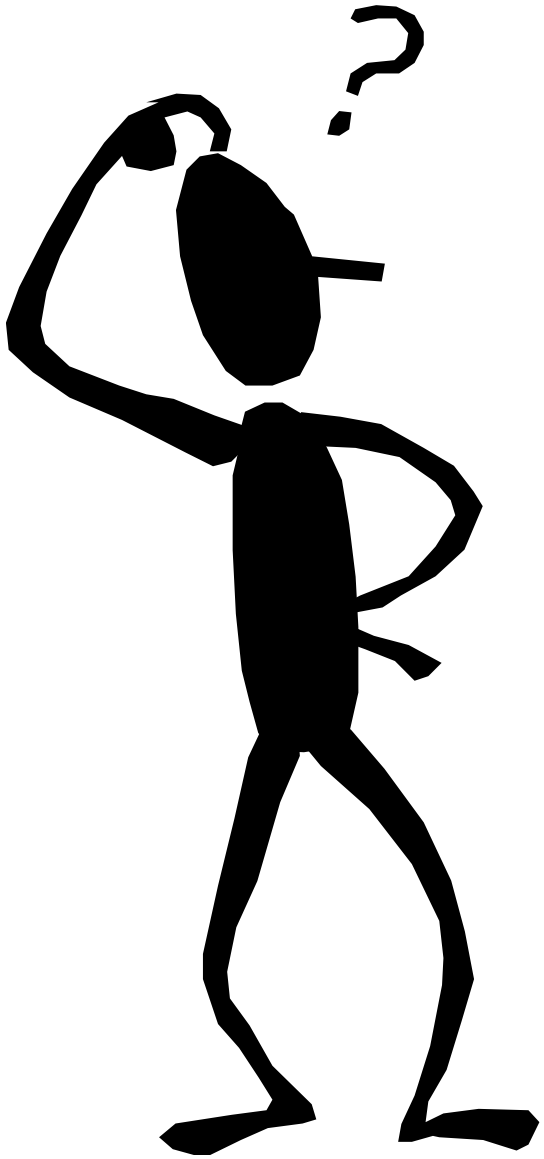
SONOGRAPHIC PHYSICS, INSTRUMENTATION & DOPPLER REVIEW

2012
Part 2

Intensity Measurements
&
Biological Effects

Where and when are intensity measurements made?



SATA

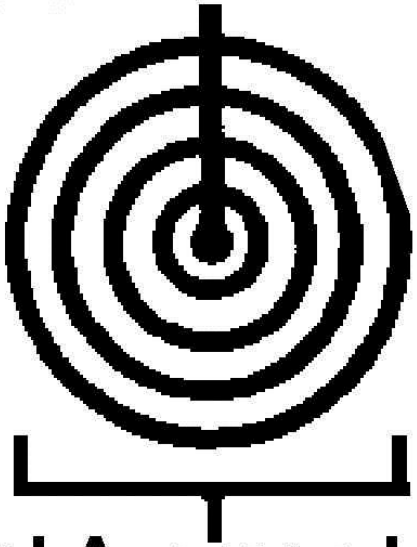
SPTA

SATP (SAPA)

SPTP (SPPA)

WHERE?

Spatial Peak Intensity
is measured at
the beam center

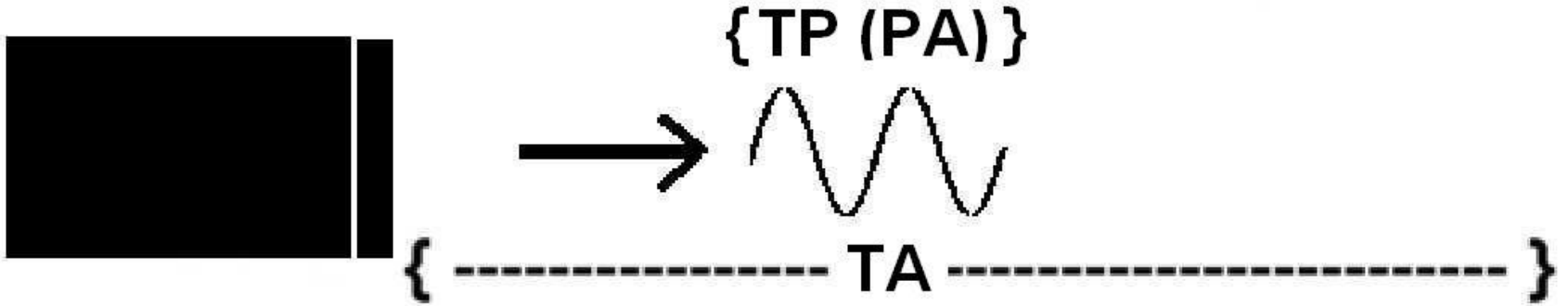


Spatial Average Intensity
is the average intensity
across the beam

The relationship between I_{SP} and I_{SA} is a function of beam uniformity ratio (B.U.R.)

