MANAGEMENT OF RAISED ICP AND ANAESTHETIC IMPLICATIONS



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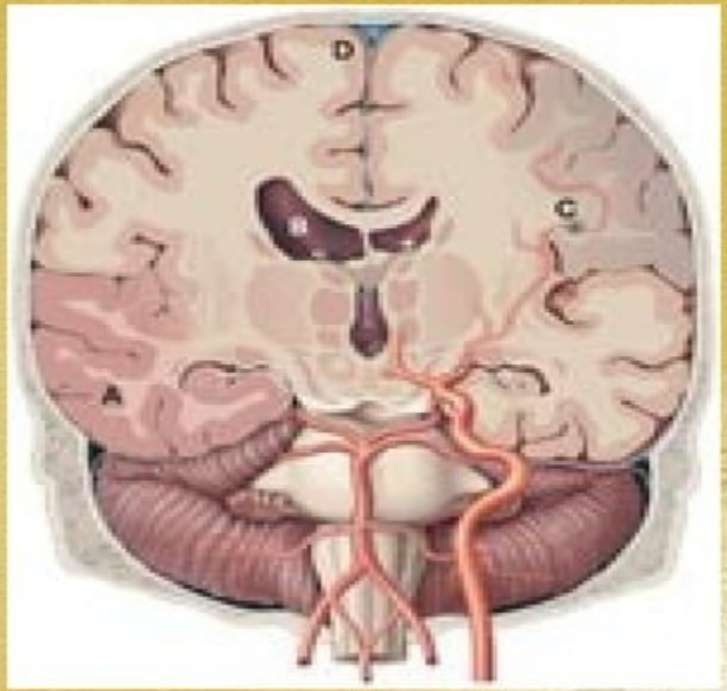
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Introduction

- Physiology of ICP Maintenance
  - Cranium:
    - A Box with only one opening
    - Opening at the base
    - No possibility of expansion
    - Primary Function: Protection of brain
    - Also maintain an equilibrium

Cranium



Intracranial Contents

- Brain 80 – 85 %
- CSF 8 – 12 %
- Cerebral blood volume 5 – 8 %

- Total Intra cranial volume 1500 ± 100ml

Compensatory Mechanisms

- ***Autoregulation of cerebral blood flow***
- ***Regulation of CSF***
- ***Regulation with help of metabolic changes***

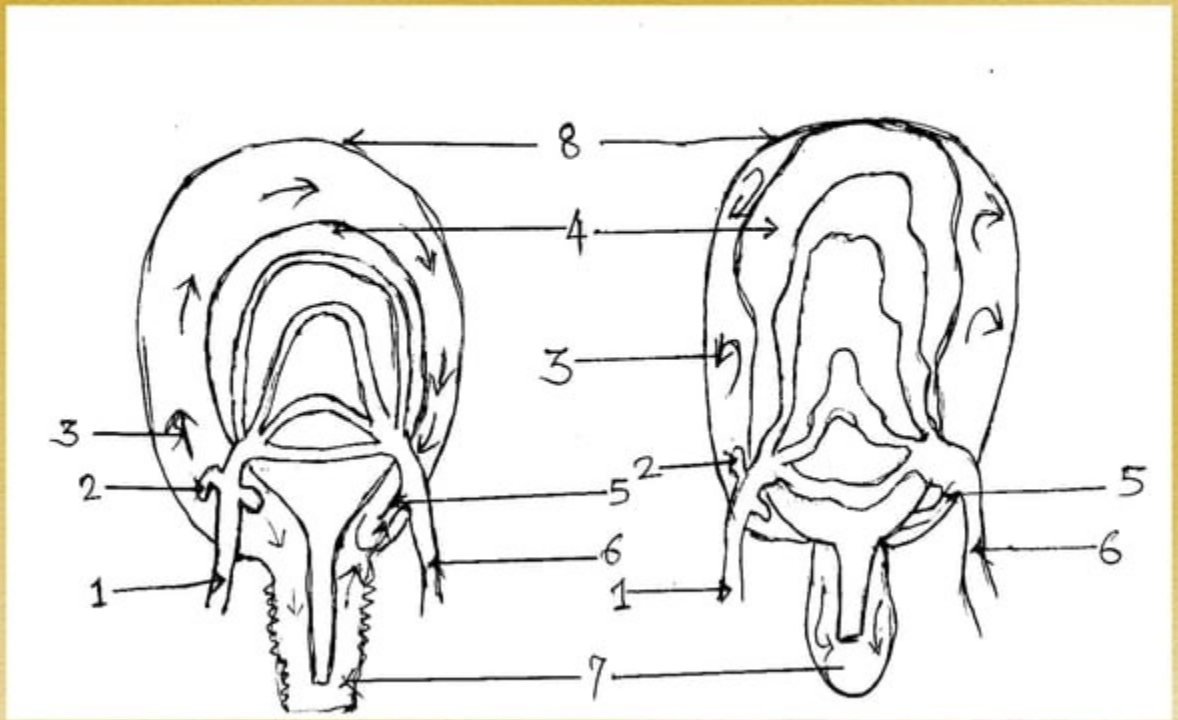
Monro-Kellie Hypothesis

- ***Pathologic States that increase the volume of one component necessitate decrease in the volume of another to maintain normal Intra-Cranial Pressure***

INTRA CRANIAL PRESSURE (ICP)

