

BRAIN AND ANESTHESIA



WHAT'S THE DEAL?

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OUTLINE

- **NEUROPHYSIOLOGY**

- CEREBRAL METABOLISM
- CEREBRAL PERFUSION PRESSURE
- CEREBRAL BLOOD FLOW (CBF)
- AUTOREGULATION
- INTRACRANIAL PRESSURE

- **ANESTHETICS AND THE CNS**



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NEUROPHYSIOLOGY

IS IT IMPORTANT ?

EXTREMELY!!!!!!!!!!!!

ITS KNOWLEDGE ENABLES US TO :

- *SAFELY DELIVER ANESTHESIA*
- *FACILITATE SURGERY*
- *IMPROVE NEUROLOGIC OUTCOME*
- *AVOID SECONDARY BRAIN INJURY*

CEREBRAL METABOLISM

- Brain consumes **20%** of total body oxygen

- **CMRO₂** :

- ✓ 3-3.5ml O₂ / 100gm / min (**ADULTS**)

- ✓ 4-6 ml O₂ / 100gm / min (**PEDIATRIC**)

- High O₂ consumption with limited reserve

(**EXTRACTION RATIO 50 – 60 %**)



VERY SENSITIVE TO DECREASES IN PERFUSION



AVOID HYPOXIA



AVOID HYPOTENSION

CEREBRAL PERFUSION PRESSURE (CPP)

$$\mathbf{CPP = MAP - ICP}$$

- NORMAL CPP IS **70 – 80 mmHg**
- ISCHEMIA OCCURS AT CPP OF **30 – 40 mmHg**

CPP < 25 mmHg



**IRREVERSIBLE
BRAIN DAMAGE**

CEREBRAL BLOOD FLOW

- **15%** of the COP
- Global CBF **750 ml / min**
- Regional blood flow ranges from
 - 20 ml / 100gm / min in the **white matter**
 - 70 ml / 100gm / min in the **grey matter**
- Difference in regional blood flow is due to difference in **metabolic activity**

CEREBRAL BLOOD FLOW (CONT.)

- **THRESHOLD FOR CEREBRAL ISCHEMIA**

- ✓ $< 50 \text{ ml} / 100\text{gm} / \text{min}$  Acidosis
- ✓ $< 40 \text{ ml} / 100\text{gm} / \text{min}$  Impaired protein synthesis
- ✓ $< 30 \text{ ml} / 100\text{gm} / \text{min}$  Edema
- ✓ **$< 20 \text{ ml} / 100\text{gm} / \text{min}$**  **CRITICAL CBF**

ISOFLURANE ANESTHESIA  **$12 \text{ ml} / 100\text{gm} / \text{min}$**

CELL DEATH AT $< 10 \text{ ml} / 100\text{gm} / \text{min}$

CEREBRAL BLOOD FLOW (CONT.)



100 ml BLOOD → **20 ml O₂**

20 ml BLOOD → **4 ml O₂**

CMRO₂ = 3 ml / 100gm / min

CEREBRAL BLOOD FLOW (CONT.)