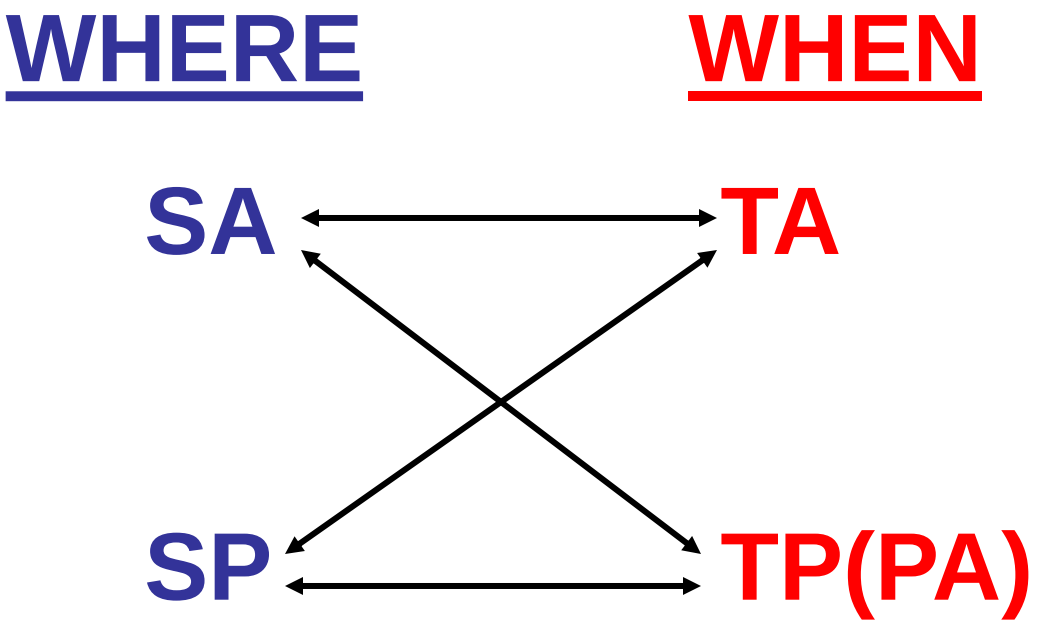
WHEN?

Temporal Peak (Pulse Average) Intensity is measured when the pulse is present



Temporal Average Intensity is measured when the pulse is present and when it is not present

The relationship between $I_{TP}(I_{PA})$ and I_{TA} is a function of duty factor (D.F.)


WHERE
WHEN
SA
TA
SP
TP(PA)

WHERE WHEN

SATA

SPTA

SATP(PA)

SPTP(PA)

Which method produces the lowest result?

Which method produces the highest result?

$$I_{SATA} \bullet I_{SPTA} \bullet I_{SATP}\ (I_{SAPA}) \bullet I_{SPTP}\ (I_{SPPA})$$

Lowest  **Highest**

BIOEFFECTS

HEAT (Thermal)

CAVITATION (Mechanical)

Stable

Transient

MECHANICAL INDEX

THERMAL INDEX

MECHANICAL INDEX

MI

A value used as a guide in determining the probability of mechanical bioeffects (mainly cavitation) occurring

THERMAL INDEX

TI

A value used to estimate the rise in temperature in ºC

ALARA

“As low as reasonably achievable”

Nonfocused: SPTA < 100 mW / cm²

(0.1 Watt per square centimeter)

