, refined post-op care, careful patient selection, yielded improved clinical outcome
- Renewed interest in Procedure

INDICATIONS FOR DECOMPRESSIVE CRANIECTOMY

- Traumatic brain injury
- Cerebral Infarction
- Aneurysmal SAH
- Central Venous thrombosis
- Encephalitis
- Intracerebral hematoma
- Metabolic Encephalopathies

TRAUMATIC BRAIN INJURY

- Heterogeneous lesions in cerebral parenchyma
- Focal (contusions/hematoma) and diffuse subtype
- ICP management is key in treatment of both
- Focal injuries facilitates surgical resection
- Management of diffuse injuries relies on optimizing hemodynamic, metabolic and osmotic parameters

TRAUMATIC BRAIN INJURY

- American Academy of Neurological Surgery (AANS)
- European Brain Injury Consortium

  Decompressive Craniectomy represent Second-Tier treatment

Decompressive Craniectomy in Traumatic Brain Injury

- Evidence supporting emergent Decompressive Craniectomy in Trauma remains controversial
- In animal studies, craniectomy has been a/w increased cerebral edema, hemorrhagic infarcts and cortical necrosis

Forsting M, Reith W(1995)

Wagener S et al(J Neurosurg 94:693-696, 2001)

Decompressive Craniectomy in Traumatic Brain Injury

- Decreased ICP
- Improved Oxygen tension
- Improved cerebral perfusion

Burket W. Zentralbl Neurochir 50:318-323, 1988

Gaab M et al Childs brain 5:484-498, 1979

Hatashita S, J Neurosurg 67:573-578, 1987

Decompressive Craniectomy in Traumatic Brain Injury

JOURNAL OF NEUROTRAUMA
Volume 23, Number 10, 2006
© Mary Ann Liebert, Inc.
Pp. 1502–1509

Aspects on Decompressive Craniectomy in Patients with Traumatic Head Injuries

THOMAS S. SKOGLUND,[1] CATHERINE ERIKSSON-RITZÉN,[2] CHRISTER JENSEN,[3] and BERTIL RYDENHAG[1]

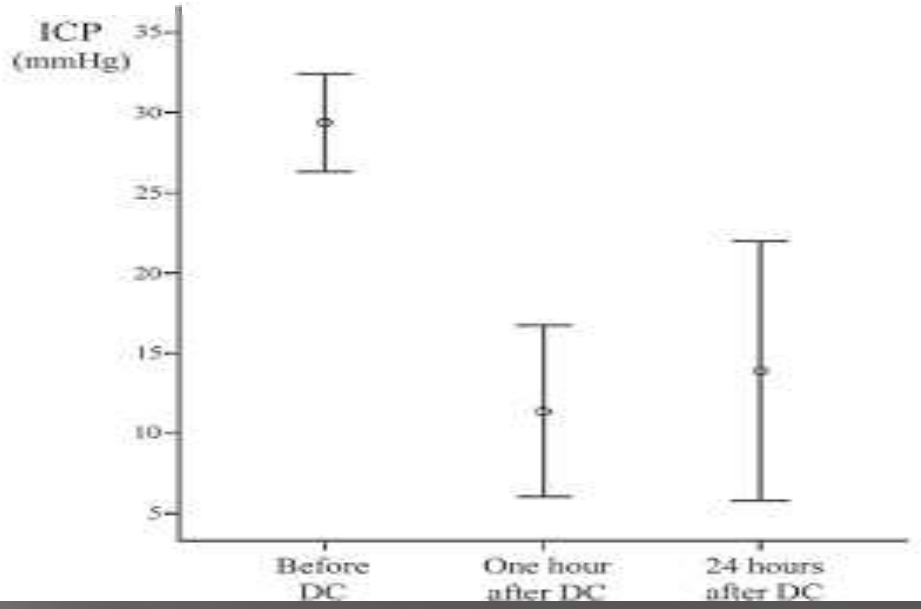


FIG. 1. Mean intracranial pressure (ICP) with 95% confidence interval of the patients before, 1 h after, and 24 h after decompressive craniectomy (DC); n = 9 patients.