- Measure of CSF Pressure within Cranium
- Normal range 5 – 15 mm Hg




8
4
3
3
2
5
6
1
7
3
2
5
6
1

CONSEQUENCES

- Internal herniation:- Temporal lobe is pushed down though Tentorium incisura

- External herniation:- Cerebellar tonsills/ peduncle herniate through foramen magnum → Compressing over IV ventricle → ↓CPP → Death == “CONING”

CEREBRAL PERFUSION PRESSURE (CPP)

- ***Effective pressure that allows the perfusion of blood through the brain***
- CPP = MAP – ICP
- Mean arterial pressure (MAP) = DP+ (SP-DP)
- DP + PP/3 3

- (ICP ≈ CVP)
- CPP ≈ MAP – CVP

CEREBRAL BLOOD FLOW

- Normal **CBF** 45 – 50 ml / 100 gm / min
- Range 20 ml / kg / min to 70 ml / kg / min

- CBF Highest Frontal region
- CBF Medium Parietal region
- CBF Lowest Temporal area

HAEMODYNAMIC AUTO REGULATION

- Cerebral Autoregulation
- Normal range MAP 50 – 150 mm Hg

- In Head injured ~~ Failure of autoregulation
- CBF = < 20ml / kg /min.
- Adverse effect on ICP

FACTORS EFFECTING C.B.F.

- Hypoxia
- Hypercapnea
- Inhalational anaesthetic agents
- Acidosis



METABOLIC AUTOREGULATION OF C.B.F.

- Hypercapnea
- “Luxury perfusion syndrome”



METABOLIC AUTOREGULATION OF C.B.F. (Cont.)

- “Steal syndrome”
- “Inverse steal”
- ↑ CBF – $PaCO_2$ drops below 50 mm Hg

INCREASED I.C.P.

- ICP <15 mmHg – Intracranial hypertension
  - Acute
  - Chronic

	ICP in mmHg
Normal	5 – 15
Mild	16 - 20
Moderate	21 - 30
Severe	31 - 40
Very Severe	41 & Above

PATHO-PHYSIOLOGY OF INCREASED I.C.P.

- CPP α CBF
- CPP α 1/ICP
- ↑ICP → ↓CBF, ↓Blood volume, ↑CO_2

FACTORS CAUSING INCREASED I.C.P.

- Cerebral Oedema
  - Vasogenic
  - Cytotoxic oedema
    - Hypoxemia
    - Hyponatremia/ Water Intoxication
    - Post-Cardiac Arrest
    - Inflammatory—Meningitis/Encephalitis
  - Interstitial oedema
- Intra Cranial Space Occupying Lesions
- Enlarged ventricular system
- Pneumocephalus
- Increase in C.B.F.
- Impaired cerebral venous drainage

FACTORS CAUSING INCREASED I.C.P. IN CHILDREN

Neonates/Infants

- Secondary cerebral oedema to peri-natal hypoxia or trauma
- Congenital hydrocephalus

Older Infants/Toddlers/Children

- Meningitis
- Brain tumors (Infra tentorial)
- Pseudo tumor cerebrii
- Trauma
- Reye's syndrome

ASSESSMENT OF ICP

- Thorough clinical assessment
- “WARNING SIGNS”:

  Confusion, agitation, restlessness, aggressiveness

  Personality changes

  Glasgow Coma Score (GCS)

GLASGOW COMA SCORE

Findings	Score
1) Eye opening	
Spontaneous	4
To voice	3
To Pain	2
None	1
2) Best verbal response	
Oriented	5
Confused speech	4
Inappropriate words	3
Incomprehensible sounds	2
None	1

Findings	Score
3)Best motor response	
Obeys Commands	6
Localizes pain	5
Withdraws	4
Abnormal flexion	3
Extension	2
None	1

Prognostic value as per GCS

Score	Percentage
GCS 3/ less	100
GCS 3 – 5	60 – 84
GCS 6 – 8	36 – 46

I.C.P. MONITORING (Cont.)

- Pupillary light reflex
- Corneal reflex
- Occulocaloric reflex
- Occulocephalic reflex



CUSHING'S TRIAD

- ↑ Systolic blood pressure
- Widening of pulse pressure
- Bradycardia
- Projectile vomiting
- Irregular respiratory pattern



INTRACRANIAL PRESSURE MONITORING

- Def:

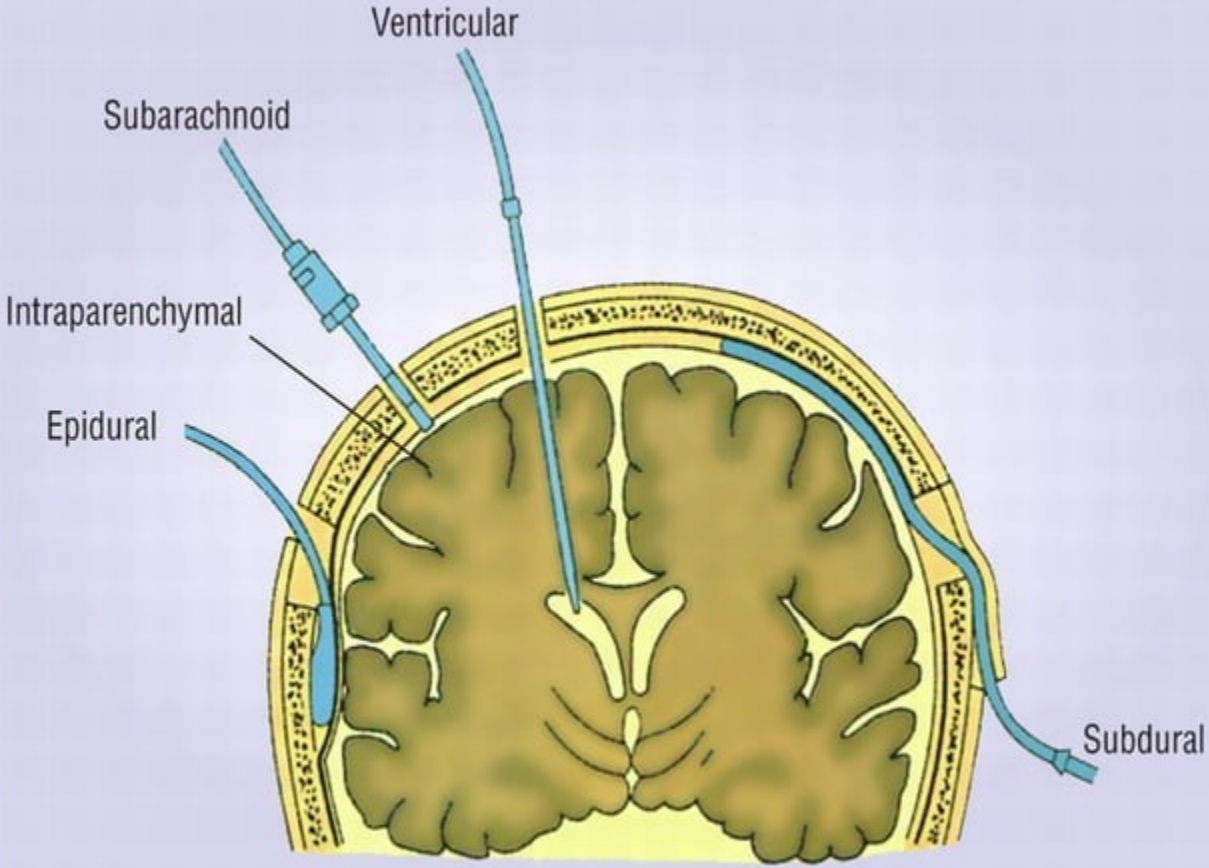
- Ventricular system
- Sub-arachnoid space
- Epidural space
- Brain parenchyma



METHODS OF I.C.P. MONITORING

- Intraventricular catheter
- Subarachnoid screw or bolt
- Epidural sensor



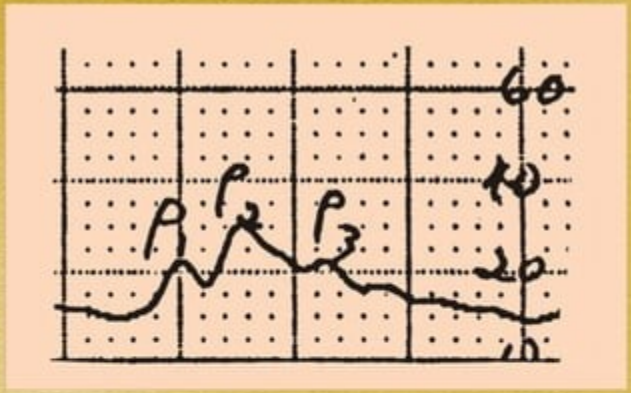


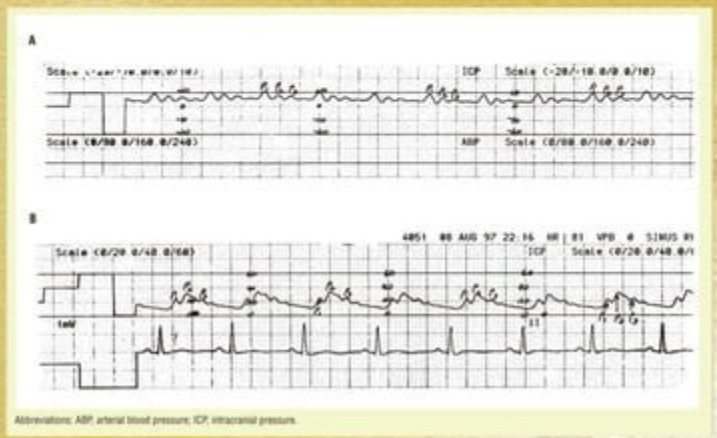
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ICP WAVE FORMS

- A, B, & C waves

- Factors influencing waves
  - Systolic blood pressure
  - Alterations in respiration
  - Deteriorating neurological status
- Components of waves
  - P_1 (upward spike)
  - P_2 (tidal wave)
  - P_3 (small notch)