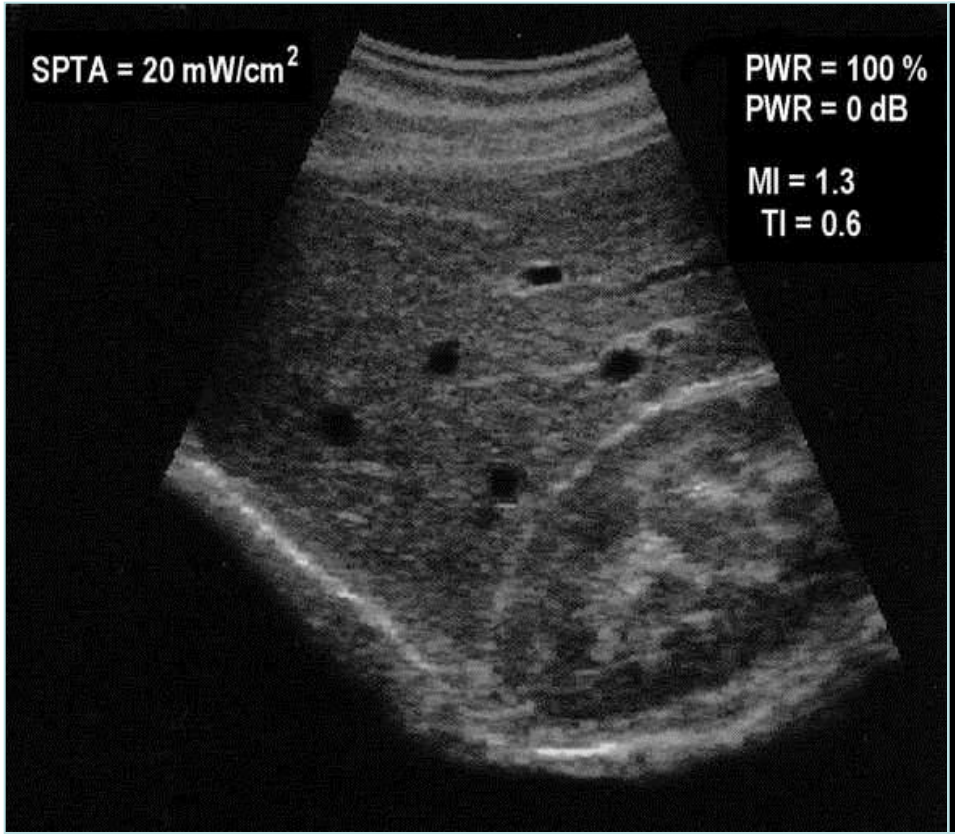
Focused: SPTA < 1 W / cm²

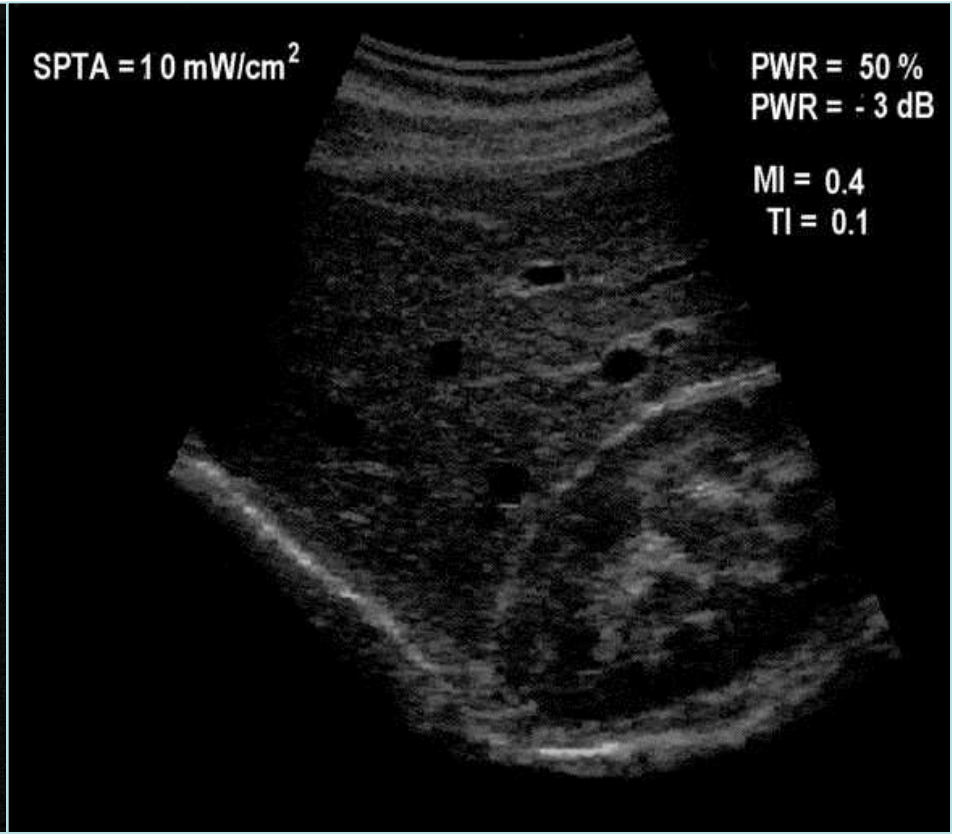
INTENSITY

POWER ÷ AREA

POWER	BEAM DIMENSIONS	AREA	INTENSITY
100 mw	1 cm x 1 cm	1 cm^2	100 mW / cm^2
100 mw	1.414 cm X 1.414 cm	2 cm^2	50 mW / cm^2
100 mw	2 cm x 2 cm	4 cm^2	25 mW / cm^2
50 mw	1.414 cm x 1.414 cm	2 cm^2	25 mW / cm^2

OUTPUT POWER SETTINGS

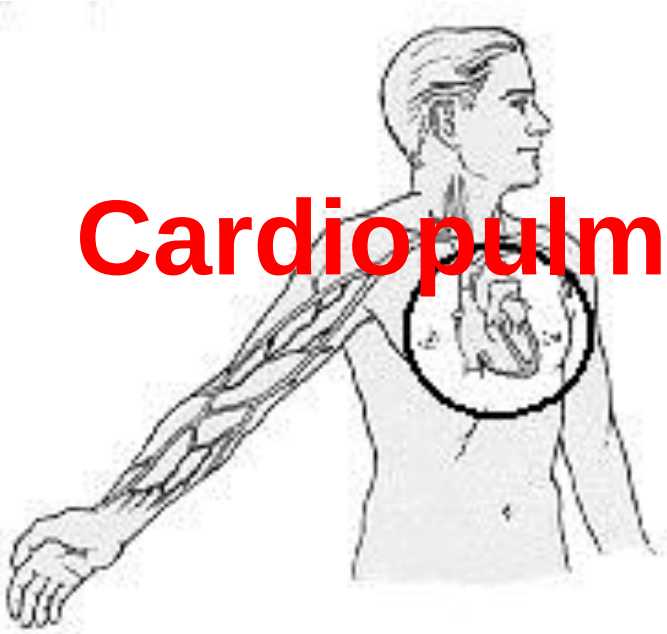




MAXIMUM **ONE - HALF**

Arterial and Venous Hemodynamics

MAJOR SYSTEMS OF CARDIOVASCULAR CIRCULATION



Cardiopulmonary

Systemic

ENERGY

Kinetic energy

Potential energy

Total fluid energy

TOTAL FLUID ENERGY

Combination of the kinetic energy (blood flow) and the potential energy (blood pressure) present.

GRADIENT

ΔP