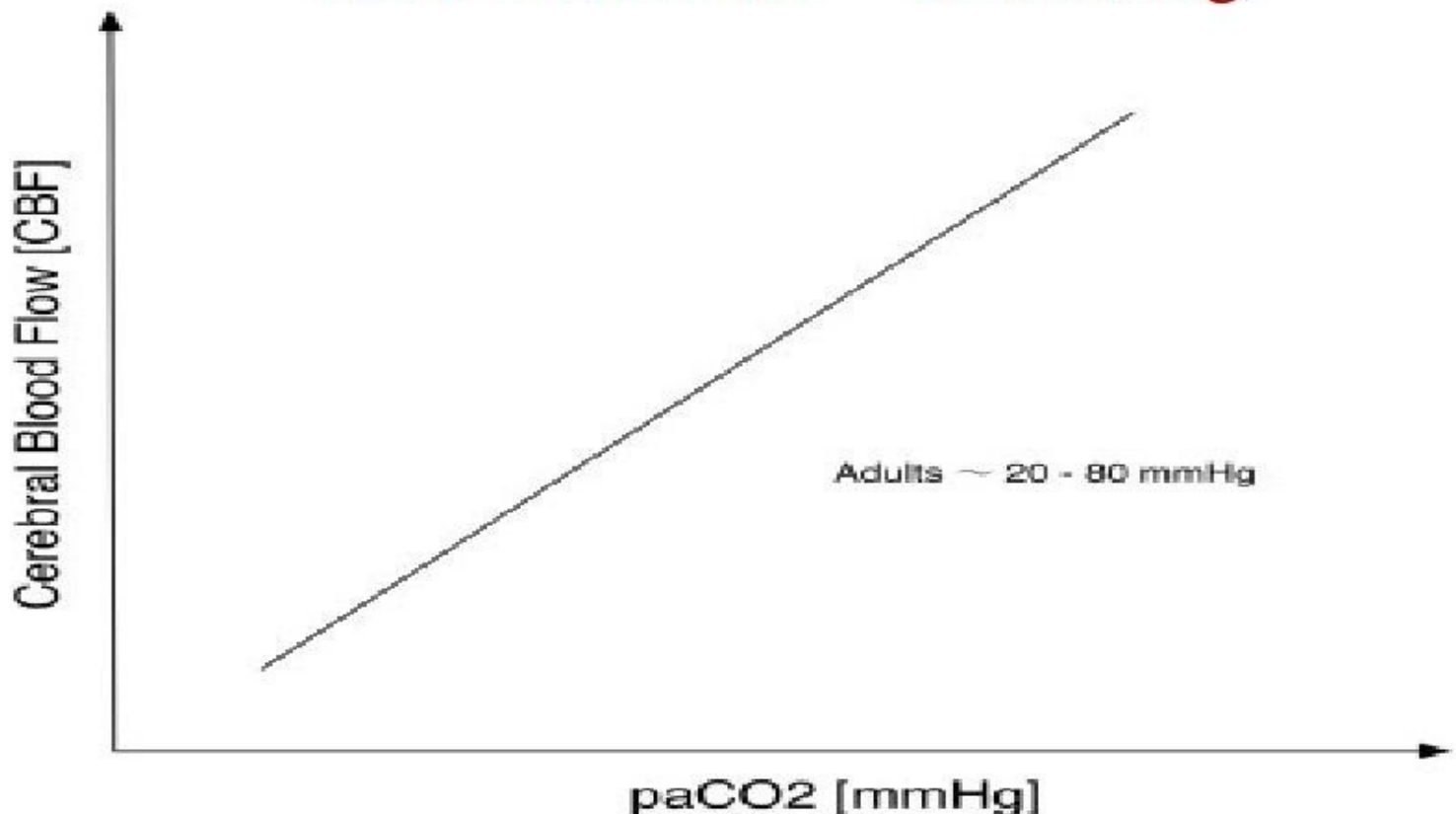
FACTORS AFFECTING CBF INCLUDE

- RESPIRATORY GAS TENSION
 - ✓ **PaCO₂ (MOST IMPORTANT)**
 - ✓ PaO₂
- TEMPERATURE
- VISCOSITY
- **CMRO₂ (REGIONAL CBF)**
- ANESTHETIC DRUGS

ARTERIAL CO₂ TENSION

$$\text{CBF} \propto \text{PaCO}_2$$

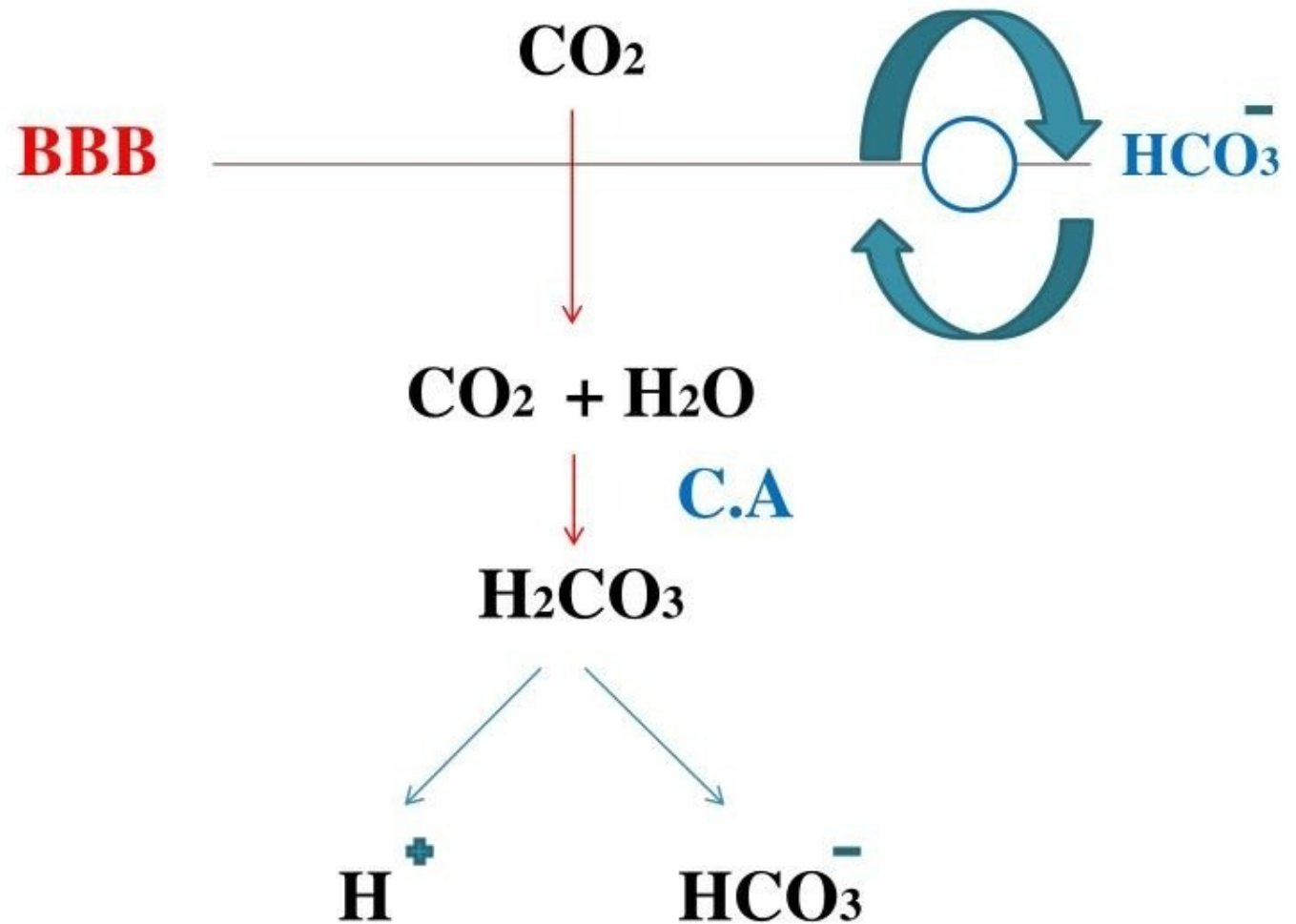
-  PaCO₂ by 1 mmHg   CBF by 1-2 mL / 100gm / min
BETWEEN 20 – 80 mmHg



