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Cerebral Blood Flow

M1 – Cardiovascular/Respiratory Sequence

Louis D'Alecy, Ph.D.

Fall 2008

Monday 11/10/08, 9:00

Control of Cerebral Blood Flow

19 slides, 50 minutes

1. Normalized blood flow
2. Determinants of CeBF
3. Autoregulation
4. Cushing Response
5. Resistance Control
6. Hypoxia vs. Ischemia
7. Cerebral Ischemia

Cerebral Blood Flow mL / min?

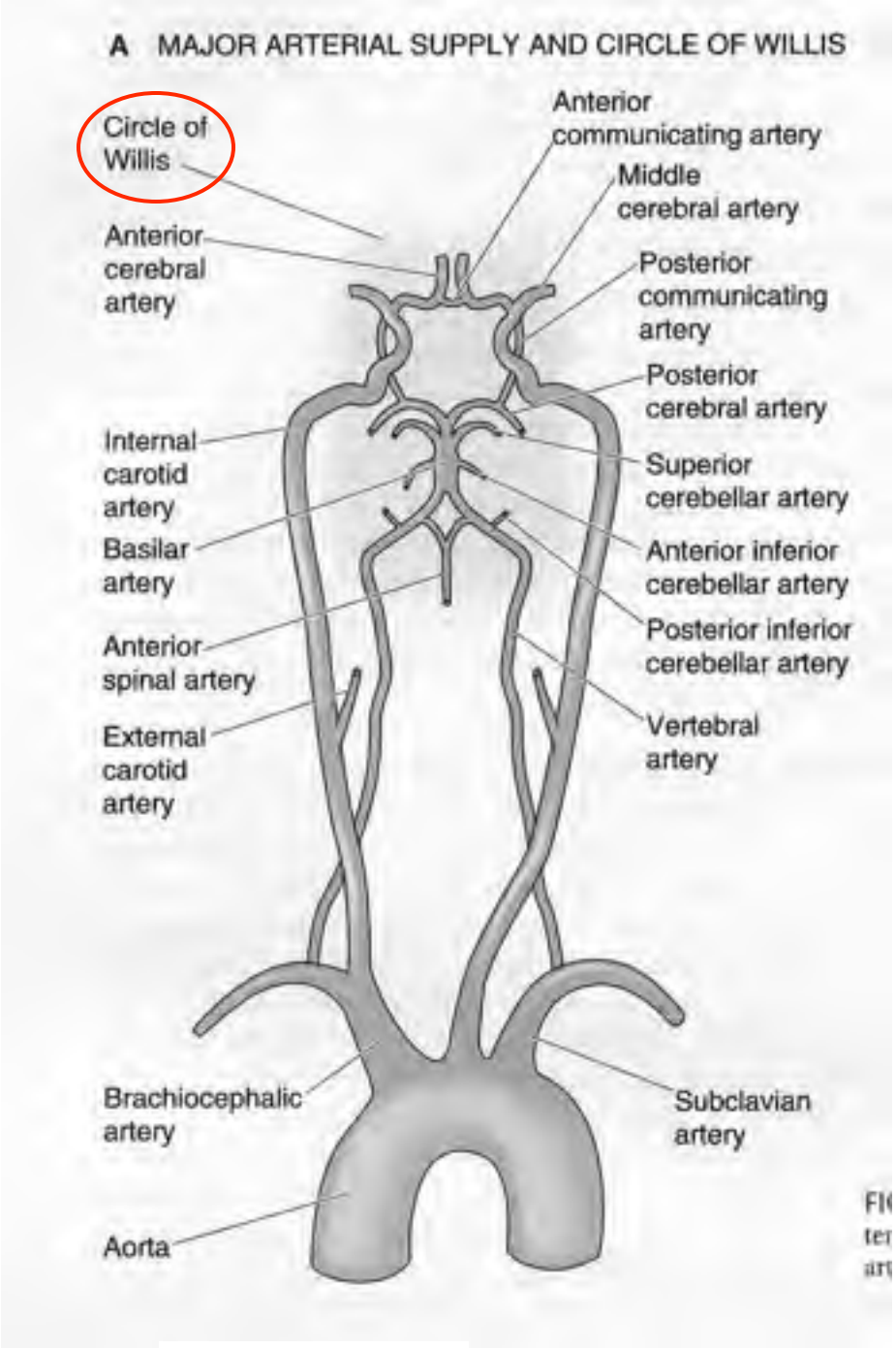
But how big is the tissue or organ?

Normalized to mL / 100g / min

Liver	57.7
Kidneys	420.0
Brain	54.0
Skin	12.8
Skeletal Muscle	2.7
Heart	84.0
Rest of body	1.4

**To change organ blood flow you increase CO

or redistribute flow (CO).