The difference in pressure (pressure drop) between the two ends of a vessel or the difference in pressure across a valve.

POISEUILLE'S LAW

Poiseuille's Law

$$\Delta P = Q \times R$$

$$Q = SV \times HR$$

$$R = \frac{\eta \times L \times 8}{\pi r^4}$$

Q = flow
R = resistance
η = viscosity
L = length
r = radius of vessel
SV = stroke volume
HR = heart rate

VISCOSITY
(Internal friction)

Increases with increasing hematocrit.

PERCENTAGE OF RESISTANCE IN THE VASCULAR SYSTEM

Aorta	**4%**
Large Arteries	**5%**
Main Branches	**10%**
Terminal branches	**6%**
Arterioles	**41%**
Capillaries	**27%**
Total venous	**7%**

FLOW PATTERNS:

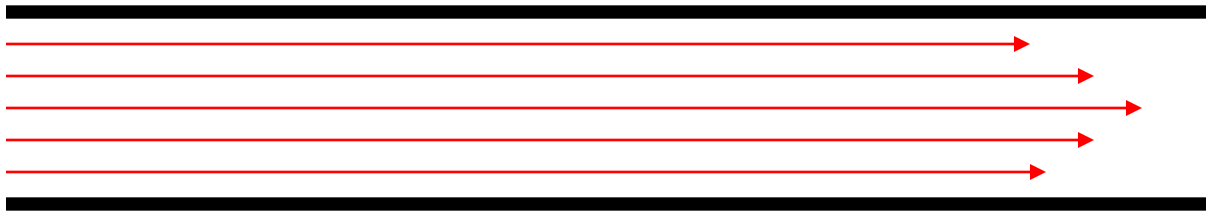
- **plug**
- **laminar (parabolic)**
- **disturbed**
- **turbulent**