ARTERIAL CO₂ TENSION (CONT.)

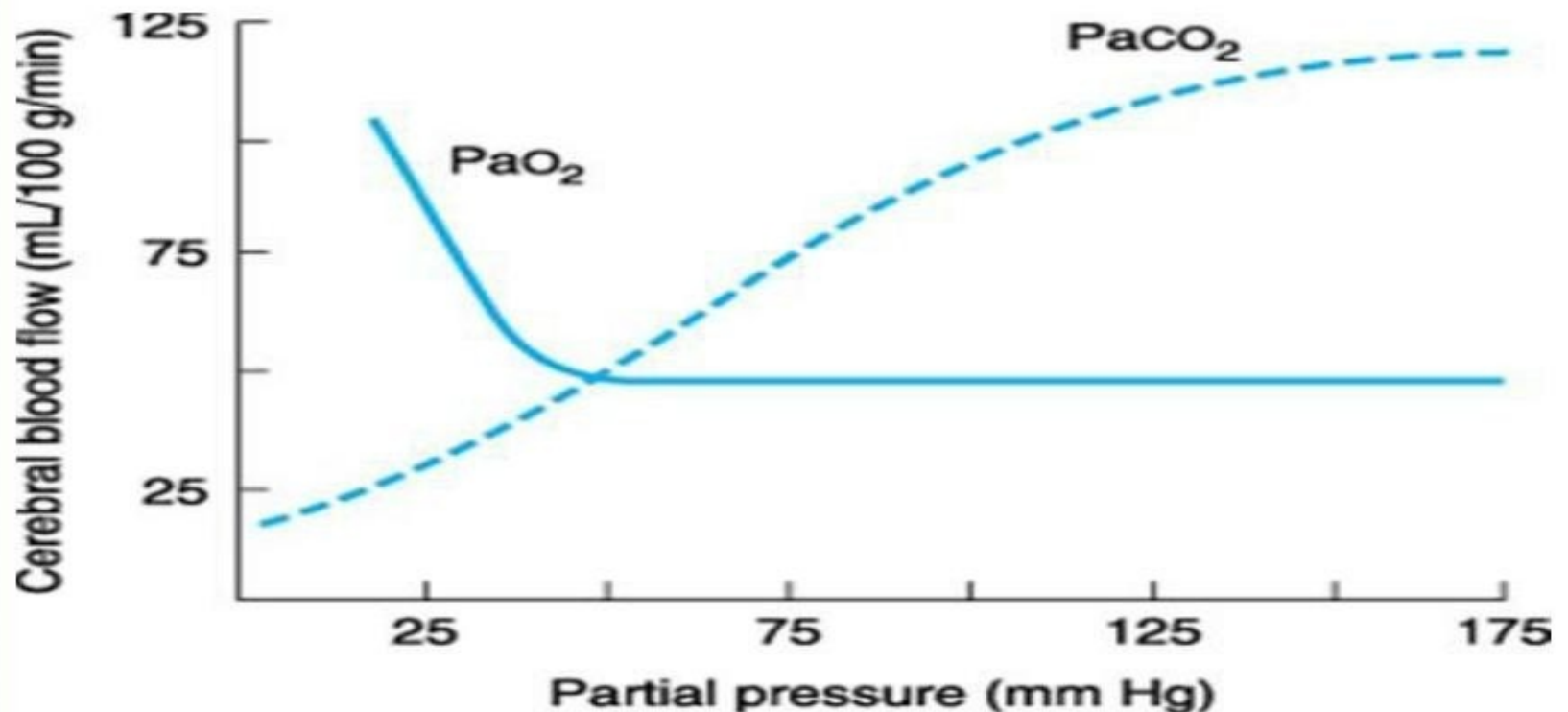
- The response is **ALMOST IMMEDIATE**
- Mediated by variation in CSF **PH**
- But the effects are short lived (**6 HOURS**)
- **ACTIVE TRANSPORT** of **BICARBONATE** into and from the CSF
- Carries the risk **REBOUND HYPEREMIA** with **RAPID** restoration of **NORMOCAPNIA**

ARTERIAL CO_2 TENSION (CONT.)