Arterial supply

redundancy

Venous drainage

DETERMINANTS OF CEREBRAL BLOOD FLOW

1 PERFUSION PRESSURE

- **Arterial and venous pressure**
- **Flow Autoregulation with changes in perfusion pressure**

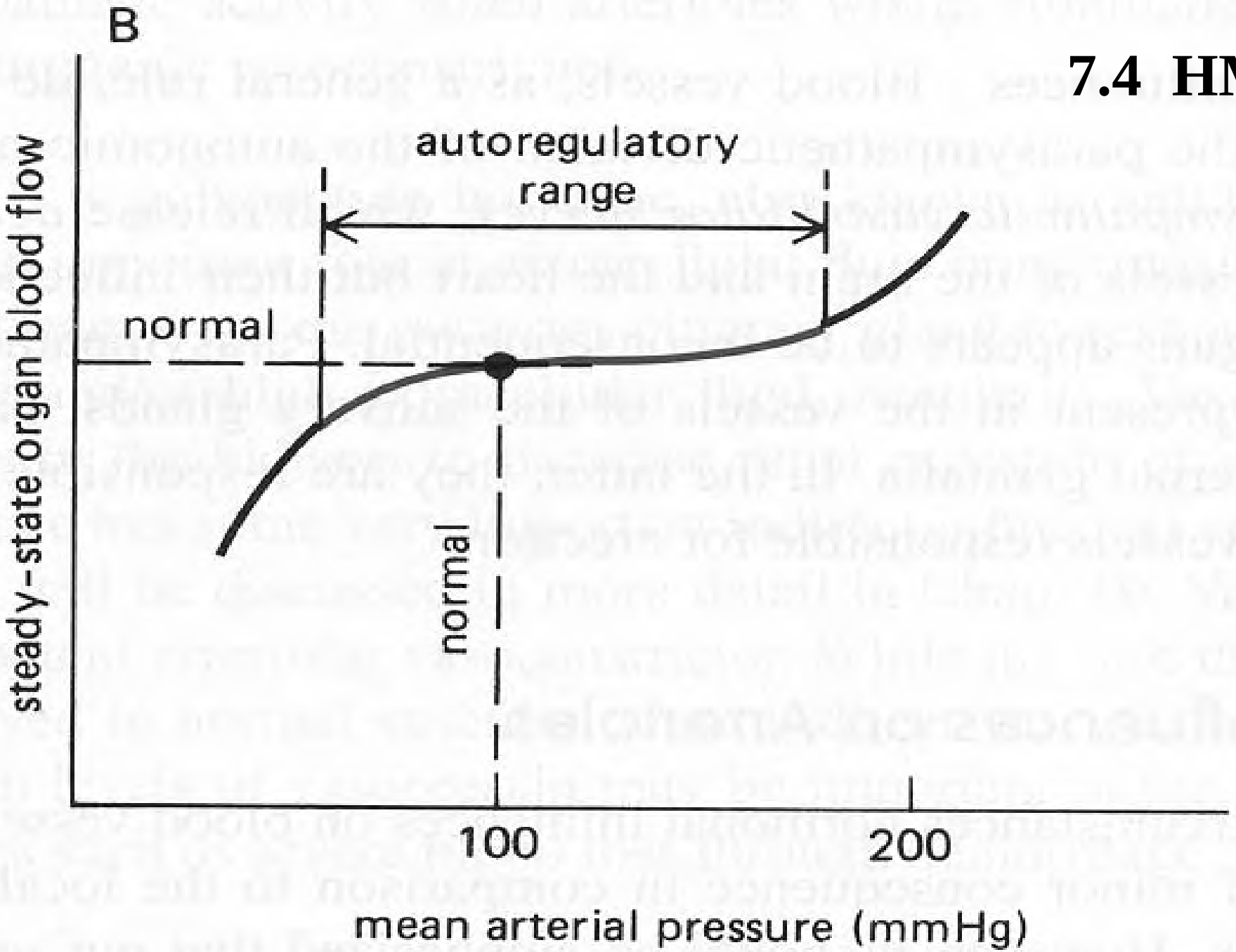
2 INTRACRAINIAL PRESSURE COMPRESSION

- **Cerebral Ischemic Reflex**

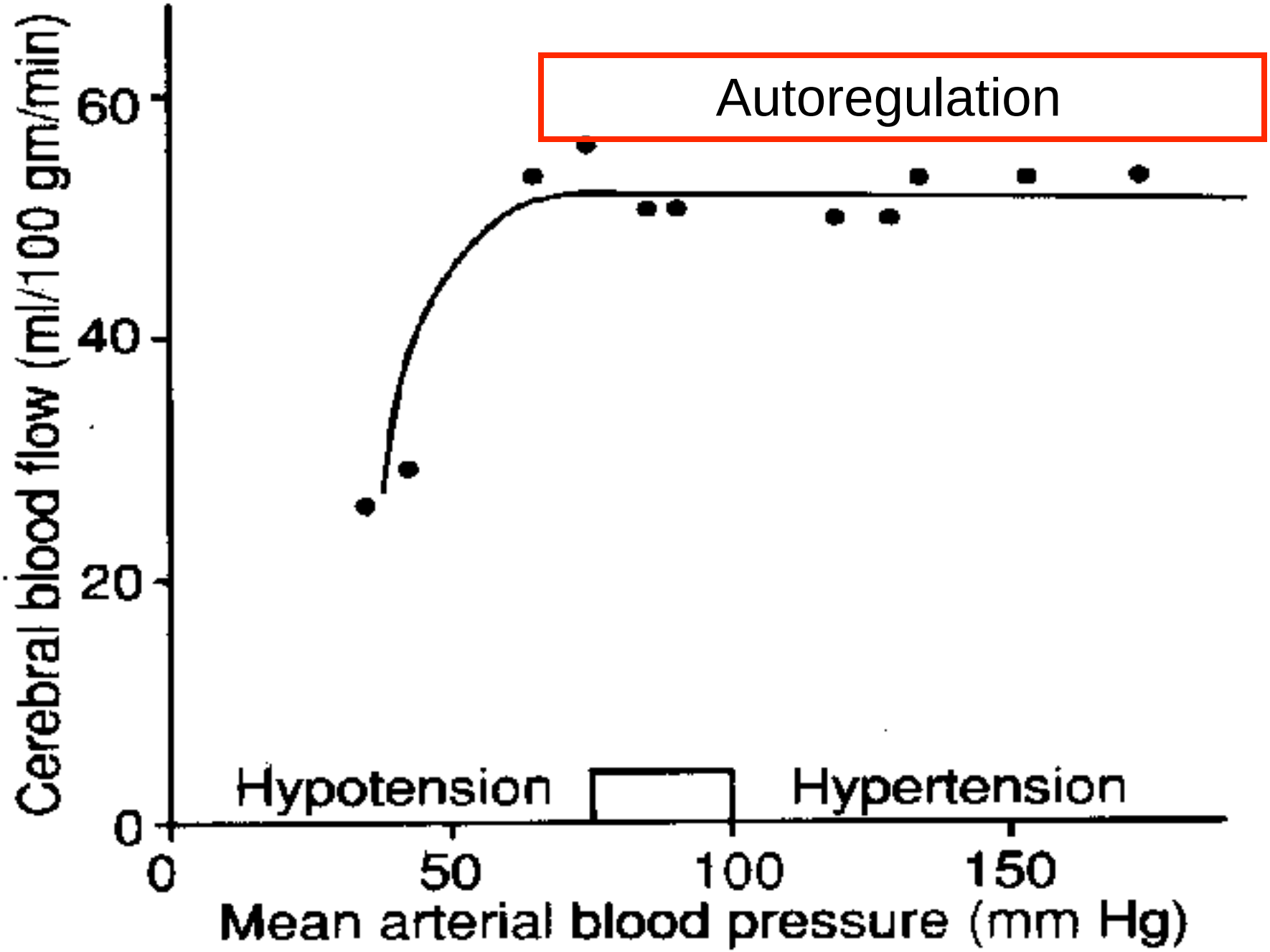
3 METABOLIC CONTROL (Resistance Control)