Decompressive Craniectomy in Traumatic Brain Injury

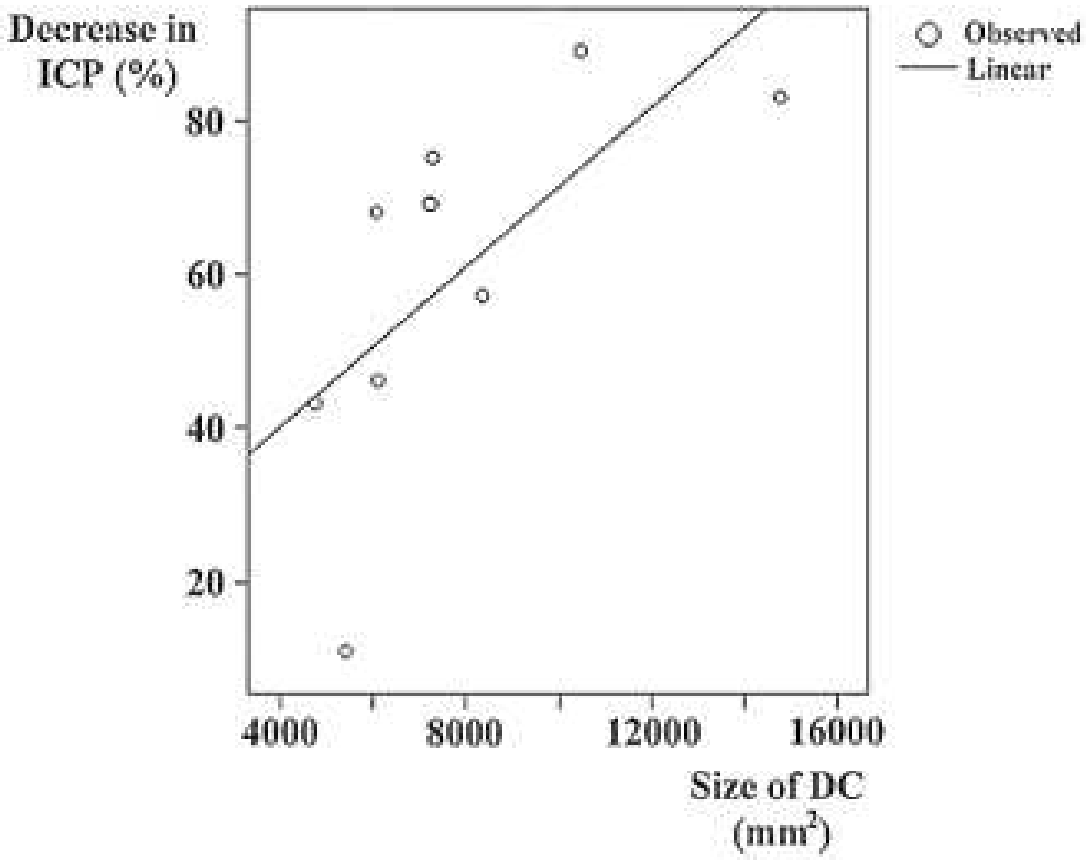


FIG. 2. Scatter plot, with regression line, of the size of the craniectomy (mm^2) versus the decrease in intracranial pressure (ICP) (expressed as %) after the craniectomy; $n = 9$ patients.

Decompressive Craniectomy in Traumatic Brain Injury

- Munch E. et al (2000) in review of more than 30 studies in context of severe head injury failed to demonstrate clear benefit
- Studies are predominantly retrospective with few prospective efforts.
- Studies consists of small no. of patients
- Confounded by lack of randomization, contemporary comparison groups, intensity and timing of therapeutic intervention.