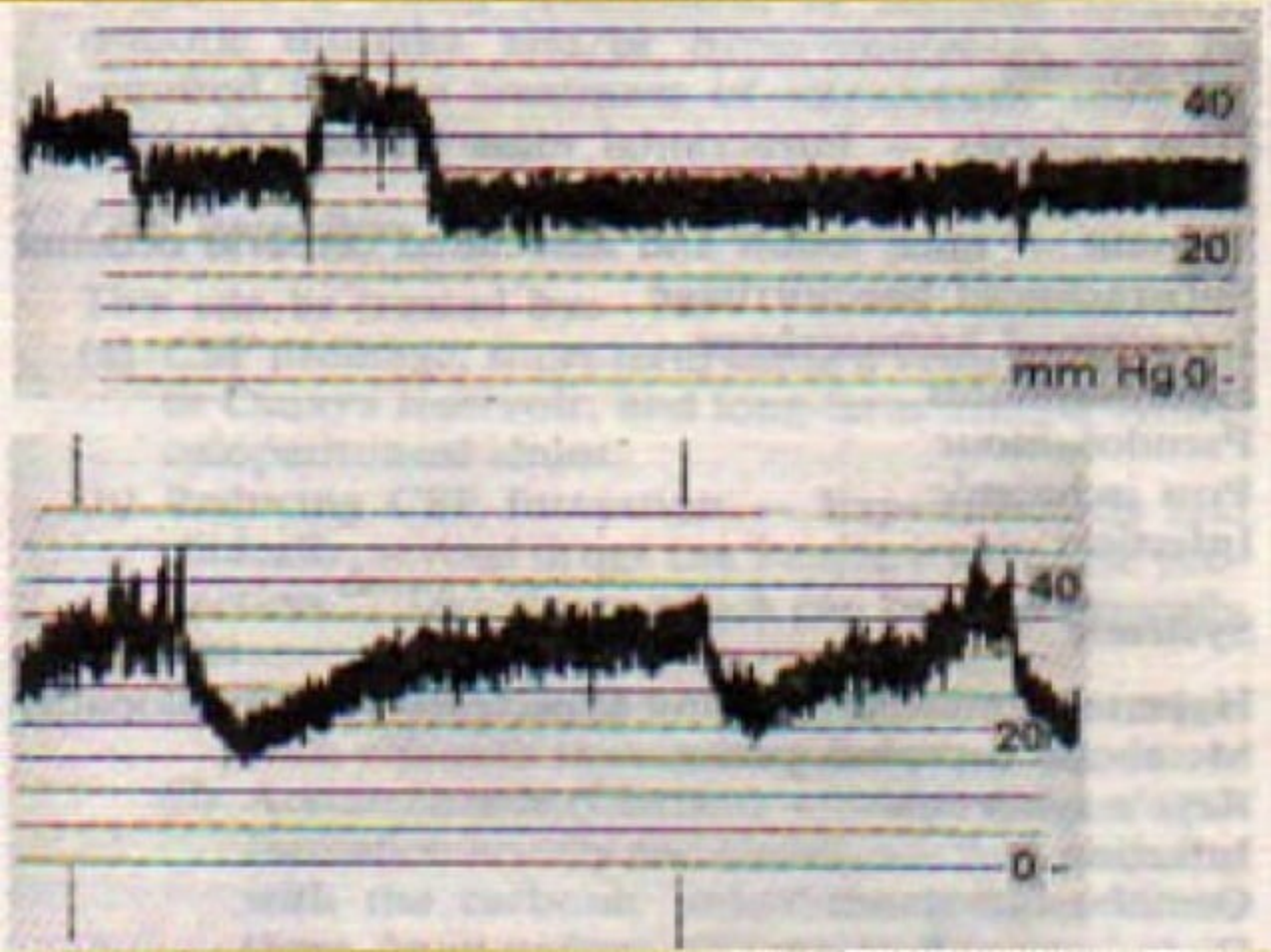


Abbreviations: ABP, arterial blood pressure; ICP, intracranial pressure.

ICP WAVE FORMS (CONT.)