ARTERIAL O₂ TENSION

- ONLY **MARKED** CHANGES IN PO₂ ALTER CBF
 - ✓ Hyperoxia decreases CBF by **10%**
 - ✓ Severe hypoxemia (**< 50 mmHg**) causes a marked increase in CBF



TEMPERATURE & VICOSITY

- CBF changes by **7% PER 1°C** change in temperature
- Hypothermia decrease both **CBF AND CMRO₂**
- CMRO₂ decreases by **50% AT 27°C**
- **HEMATOCRIT** is the determinant of viscosity
- CBF is **INVERSELY PROPORTIONAL** to viscosity
- But a low hematocrit will **DECREASE O₂ DELIVERY**

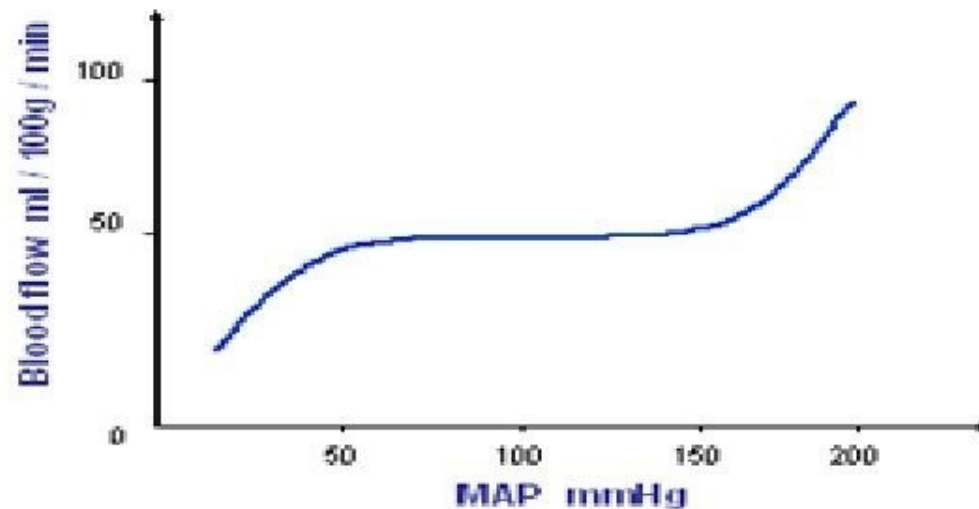
AUTOREGULATION

- Ability to maintain a **constant CBF** over a wide range of MAP

50 – 150 mmHg

- **Myogenic theory**

Autoregulation of Cerebral Blood Flow



AUTOREGULATION (CONT.)

RIGHT SHIFT



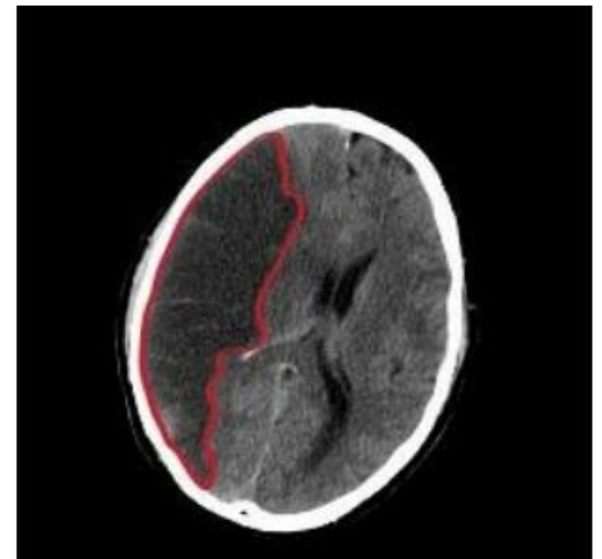
**CHRONIC
HYPERTENSION**

MAINTAIN HIGH CPP

NORMOTENSION



ISCHEMIA



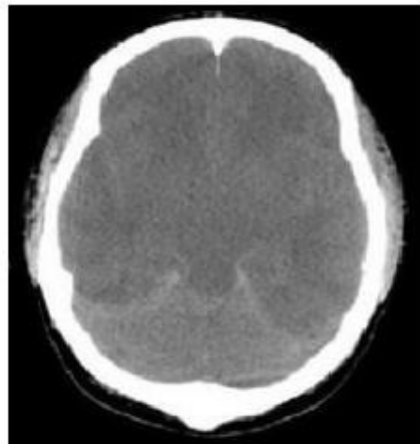
AUTOREGULATION (CONT.)