Decompressive Craniectomy in Traumatic Brain Injury

- Studies were published over span of 40 yrs
- Results need to interpreted in context of evolving surgical technique and changes in critical care
- Cooper and Colleague (1976) initially reported 40% survival for traumatic cerebral edema
- Prospective treatment of 50 patients yielded only 10% total survival rate

Decompressive Craniectomy in Traumatic Brain Injury

- Pollin (1997) and colleague analyzed 35 DC retrospectively in patients from IC-HTN
- Compared outcome against 92 controls selected from Traumatic Coma Data Bank
- Patients with focal traumatic injuries excluded
- Controls matched in terms of Sex, Age, GCS and maximum Pre-operative ICP

Decompressive Craniectomy in Traumatic Brain Injury

The Glasgow Outcome Scale Five categories exist –

1. **Death**
2. **Persistent Vegetative State** – see below.
3. **Severe Disability** – *dependent* for some support in every 24 hour period.
4. **Moderate Disability** – *independent* but disabled. May or may not be capable of return to work.
5. **Good recovery** – *good*, but not necessarily complete recovery. e.g. cranial nerve deficit. Could (although may not) return to work.

Decompressive Craniectomy in Traumatic Brain Injury

- 37% of decompressed patients and 16% of control patients showed favorable recovery ($p=0.014$)
- Prolonged raised ICP causes irreversible cerebral damage
- Subset analysis excluding patients with ICP> 40 mmHg, Decompression done > 48 hrs
- Favorable outcome for decompressed patient was 60% and 18% for control patients ($p<0.001$)

Decompressive Craniectomy in Traumatic Brain Injury

- Whitefield and colleagues (2001) retrospectively examined 26 pts with refractory, Post traumatic IC-HTN treated with Decompressive Craniectomy
- Control group of contemporary, randomized trial investigating therapeutic effect of NDMA antagonist
- Demographic distribution and therapeutic intensities of both groups were comparable

Decompressive Craniectomy in Traumatic Brain Injury

- In both studies, favorable outcome was defined as GOS of 4 or 5 at 6 months follow-up
- 61% of pts with decompression attained favorable outcome, compared with 30% in control group
- Improved outcome was associated with reduction in ICP

Decompressive Craniectomy in Traumatic Brain Injury

- Guerra and colleagues(1999) reported prospective series for surgical decompression
- Patients accrued in 1977 with standard protocol
- Initially Pt > 30 yrs excluded from study
- Pts < 40 yrs were accepted from 1989
- Pts < 50 yrs were accepted from 1991
- Pts with initial and persistent GCS score of 3, bilateral dilated, fixed pupils were excluded

Decompressive Craniectomy in Traumatic Brain Injury

- In total, 57 patients underwent unilateral or bilateral hemicraniectomy for diffuse cerebral edema a/w IC-HTN
- 58%(n=33) of patients survived with GOS 4 or 5
- 11%(n=6) severe neurological deficit (GOS-3)
- 9%(n=5) remained in persistent vegetative state
- 19%(n=11) of patient died

Favorable results when compared with control group derived from NMDA trial

Decompressive Craniectomy in Pediatric Population

- Taylor et al (2001) randomized children over age of 12 months with post traumatic IC-HTN and Neurological deterioration
- Conventional management and bitemporal craniectomy
- Surgery was done within 6 hrs of deterioration
- Total 27 patients
- 13 Craniectomies v/s 14 Conservative group

Decompressive Craniectomy in Pediatric Population

- ICP in craniectomy group was significant lower
- 54% (7/13) recovered with mild disability after 6 months
- Whereas 14% (2 out of 14) recovered with mild disability of medically managed group
- Difference though very suggestive, didn't achieve statistical significance

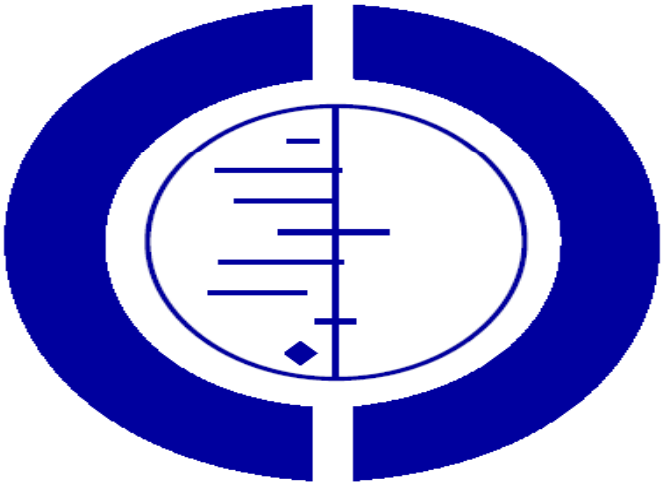
Decompressive Craniectomy in TBI

Table 1 Summary of clinical outcomes following decompressive craniectomy in traumatic brain injury