A waves

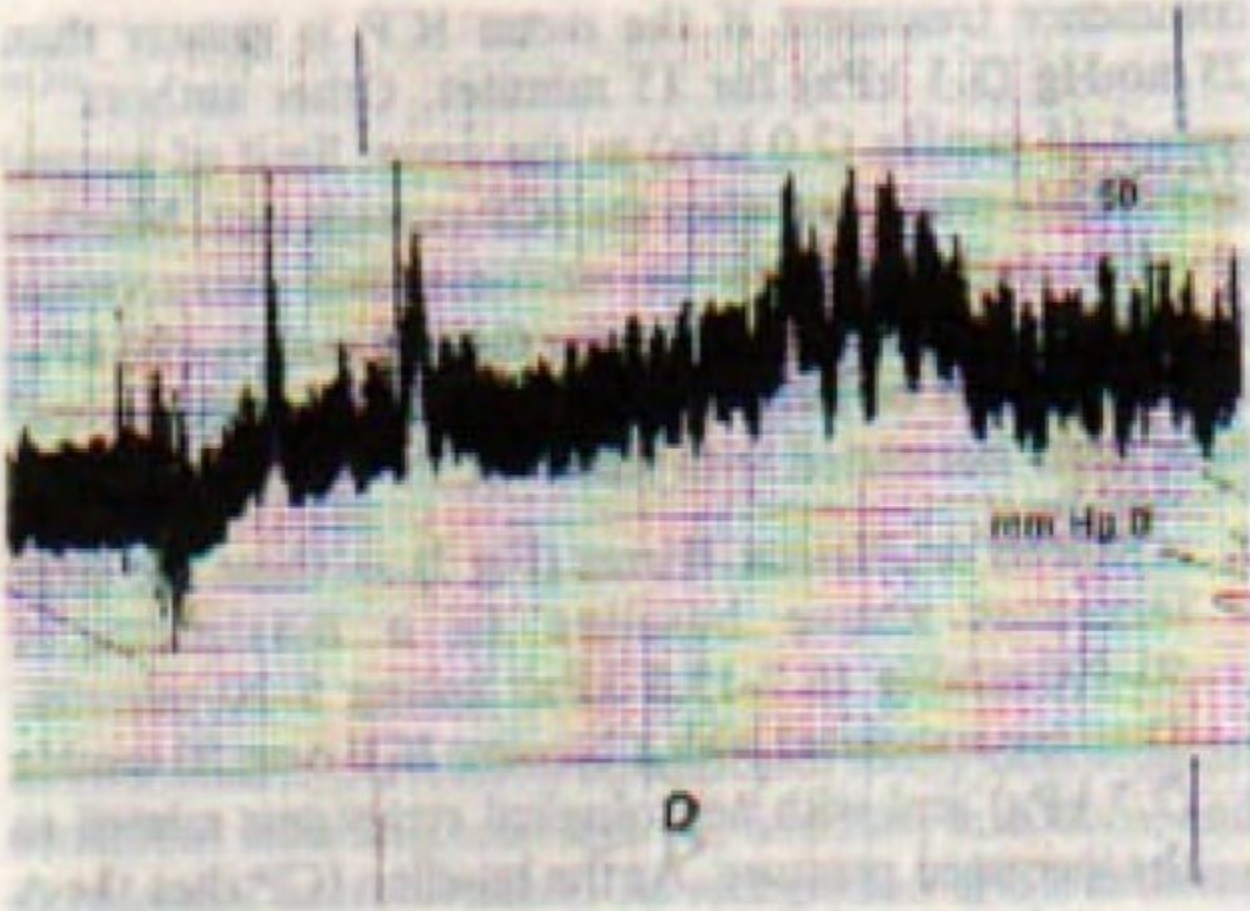
- Plateau waves
- Most life threatening
- Seen in 5-20 min intervals
- Increased I.C.P.
- CPP compromised
- Amplitude 50 – 60 mmHg


40
20
mm Hg 0
40
20
0

ICP WAVE FORMS (CONT.)

B waves

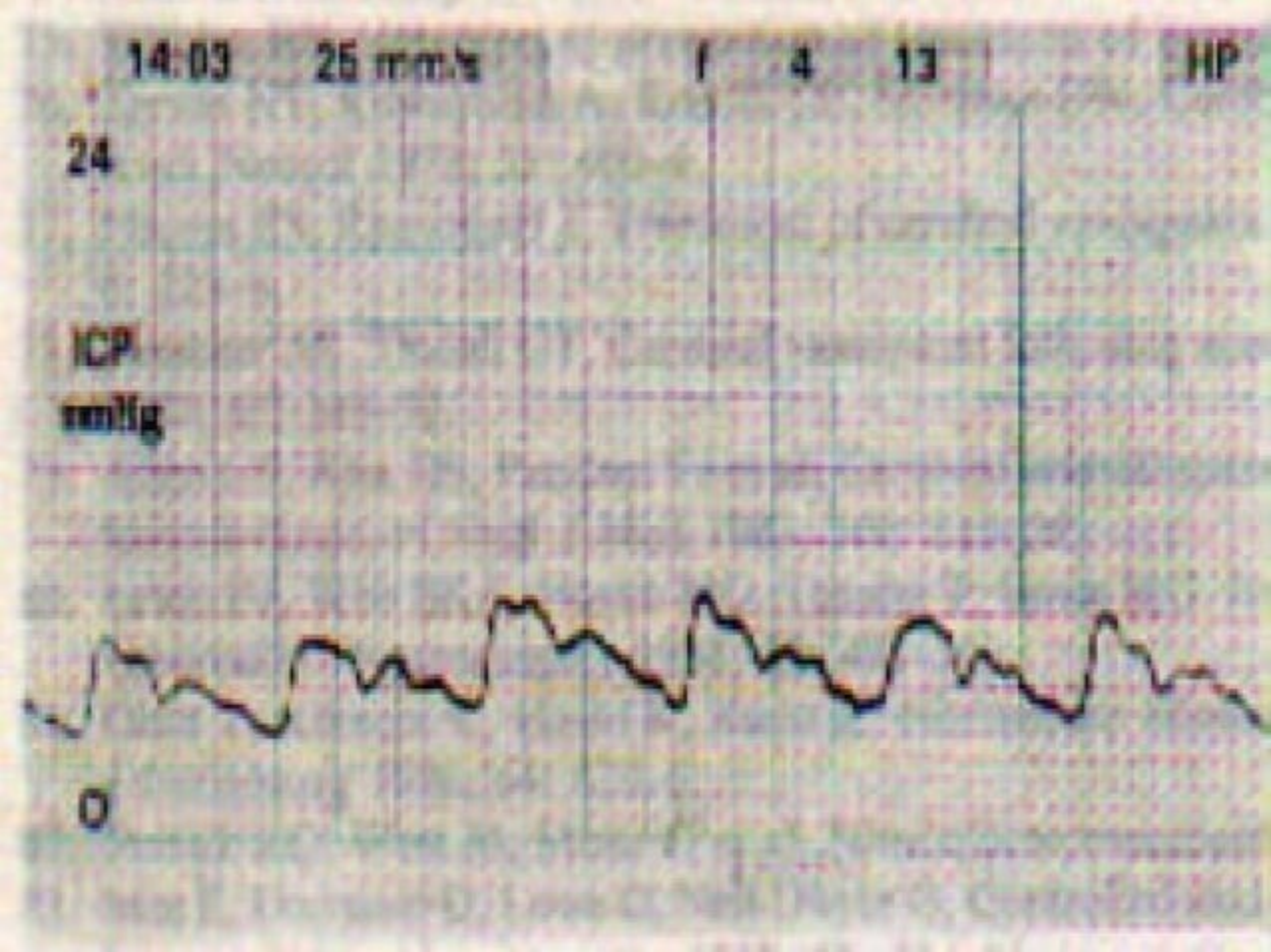
- Saw toothed appearance
- Occur every 30 – 60 sec
- Amplitude 25 – 50 mmHg
- Indicates Unstable ICP& unconsciousness
- Stimulation ↑ amplitude