LEFT SHIFT

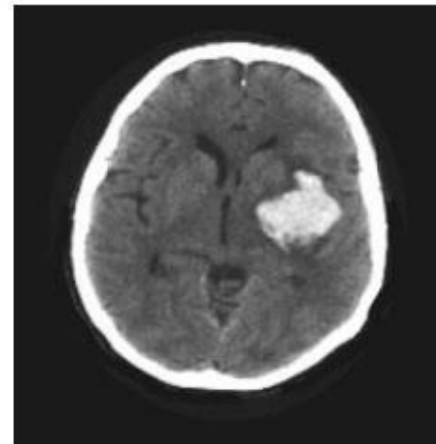


NEONATE

AVOID SUDDEN ↑ MAP



EDEMA



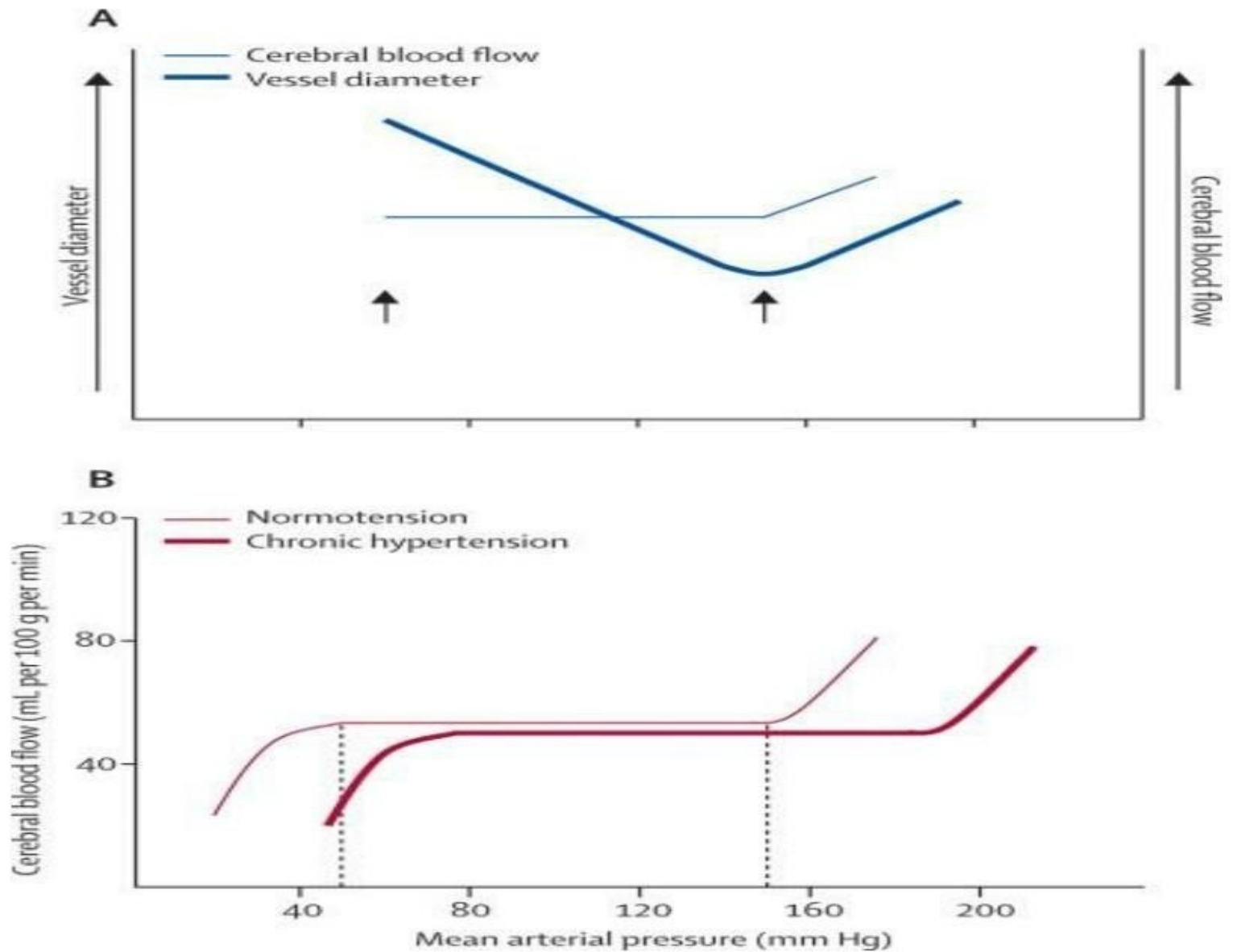
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AUTOREGULATION (CONT.)