First author	Year	Number of patients	Outcome based on Glasgow Outcome Scale			Additional details
			Favourable	Unfavourable	Dead	
Venes	1975	13	Increase in survival, but high morbidity, with only on patient returning to pretrauma level of neurological function			Retrospective, observational study
Cooper	1976	50	4	6	90	Retrospective outcome analysis of hemicraniectomy performed for ASDH
Pereira	1977	12	42	8	50	Bifrontal decompressive craniectomy performed for a treatment of traumatic brain oedema
Britt	1978	42			55	Retrospective case series
Gerl	1980	30	17	13	70	Retrospective case series
Shigemori	1980	15			67	Retrospective case series
Gower	1988	10 and 17 (barb)			40 (82 in barbiturate group)	Comparison of craniectomy and barbiturates versus barbiturates alone
Gaab	1990	37	78	8	14	Prospective single centre study, with exclusion criteria
Ammar	1993	5	Improvement in brain stem function			Observational study in paediatric patients
Razack	1997	20			20	Retrospective case series
Polin	1997	35	37	40	23	Retrospective case series
Kunze	1998	28	56	32	11	Retrospective case series
Guerra	1999	57	58	20	19	Patients over certain age are excluded
Munch	2000	49	No beneficial effect on outcome			Some improvement in CT appearance
De Luca	2000	22	41	41	18	23% of patients with persistent vegetative state
Coplin	2001	29	Similar outcome with higher severity			
Taylor	**2001**		**56 vs. 14**			**Prospective randomized controlled trial**
Whitfield	2001	26	69	8	23	Retrospective case series
Csokay	2002	21	38	19	43	Case series
Soukiasian	2002	24 vs. 96			37.5 vs. 18	Craniectomy compared to craniotomy
Kontopoulos	2002	9	66	11	22	Retrospective case series
Schneider	2002	62	29	48	23	Documented improvement in ICP control
Messing-Junger	2003	51	Some benefit, particularly in younger patients			Case series
Albanese	2003	40	19	30	14	Early versus late decompression
			38	38	23	
Ziai	2003	18	30	48	22	Mixed group
Ucar	2005	100	16	30	54	Worse outcome in patients with low GCS
Timofeev	2005	49	61	20	18	Retrospective series. Decompressive craniectomy is driven by the intensive care protocol.

Decompressive craniectomy for the treatment of refractory high intracranial pressure in traumatic brain injury (Review)

Sahuquillo J, Arikan F



THE COCHRANE COLLABORATION®

The Cochrane Database of Systematic Reviews
The Cochrane Library, Copyright 2006,
The Cochrane Collaboration Volume (1), 2006
Decompressive craniectomy for the treatment of refractory high intracranial pressure in traumatic brain injury
Sahuquillo, J; Arikan, F

- There is no evidence to support the routine use of secondary DC to reduce unfavourable outcome in adults with severe TBI and refractory high ICP. In the pediatric population DC reduces the risk of death and unfavourable outcome.