50
mm Hg 0
D

ICP WAVE FORMS (CONT.)

C waves

- Lowest amplitude
- Occur in 4 – 8 min intervals
- Never get elevated >20 – 25 mmHg
- Clinical significance unknown


14:03
25 mm/s
4
13
HP
24
ICP
mmHg
0

COMPLICATIONS OF ICP MONITORING

- Infection
- intracranial hemorrhage or haematoma
- CSF Leakage
- Mechanical failure or blockage
- Over drainage of CSF

MANAGEMENT OF INCREASED I.C.P.

"ABC" APPROACH (U.K.)

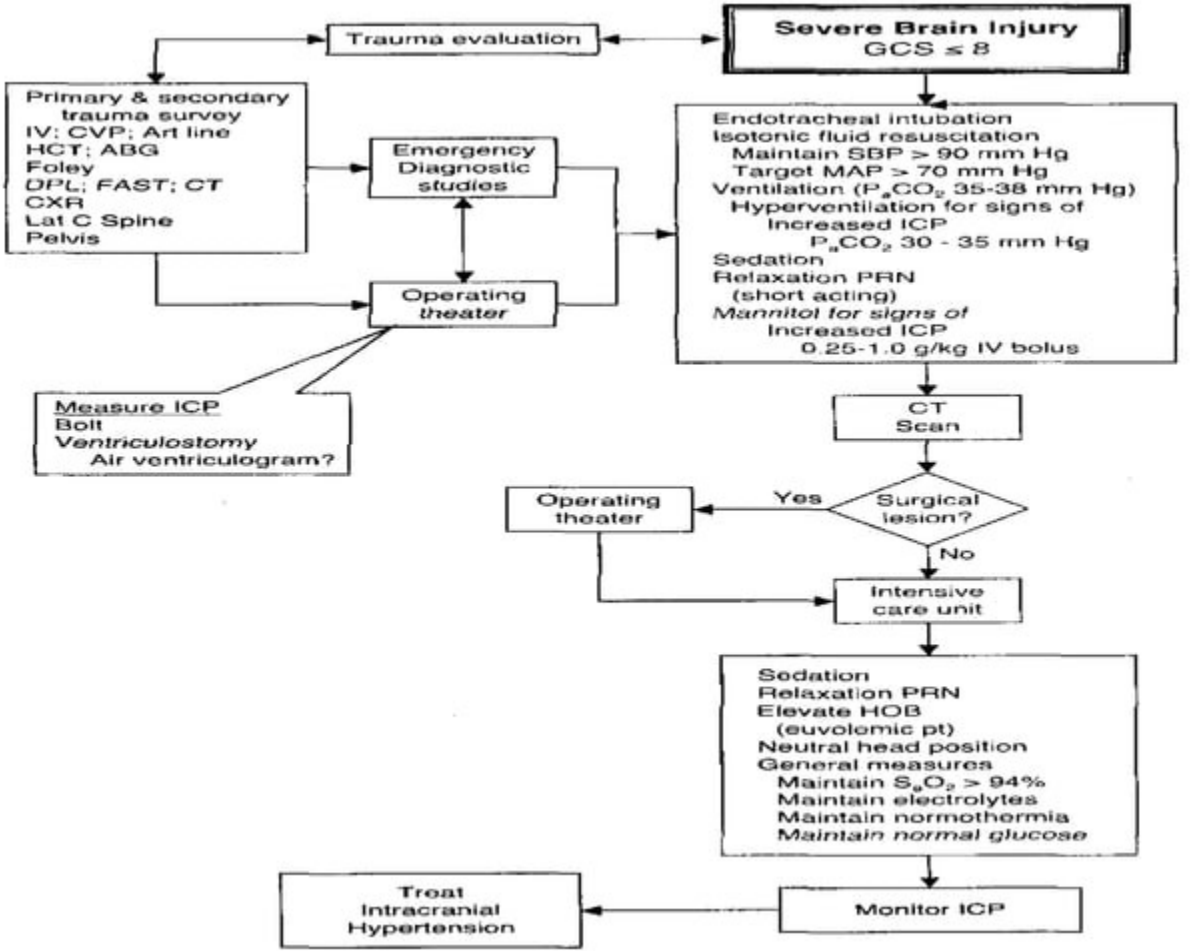
- Airway
- Breathing
- Circulation
- Drugs
- Exposure
- Fluids
- Glucose
- Haematology
- Investigations