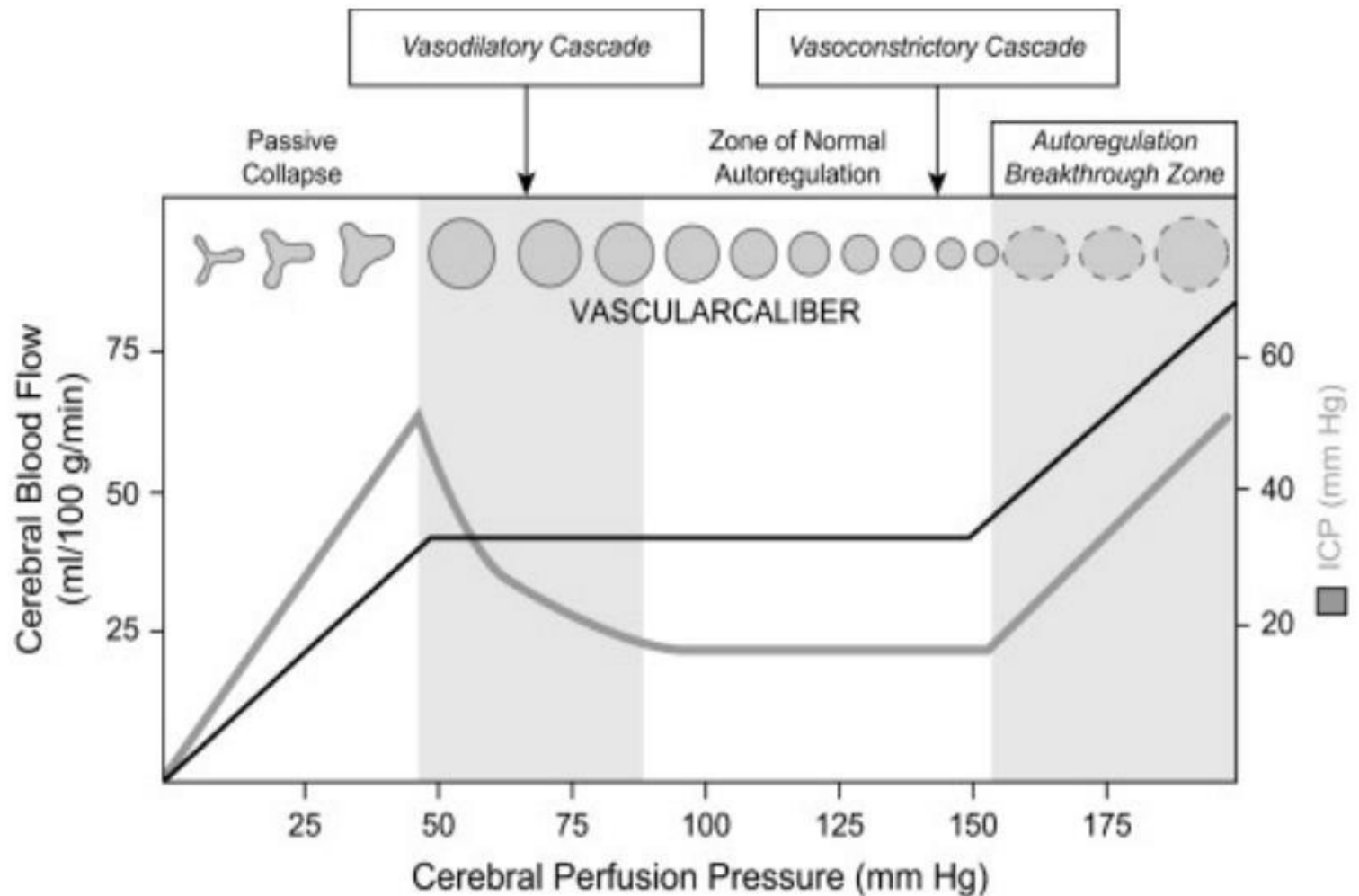
ABOLISHED  **HYPERCAPNIA (> 80 mmHg)**
HYPOXIA (< 50mmHg)
TUMOURS
HEAD TRAUMA
VOLATILE ANESTHETICS

CBF  **MAP DEPENDENT**

AUTOREGULATION (CONT.)



AUTOREGULATION (CONT.)