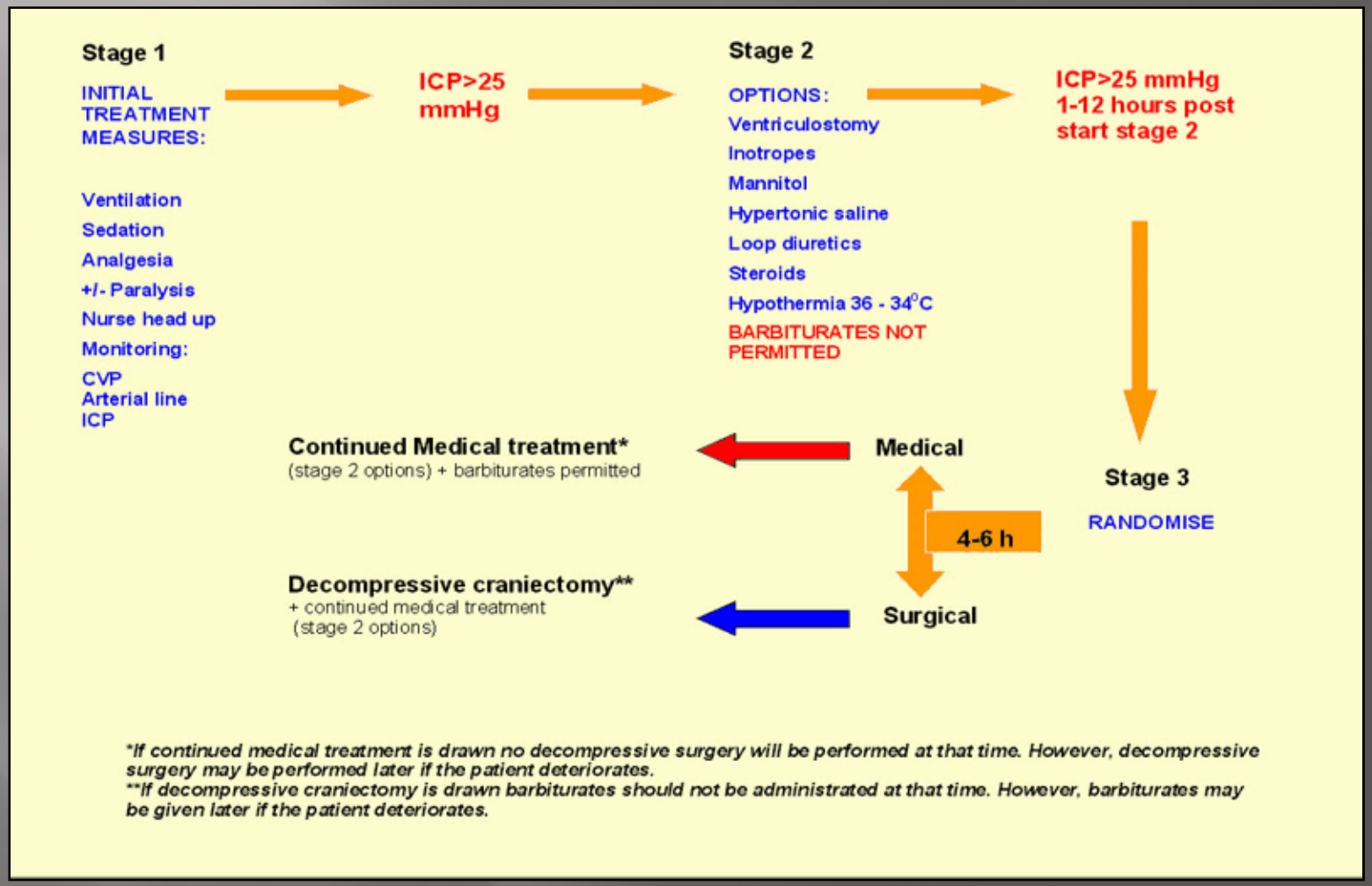
The Cochrane Database of Systematic Reviews
The Cochrane Library, Copyright 2006,
The Cochrane Collaboration Volume (1), 2006
Decompressive craniectomy for the treatment of refractory high intracranial pressure in traumatic brain injury
Sahuquillo, J; Arikan, F

- However, the results of non-randomized trials and controlled trials with historical controls involving adults, suggest that DC may be a useful option when maximal medical treatment has failed to control ICP