4 NEURAL CONTROL (Resistance Control)

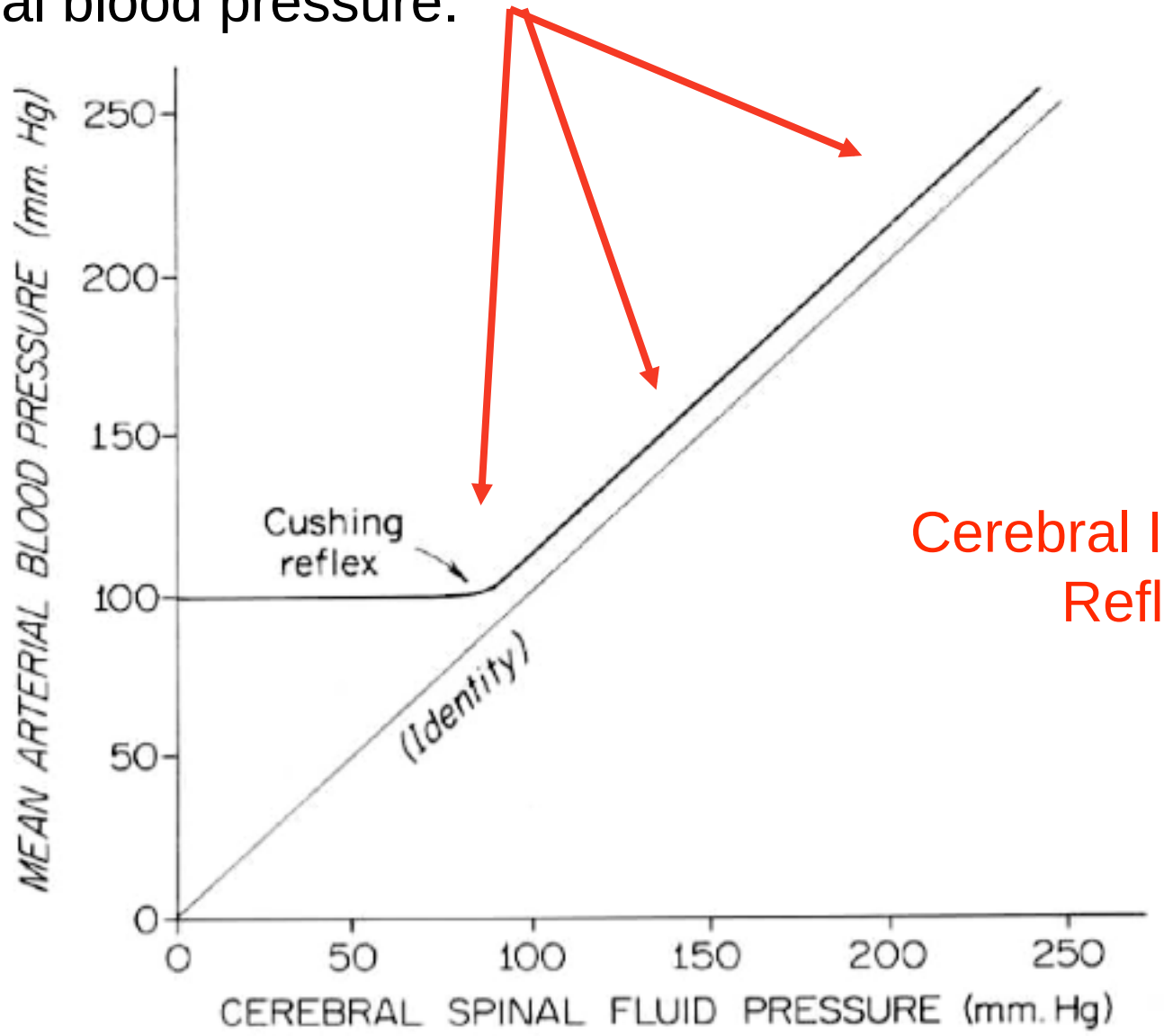
7.4 HM



 Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.



When intracranial pressure (ICP) approaches arterial pressure the Cushing reflex produces a sustained increase in arterial blood pressure.



Cerebral Ischemic Reflex

Cushing (Cerebral Ischemic Reflex)

-response to compressive ischemia in CNS

-marked increase in arterial blood pressure

-over rides arterial baroreceptor reflex !!

-may involve central chemoreceptors

-presumed to be “protective” of ischemic CNS

-presumably maintains CBF when ICP increases

TISSUE RESISTANCE

(***Assume Perfusion Pressure is Constant ***)

- Vasoconstriction $\Rightarrow \Downarrow r \Rightarrow \Uparrow R_{tissue} \Rightarrow \Downarrow F_{tissue}$

- Vasodilation

$\Rightarrow \Uparrow r \Rightarrow \Downarrow R_{tissue} \Rightarrow \Uparrow F_{tissue}$