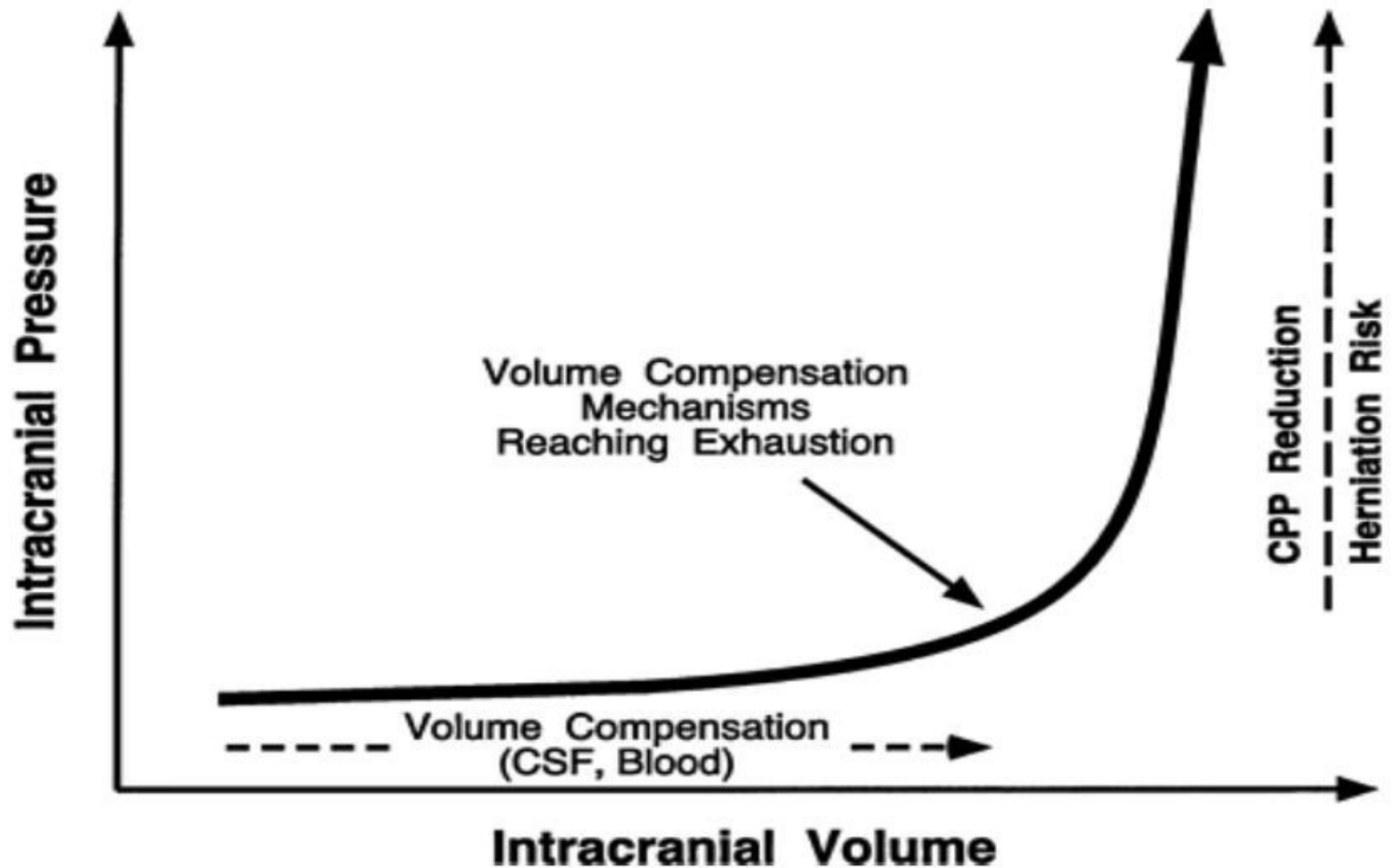


INTRACRANIAL PRESSURE

- Normal ICP **10 – 15 mmHg**
- Skull is a rigid box containing
 - ✓ BRAIN TISSUE (**80%**)
 - ✓ BLOOD (**12%**)
 - ✓ CSF (**8%**)
- Minimal compressibility (**ADULTS**) with limited scope for compensation
- **INCREASE** in one component will cause **a rise in ICP** unless the volume of another component **DECREASES**

MONROE-KELLIE HYPOTHESIS

INTRACRANIAL PRESSURE (CONT.)



CLINICAL APPLICATIONS

- AVOID **HYPOXIA**
- MAINTAIN CPP **> 80mmHg** (FLUIDS , VASOPRESSEORS)
- MAINTAIN **NORMOCAPNIA**
- ENSURE **ADEQUATE VENOUS DRAINAGE**
 - ✓ Avoid extreme neck rotation or extension
 - ✓ Avoid tight tube ties (**USE TAPE**)
- TREAT **PYREXIA AND SEIZURES**
- MAINTAIN **NORMOGLYCEMIA** (< 140 mg/ dl)