2 Controlled Trials Ongoing

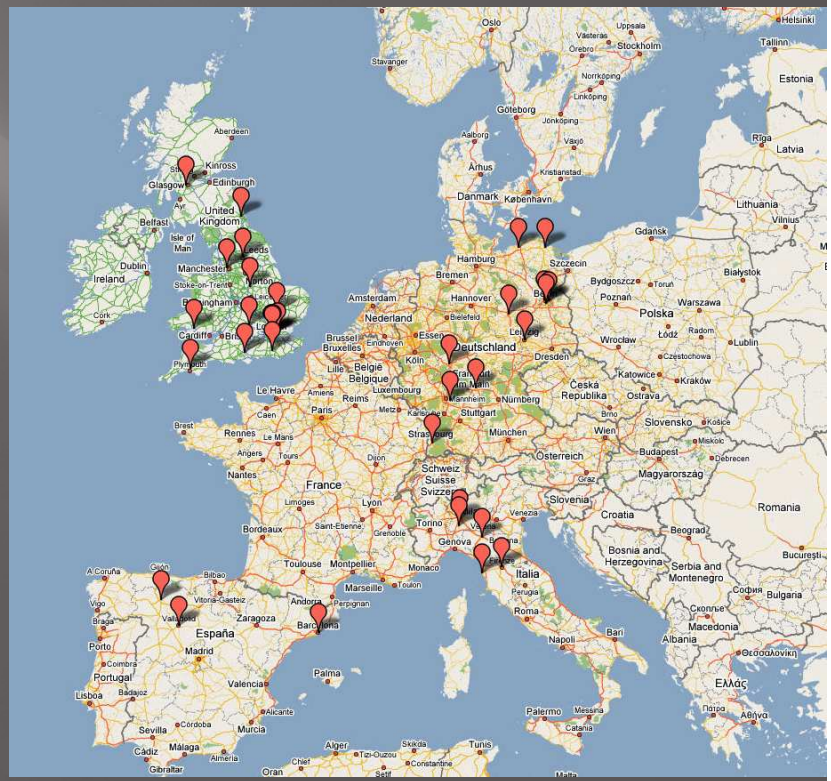
- DECRA Trial: Early **De**compressive **Cra**niectomy in Patients With Severe Traumatic Brain Injury
- Multicenter-Australia-Start 2003-Estimated completion July 2010- 165 patients.
- RESCUEicp : Randomised Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of ICP
- Worldwide but mainly UK. Hope for 600pts over 3 years –with 2 years follow-up. 150pts As of May 2008

RESCUEicp : Randomised Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of ICP



Study Centres

- 24 centres are currently contributing patients
- 28 centres are initiating
- Aim ≈ 80 centres worldwide
- > 100 interested centres



Study population

- Inclusion criteria
  - Patients with head injury requiring ICP monitoring
  - Age 10-65 years
  - Abnormal CT scan
  - Patients may have had an immediate operation for a mass lesion but not a "decompressive" craniectomy
- Exclusion criteria
  - Bilateral fixed and dilated pupils
  - Bleeding diathesis
  - Devastating injury not expected to survive 24 hours
  - Brainstem damage
  - Follow up not possible

Summary

- Indication of DC in TBI remain controversial
- ICP is reduced by Craniectomy
- Whether clinical course altered is a QUESTION that awaits definite definitive randomized trials
- Young patients with GCS > 4 may benefit from decompression when intervention is early

Summary

- Most studies included diverse study population suffering from variety of injuries
- Further studies that focus on distinct subpopulations may offer best information regarding subgroups most likely to benefit from this procedure

Malignant Cerebral Infraction

- Refers to large territorial parenchymal infarctions with post ischemic edema and associated uncal and brainstem herniation
- Accounting for 7-15% of all strokes
- Mortality ranges from 70-80%
- Rapid neurological deterioration 2 to 4 days after initial onset of stroke
- Gaze towards side of infarction, contralateral hemiplegia, deterioration in consciousness

Hemicraniectomy in Treatment of Malignant Infarction

- Retrospective case series, prospective nonrandomized clinical trials, yielded favorable results.
- Reduces associated mortality from 80% to 30%
- Chen T.(2003) Mortality can be reduced to 10% if decompression undertaken within 24 hrs
- In younger patient prognosis is generally more favorable irrespective of surgical intervention