$$F_{tissue} = \frac{\text{Perfusion Pressure}}{R_{tissue}}$$

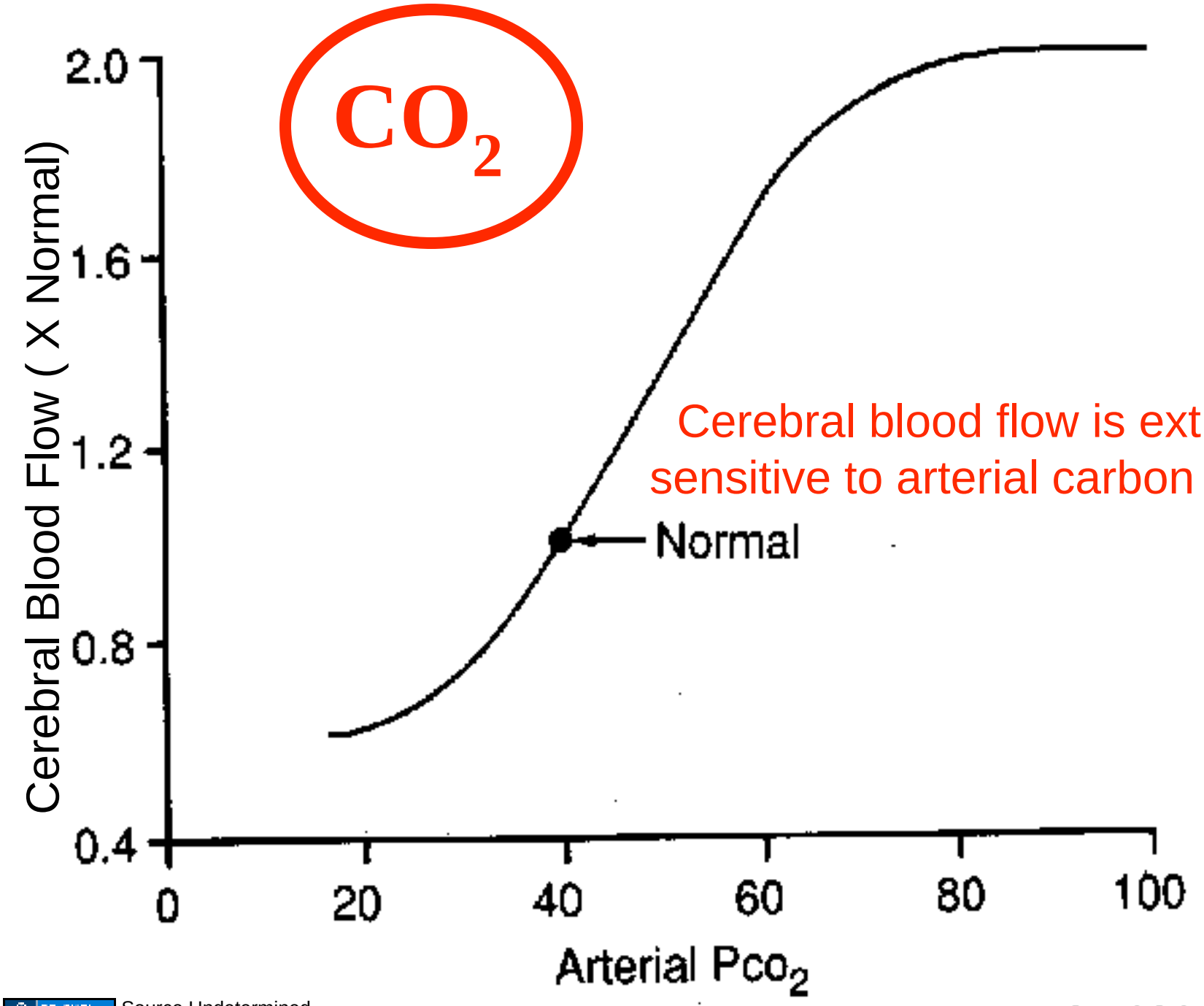
Vasodilators

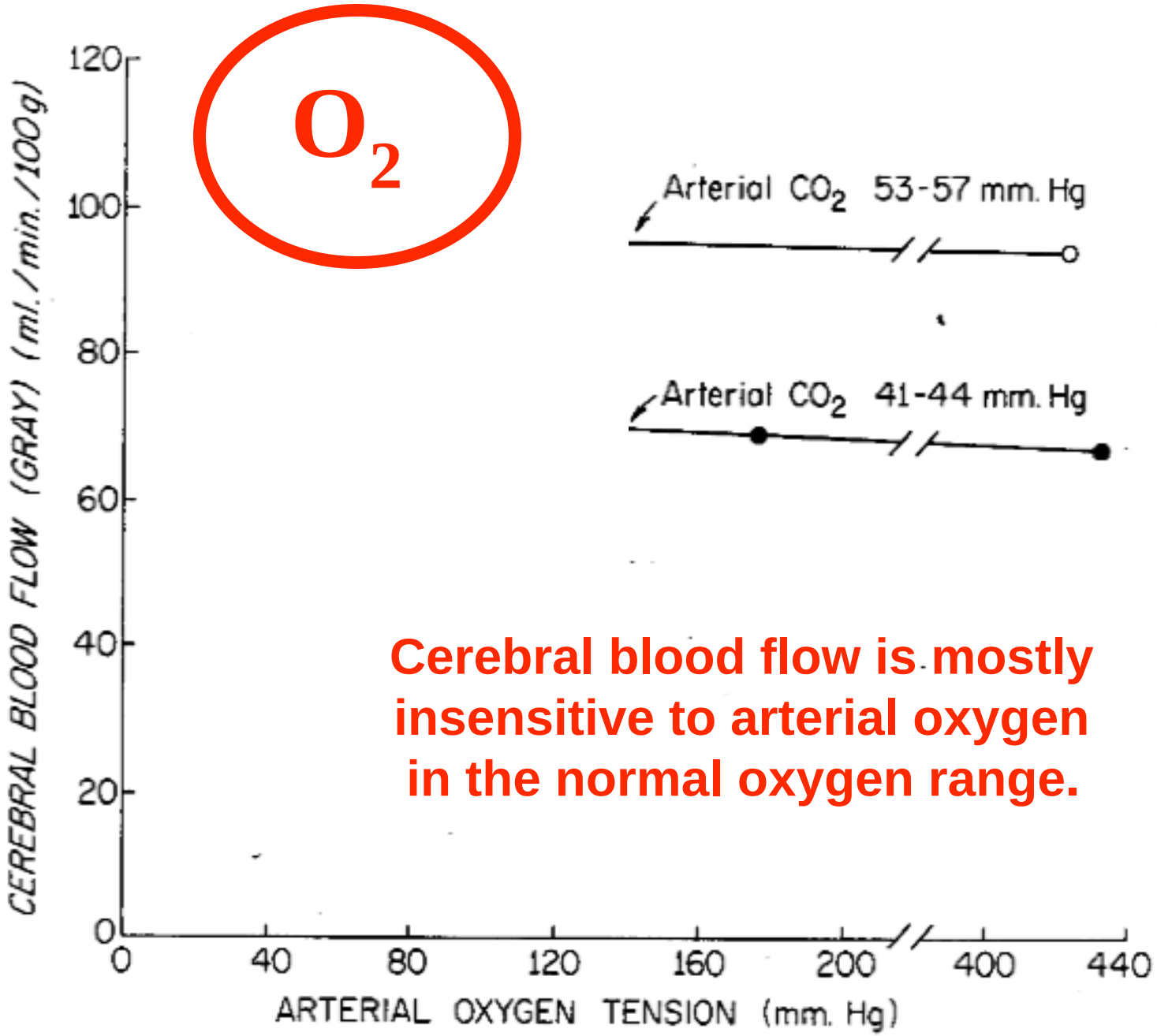
"Metabolic"