ANESTHETICS AND THE CNS

- **VOLATILE ANESTHETICS**
- **INTRAVENOUS ANESTHETICS**
- **OPIOID ANALGESICS**
- **NEUROMUSCULAR BLOCKING AGENTS**

VOLATILE ANESTHETICS

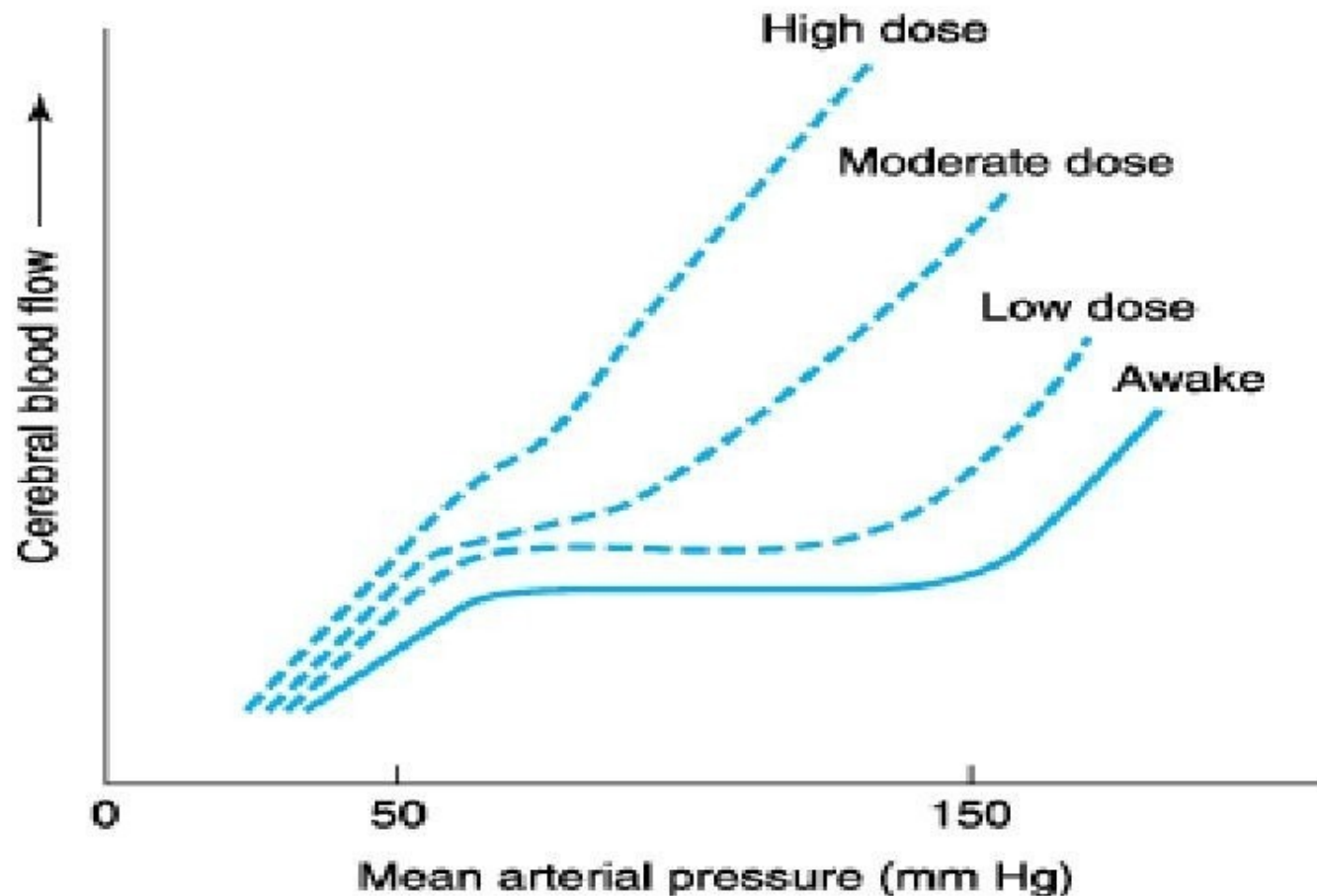
- **CMRO₂**

- ✓ Dose dependent decrease
- ✓ **ISOFLURANE** causes the greatest reduction **50%**
- ✓ **DESFLURANE** and **SEVO** are similar to isoflurane

- **CBF**

- ✓ Cerebral vasodilation with impairment of autoregulation
- ✓ **HALOTHANE** has the greatest effect
- ✓ **> 1 MAC** with **ISOFLURANE** & **> 1.5 MAC** with **SEVO**
- ✓ Time dependent and returns to normal **WITHIN 2-5 HRS**
- ✓ CO₂ responsiveness is **maintained**

VOLATILE ANESTHETICS (CONT.)



INTRAVENOUS ANESTHETICS

- All decrease **CMRO₂** , **CBF** & **ICP** **EXCEPT KETAMINE**
- **Vasoconstriction** of cerebral blood vessels (**BARBITURATES**)
- Maintain CO₂ responsiveness and autoregulation
- Barbiturates and etomidate **ENHANCE CSF ABSORPTION**
- **Anticonvulsant** properties

OPIOID ANALGESICS

- Minimal effect on **CBF** , **CMRO₂** & **ICP**
- **ICP MAY INCREASE IF :**
 1. **Hypoventilation**
 2. Hypotension with reflex vasodilation
 3. **Histamine release**
 4. Accumulation of normeperidine (**SIEZURES**)
- **AVOID MORPHINE** ➡ Prolonged sedation
- **Fentanyl** decreases ICP
- **Remifentanyl** has a rapid offset

NEUROMUSCULAR BLOCKING AGENTS

- Lack direct action on the brain
- Histamine releasing agents (**ATRACURIUM**)
 - ✓ Cerebral vasodilation with increase in ICP
- Succinyl choline increases ICP



ANESTHETICS AND THE CNS (CONT.)

Table 25–1. Comparative Effects of Anesthetic Agents on Cerebral Physiology.¹

Agent	CMR	CBF	CSF Production	CSF Absorption	CBV	ICP
Halothane	↓↓	↑↑↑	↓	↓	↑↑	↑↑
Isoflurane	↓↓↓	↑	±	↑	↑↑	↑
Desflurane	↓↓↓	↑	↑	↓	↑	↑↑
Sevoflurane	↑↑↑	↑	?	?	↑	↑↑
Nitrous oxide	↓	↑	±	±	±	↑
Barbiturates	↑↑↑↑	↓↓↓	±	↑	↓↓	↓↓↓
Etomidate	↑↑↑	↓↓	±	↑	↓↓	↓↓
Propofol	↑↑↑	↓↓↓↓	?	?	↓↓	↓↓
Benzodiazepines	↑↑	↓	±	↑	↓	↓
Ketamine	±	↑↑	±	↓	↑↑	↑↑
Opioids	±	±	±	↑	±	±
Lidocaine	↓↓	↓↓	?	?	↓↓	↓↓

INDUCTION AGENT OF CHOICE?

- HEAD TRAUMA (GCS 10/15) WITH ACUTE SUBDURAL HEMATOMA
- HYPOTENSIVE (80/50)
- HISTORY OF EPILEPSY (LAST ATTACK 2 WKS AGO)
- FULL STOMACH





Thank
you