Hemicraniectomy in Treatment of Malignant Infarction

- Wijdicks and Dirinder (1998): Mortality a/w Malignant Infarction managed medically is 40% in patient < 60 yrs, 90% over age of 60 yrs
- Holtkamp et al (2001) retrospectively compared survival rate of 24 pts > 55 yrs of age
- Twelve of 24 patients underwent hemicraniectomy and 12 were managed medically
- Mean age, age distribution, extent of infarct between two groups were not statistically significant

Hemicraniectomy in Treatment of Malignant Infarction

- 8 of 12 (67%) patients who underwent hemicraniectomy survived
- Only 3 of 12 (25%) who underwent maximal medical treatment survived

Hemicraniectomy in Treatment of Malignant Infarction

- Cho. D. (2003) in Retrospective analysis of 52 decompression , stratified by time to surgery into groups
  a) < 6 hrs from ictus
  b) > 6 hrs from ictus
  c) No intervention
- Mortality 8%, 36% and 80% respectively

Hemicraniectomy in Treatment of Malignant Infarction

- Average length of ICU stay was
- 12 days (range - 6 to 21 days)
- 18 days (range – 4 to 56 days)
- 7 days (range -2 to 18 days)

Timing of surgery affect survival and length of ICU stay

Hemicraniectomy in Treatment of Malignant Infarction

- Schwab et al (1998) retrospectively stratified 63 interventions into decompression
- Within 24 hrs (early, 31 patients)
- After 24 hrs (late 32 patients)
- Mortality was 16% for early decompression and 34% for late interventions
- Average length of ICU stay was 7 days for early decompression and 13 days for late decompression

Baseline demographic profile was comparable in both studies

Functional Recovery after Hemicraniectomy

- Though often life-saving, leaves patient with moderate to severe disability
- Barthel Index: Scale for physical disability in stroke patients
- Maximum score 100 (no disability)
- Score of 60: Functional Independence despite moderate disability
- Score of 60-99: Mild to Moderate disability

Barthel Index

		With Help	*Independent*
1.	Feeding (if food needs to be cut up = help)	5	10
2.	Moving from wheelchair to bed and return (includes sitting up in bed)	5-10	15
3.	Personal toilet (wash face, comb hair, shave, clean teeth)	0	5
4.	Getting on and off toilet (handling clothes, wipe, flush)	5	10
5.	Bathing self	0	5
6.	Walking on level surface (or if unable to walk, propel wheelchair) *score only if unable to walk	0*	5*
7.	Ascend and descend stairs	5	10
8.	Dressing (includes tying shoes, fastening fasteners)	5	10
9.	Controlling bowels	5	10
10.	Controlling bladder	5	10

Functional Recovery after Hemicraniectomy

- Mean Barthel Index Score in various series ranged from 55 to 70
- Barthel Index score is higher for younger patients
- 50 to 80% of all patients < 60 yrs who underwent craniectomy attained scores of 60 at follow up
- In contrast 0 to 30% of patients over age 60 attained 60 or more
- All patients, score of 90 or more were < 45 yrs

Functional Recovery after Hemicraniectomy

- Cho et al(2003) retrospectively examined effect of early and late decompression in 42 patients
- Early (Within 6 hrs of ictus)
- Late (More than 6 hrs after ictus)
- Mean Barthel score was 70 in early decompression (range 60 to 80)
- Mean Barthel score was 53 (range 10-70) that underwent late decompression
- Difference was statistically significant

Functional Recovery after Hemicraniectomy

- Improvement in outcome was not observed in study (Schwab et al, 1998) that compared Barthel score of patients
- < 24 hrs and > 24 hrs
- Barthel score was 63 and 69 respectively

Hemicraniectomy in Treatment of Malignant Infarction

- DECIMAL
- DEcompressive Craniectomy In MALignant Middle Cerebral Artery Infarcts
- HAMLET
- Hemicraniectomy After MCA infarction with Life-threatening Edema Trial
- DESTINY
- Decompressive Surgery for the Treatment of Malignant Infarction of the Middle Cerebral Artery

DECIMAL@2007
DEcompressive Craniectomy In MALignant Middle Cerebral Artery Infarcts