- ⇓ oxygen
- ⇑ K^+, CO^2, H^+
- Osmolarity
- Adenosine
- Eicosanoids

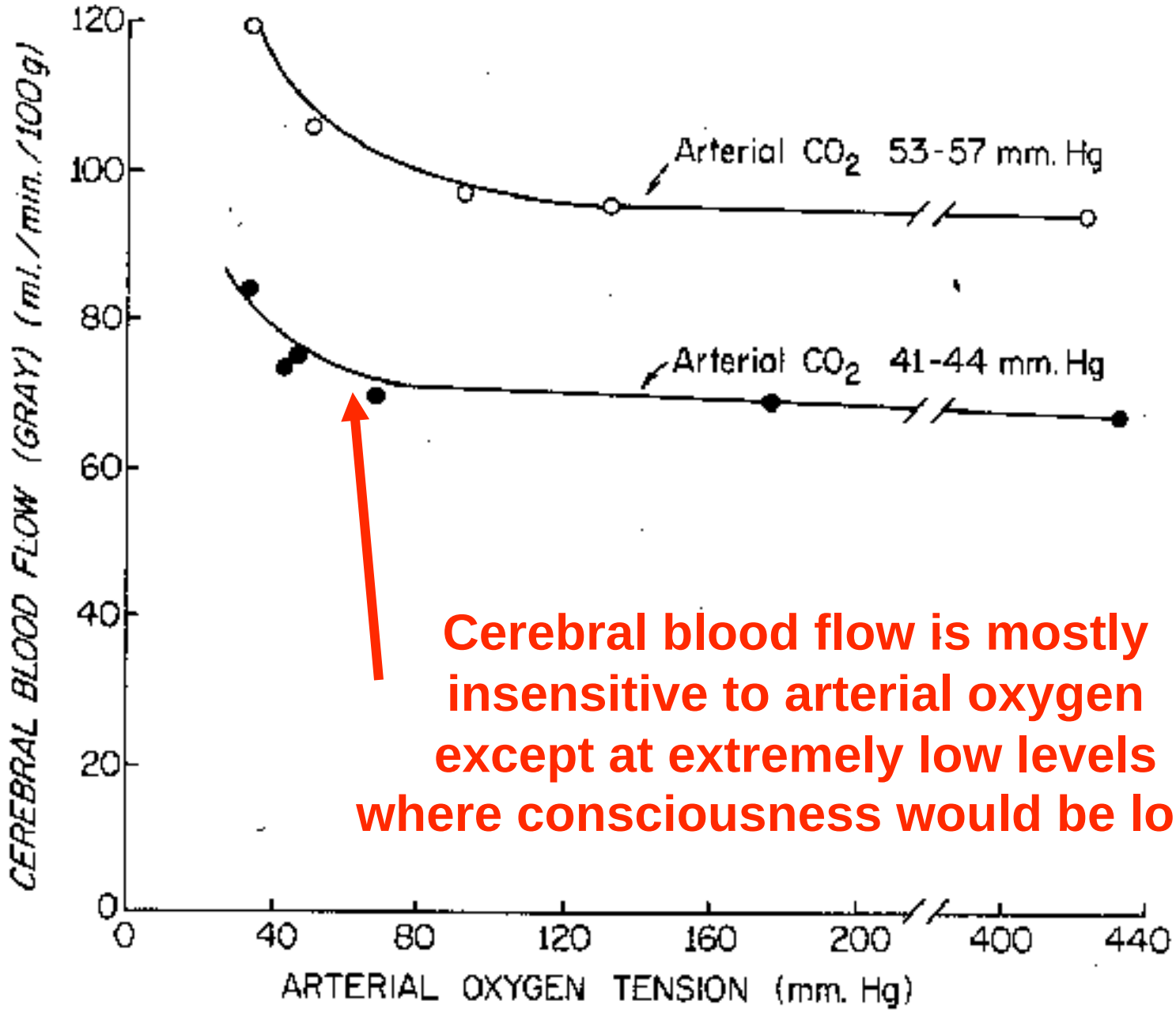
Other

- Nitric oxide
- Injury molecules
- ?





Cerebral blood flow is mostly insensitive to arterial oxygen in the normal oxygen range.



Cerebral blood flow is mostly insensitive to arterial oxygen except at extremely low levels where consciousness would be lost.