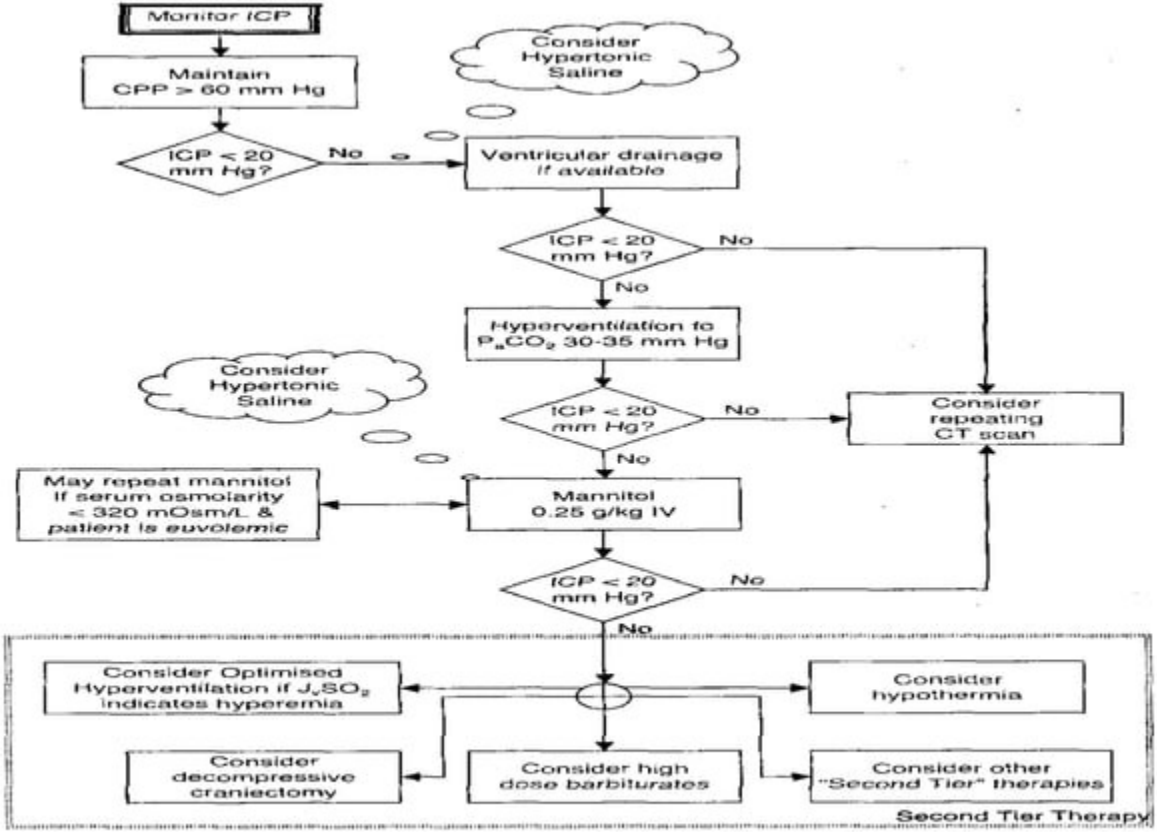


MANAGEMENT OF INCREASED I.C.P. (U.S.A.)

- Airway
- Breathing
- Circulation
- Disability
- Exposure
- Fluids
- Glucose
- Haematology
- Investigations




Trauma evaluation
Severe Brain Injury
GCS ≤ 8
Primary & secondary trauma survey
IV; CVP; Art line
HCT; ABG
Foley
DPL; FAST; CT
CXR
Lat C Spine
Pelvis
Emergency Diagnostic studies
Operating theater
Endotracheal intubation
Isotonic fluid resuscitation
Maintain SBP > 90 mm Hg
Target MAP > 70 mm Hg
Ventilation (P_aCO_2 35-38 mm Hg)
Hyperventilation for signs of Increased ICP
P_aCO_2 30 - 35 mm Hg
Sedation
Relaxation PRN (short acting)
Mannitol for signs of Increased ICP
0.25-1.0 g/kg IV bolus
Measure ICP
Bolt
Ventriculostomy
Air ventriculogram?
CT Scan
Surgical lesion?
Yes
Operating theater
No
Intensive care unit
Sedation
Relaxation PRN
Elevate HOB (euvolemic pt)
Neutral head position
General measures
Maintain S_aO_2 > 94%
Maintain electrolytes
Maintain normothermia
Maintain normal glucose
Monitor ICP
Treat Intracranial Hypertension


Monitor ICP
Maintain CPP ≥ 60 mm Hg
ICP < 20 mm Hg?
No
Consider Hypertonic Saline
Ventricular drainage if available
ICP < 20 mm Hg?
No
No
Hyperventilation to P_aCO_2 30-35 mm Hg
Consider Hypertonic Saline
ICP < 20 mm Hg?
No
Consider repeating CT scan
No
May repeat mannitol if serum osmolarity < 320 mOsm/L & patient is euvolemic
Mannitol 0.25 g/kg IV
ICP < 20 mm Hg?
No
No
Consider Optimised Hyperventilation if J_vSO_2 indicates hyperemia
Consider hypothermia
Consider decompressive craniectomy
Consider high dose barbiturates
Consider other "Second Tier" therapies
Second Tier Therapy