- Sequential design, multi-centre, randomized, controlled trial
- *Study Size Actual:* 38
- *Study Size Planned:* 60
- *Centres Actual:* 7
- *Max Time from onset:* 30 Hours
- *Max Age:* 55
- *Min Age:* 18
- *Follow-up Duration:* 1 Years

Modified Rankin Scale

0	.....	No symptoms at all.
1	.....	No significant disability despite symptoms: *Able to carry out all usual activities.*
2	.....	Slight disability.
3	.....	Moderate disability: *Requiring some help but able to walk without assistance.*
4	.....	Moderate to severe disability: *Unable to walk without assistance and unable to attend to own bodily needs without assistance.*
5	.....	Severe disability: *Bedridden, incontinent and requiring constant nursing care and attention.*

DECIMAL@2007
DEcompressive Craniectomy In MALignant Middle Cerebral Artery Infarcts

DECOMPRESSIVE CRANIECTOMY	STANDARD THERAPY GROUP
20 patient	18 patients
25%, mRS </=3 @ 6 Months	5.6% mRS </=3 @ 6 Months
50%, mRS </=3 @ 1 year	22.2% mRS</= @ 1 year
Highly significant reduction in death rate 52.8%	22%

Functional Outcome for Right-Versus Left-Sided Infarctions

- Infarction of dominant hemisphere and presentation of global aphasia often sited as poor functional prognostic indicator
- Waltz ((2002) compared functional outcome of in 18 patients
- Right sided hemicraniectomy 10 patients
- Left sided hemicraniectomy 8 patients
- No significant differences in quality of life indices

Summary


ER physician
PT/OT
neurosurgeon
Neurologist
porter
I-PA
Nurses

Summary

- Decompressive craniectomy represents an effective life preserving measure in Malignant Cerebral Infarction for all patients
  - Independent of age
  - Initial presentation
  - Side of infarction
- Age <60 yrs gain meaningful function recovery
- Maximum benefit from early intervention

Cerebral Venous Sinus Thrombosis

- Thrombosis of sinus is accommodated by recruitment of collateral venous drainage
- Exhaustion upon these pathways, venous pressure approaches arterial pressure
- Cerebral edema results in transgression of fluid in interstitial space
- Further elevation of venous pressure can impair influx of blood, causing infarct with rupture of vasculature and hematoma formation

Cerebral Venous Sinus Thrombosis

- Standard treatment of venous thrombosis involves either anticoagulation or thrombolysis
- Venous congestion increases fragility of vasculature and can hamper hemostasis
- Surgical manipulation of parenchyma is discouraged in this setting.
- Decompressive craniectomy allows control of intracranial pressure without parenchymal manipulation

Cerebral Venous Sinus Thrombosis

- Stefini et al (1999) reported 3 patients with large hemorrhagic infarcts from dural sinus thrombosis with signs of brain stem compression
- Women between age 40 to 50 yrs
- Two patients underwent hemicraniectomy at onset of clinical deterioration and recovered with mild disability
- Third patient underwent intervention several hours, remained severely disabled at 6 months

Cerebral Venous Sinus Thrombosis

- Emergent decompression should be considered in treatment of venous sinus thrombosis in patients who developed brain stem herniation

Intracerebral Hematoma

- Intracerebral hematoma arises either from spontaneous rupture of vessels
- Structural integrity is impaired by hypertension, malformations or tumor
- Indication for surgical indications remain controversial
- Recent evidence suggest subset of patients with large hematoma who showed neurological deterioration may benefit from evacuation (Broderick J 1999)

Intracerebral Hematoma

- Dierssen et al (1983) reported 31 patients with spontaneous intraparenchymal hematomas and acute neurological deterioration
- Treated with evacuation and decompressive craniectomy
- Mortality of this series was compared with another series of 20 patients treated only with evacuation
- Statistically significant improvement in mortality in group with craniectomy
- 32% vs. 70% p = 0.005

Conclusion

- IC-HTN results from many disease processes
- Decompressive craniectomy can be life preserving procedure
- Selection criteria remains in involution
- Best outcome are achieved in young patients treated early in course of disease

Thanks