Hypoxia Is Often Misunderstood

- not asphyxia (…unable to breath..)
- hypoxia is often undetectable
- hypoxia produces a feeling of well-being or belligerence
- signs and symptoms prior to unconsciousness are subtle, insidious and often imperceptible.
- many causes

Summary
Control of Cerebral Blood Flow

- Autoregulation assumed important
- CO_2 dominant control
- O_2 minimal effect normal to high O_2
  - Failsafe vasodilation to marked hypoxia
- Cerebral Ischemic (Cushing) Reflex
- Sympathetic alpha vasoconstriction possible
- Parasympathetic vasodilation possible

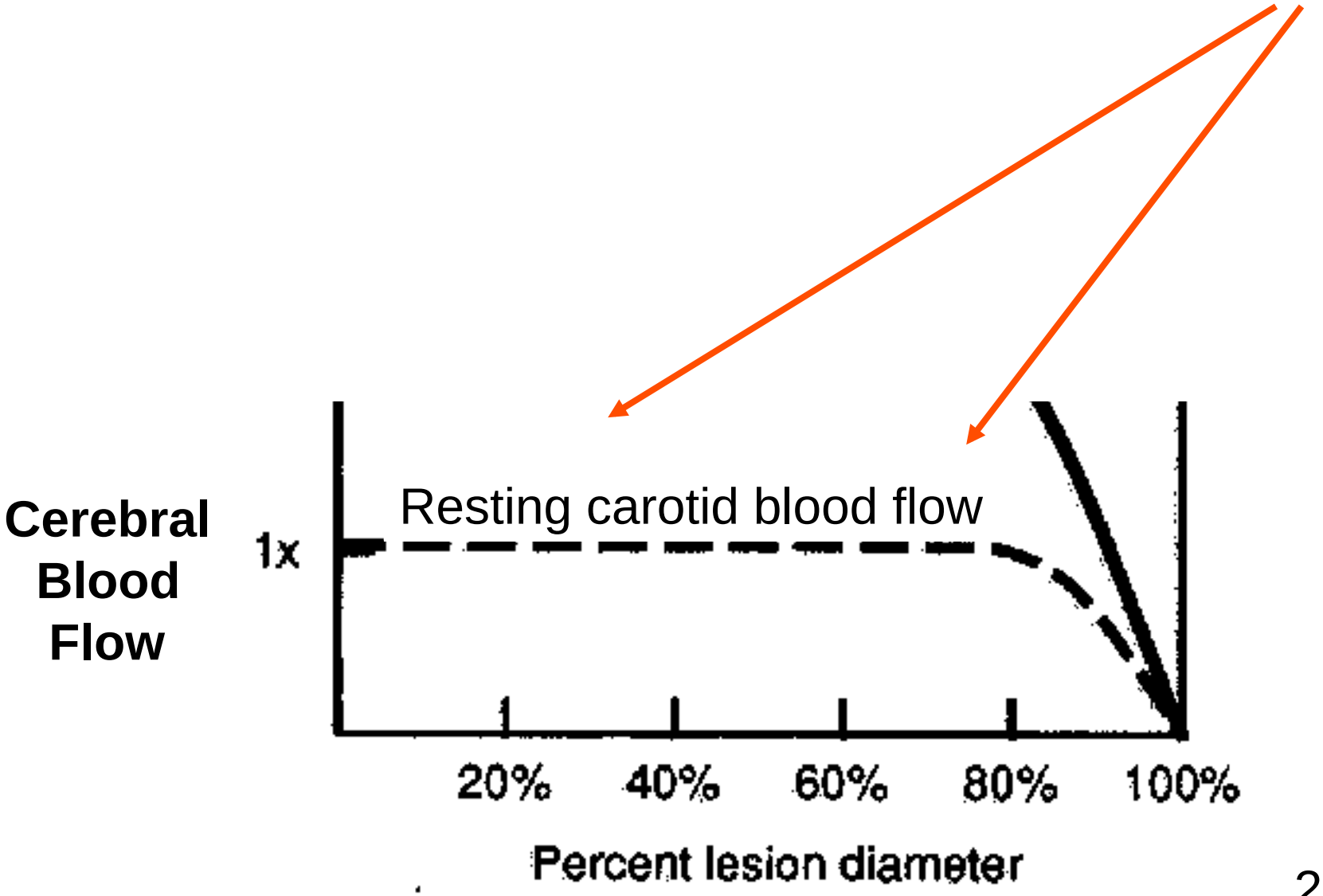
Cerebral Ischemia

-blood flow to a tissue or organ that is inadequate to maintain function.