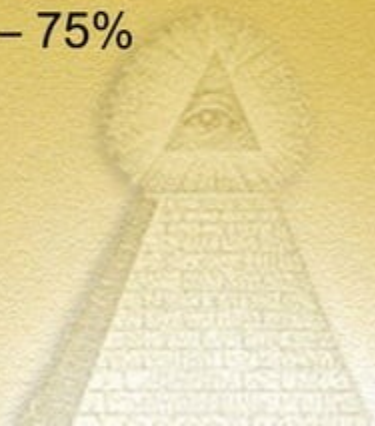
SECOND TIER THERAPY

- Optimized hyperventilation
- Barbiturate coma
- Decompressive craniectomy



OPTIMIZED HYPERVENTILATION

- Increase minute ventilation
- Maintain $PaCO_2$ below 30 mm Hg
- Monitor Jugular venous oxygen saturation
  - Normal range 65 – 75%



BARBITURATES COMA

Pentobarbitone Sodium

- Loading dose:- 10 mg / Kg IV over 30 min
- Infusion :- 5 mg / Kg / hour for 3 hrs
- Maintenance :- 1 – 3 mg / Kg / hour, Titrated to burst suppression on continuous bedside EEG
- Suppresses $CMR0_2$ & ↓ICP
- Disadvantages

DECOMPRESSIVE CRANIECTOMY

- Alternative therapy
- Allow the brain to swell in a fashion not harmful to it
- Uni / bilateral Fronto-Temporo-Parietal Craniectomies

INTERVENTION FOR REDUCING INCREASED ICP

Preliminary Management

- Maintain the patient's head in midline to facilitate bilateral blood flow
- Maintain head of bed (H O B) at 30 – 40° to facilitate venous drainage with minimal effect on arterial pressure
- Avoid all the activities which will increase / worsen ICP
  - excessive light / noise / interference / painful stimuli
  - Suctioning
- Decrease hyperthermia if present

INTERVENTION FOR REDUCING INCREASED ICP (Cont.)

- Strict intake / output balance with specific stress on over hydration which can lead to cerebral edema.
- Electrolyte monitoring: to avoid Na+ disturbances- hyper as well as hyponatremia, hypokalemia – especially if on diuretic therapy.
- Glucose level monitoring to avoid hypoglycemia.
- Avoidance of severe hypocapnia to maintain level of hyperventilation so as to maintain $PaCO_2$ between 25-35 mmHg ($\approx 30 \pm 2$ mmHg).

INTERVENTION FOR REDUCING INCREASED ICP (Cont.)

Medical management

- Anticonvulsant therapy for seizures.
- DIURETIC therapy.
- Mannitol, Glycerol, Urea, Hypertonic saline.
- “Barbiturate Coma” Therapy.
- 50% Dextrose for hypoglycemia.
- ICP monitoring & drainage if required.
- Surgical decompression (Craniotomy).
- Controversial Corticosteroid Therapy.

DIURETIC THERAPY

- Principle
- Osmotic diuretic
- Disadvantages
- Mannitol 0.5 to 1.5 gm/kg I.V 4-5 hourly
- Glycerol 1-2 gm/kg orally (loading),0.5 gm/kg every 4 hourly
- Urea: not exceeding 120 gm/day
- Hypertonic saline
- Loop Diuretics

ANAESTHETIC MANAGEMENT OF PATIENTS WITH INCREASED I.C.P.

- Polytrauma
- Head injury
- Long bone injuries
- Intra abdominal visceral trauma



PRE-OPERATIVE ASSESSMENT AND PREPARATION

"Patients Undergoing surgery at high risk for post-operative complication and death"

- Poor pre-operative physiological condition
- Age
- Type surgery they are supposed to undergo

SHOEMAKER *et al* CRITERIA

- Current /previous severe cardio respiratory illness
- Acute abdominal catastrophe with haemodynamic instability
- Acute renal failure
- Severe multiple trauma (more than 3 major organs involved or more than 2 system or surgical opening of more than 2 body cavities)
- Elderly patients (70 or more years of age)

SHOEMAKER *et al* CRITERIA (Cont.)

- Shock (MAP < 60 mmHg & urine out put < 0.5 ml/kg/hr)
- Acute respiratory failure
- Evidence of septicemia, colo-rectal injury or peritoneal soiling, intra-abdominal surgery
- Patients undergoing prolonged surgery > 1½ hrs.
- Emergency surgery
- Inexperienced surgeon
- Lack of post operative I.C.U./critical care facility

GOAL DIRECTED CARDIO-RESPIRATORY OPTIMIZATION

- Cardiac index.
- Oxygen delivery.
- Oxygen consumption

continue till

- Base Deficit ~~~ normal
- Blood Lactate ~~~ normal
- Mixed S_vO_2 > 70%

ANAESTHETIC CONSIDERATIONS

- Inhalational drugs
- Nitrous Oxide
- Intravenous Induction agents
- NMBD^{s}
- Opioids



Summary

- I.C.P. is an important parameter
- Physiology
- Pathology related to increased ICP
- Monitoring of ICP
- Interaction between ICP and anaesthetic agents
- Anaesthesiologist as Peri-operative Physician


Thank You !