-i.e. stroke, transient ischemic attack

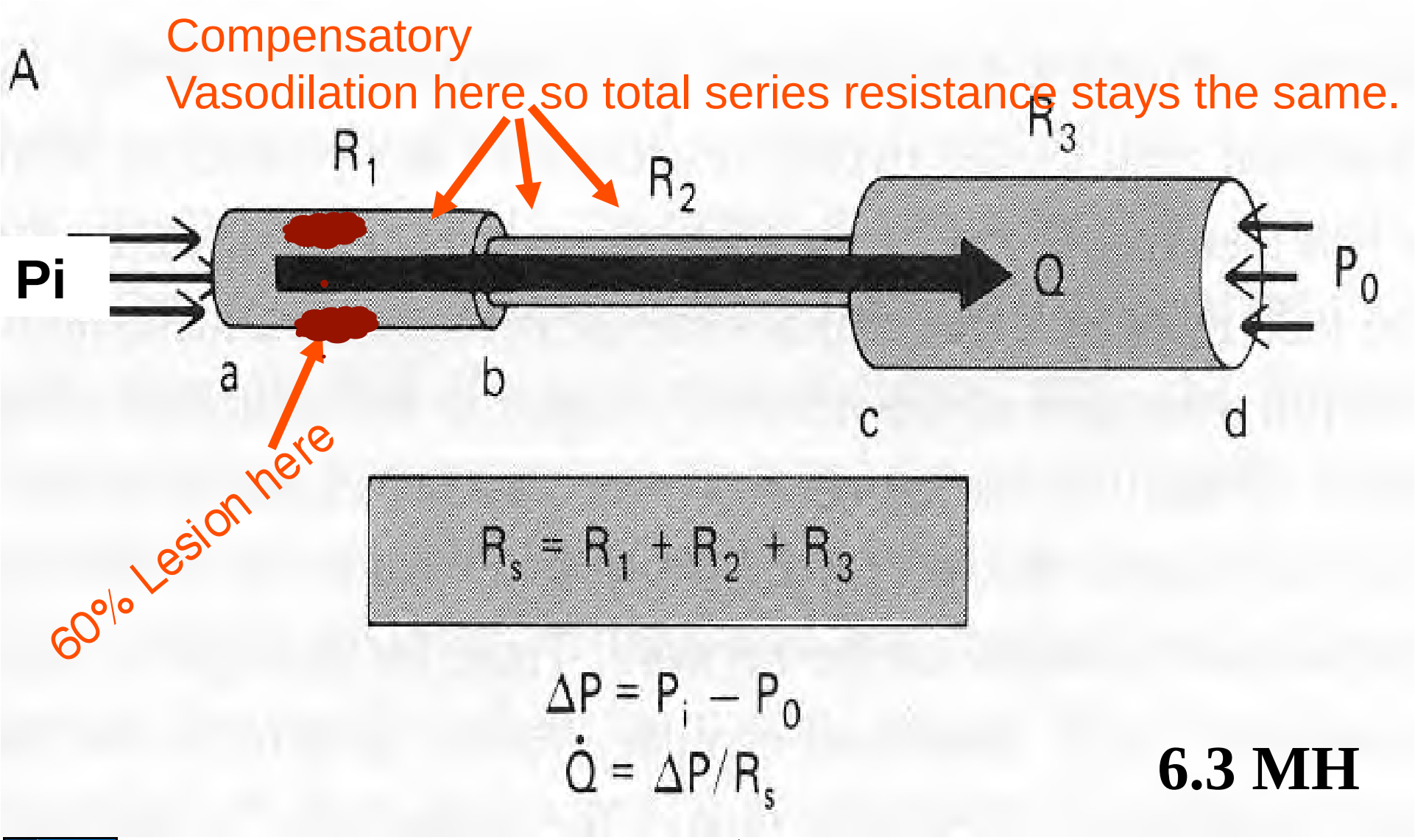
-Partially occluded carotid arteries 60 %?

How can cerebral flow remain relatively constant with an 60% “lesion”??



 Lilly, L. Pathophysiology of Heart Disease. Lippincott, 2007. 4th ed.

Series Resistance Network



6.3 MH

Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.

Hypoxia Is Misunderstood

….Rather, hypoxia is often undetectable and human responses include "Behavioral changes, such as an exceptional feeling of well-being or belligerence…". This was recognized early in aviation and mountaineering medicine. In fact, the United States Air Force, Army, and Navy have found it necessary to train aircrews, divers, and High Altitude/Low (parachute) Opening (HALO) operators in hypobaric chambers so they may recognize objective and subjective signs of impending unconsciousness as to avoid subsequent death while unconscious. This is done primarily because the signs and symptoms prior to unconsciousness are subtle, insidious and often imperceptible . Excerpted from a 1999 text used by the Royal Air Force in the United Kingdom in the characterization of human's response to hypoxia," The overt features of acute hypobaric hypoxia may be summarized as follows: Personality change, lack of insight, loss of judgment, loss of self-criticism, euphoria**,** loss of memory, mental incoordination, muscular incoordination, sensory loss, and cyanosis." 

6. **Fisher P**. Chapter 2: High Altitude Respiratory Physiology: USAF Flight Surgeon's Guide, http://wwwsam.brooks.af.mil/af/files/fsguide/HTML/Chapter_02.html, 2006.

7. **Gradwell RHaD**. *Aviation Medicine*. Oxford: Butterworth Heinemann, 1999.

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