PLUG FLOW:

- **occurs during systole in large vessels**

LAMINAR FLOW:

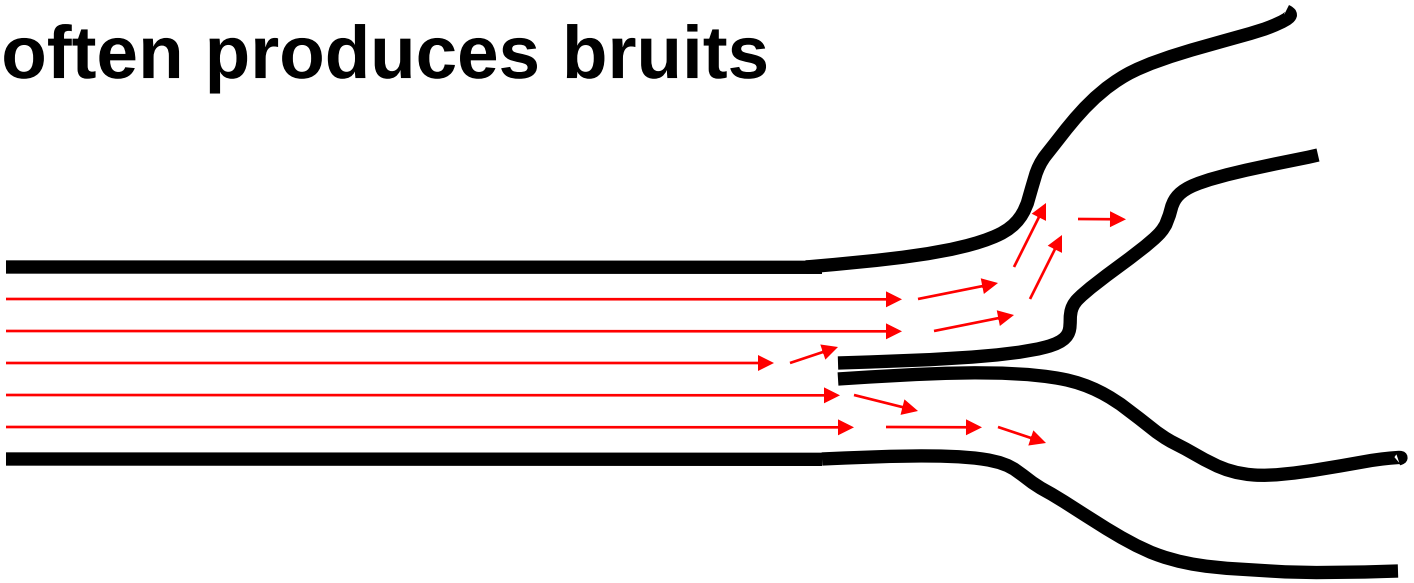
- **thought to exist in the majority of vessels**



DISTURBED FLOW:

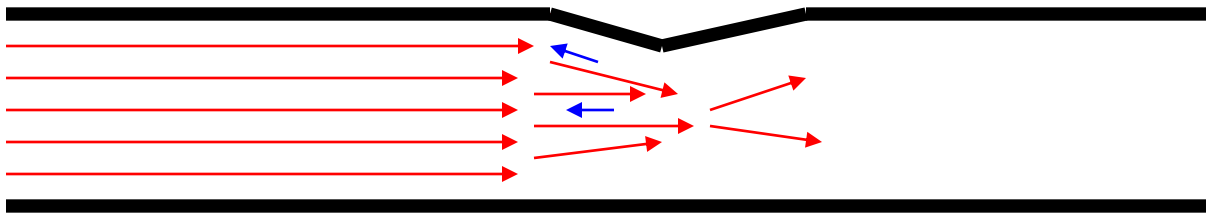
- **caused by high peak velocities, curving, branching, and divergence**

- **often produces bruits**



TURBULENT FLOW:

- **often at the location of a stenosis**
- **significant pressure gradients are present**



BERNOULLI EFFECT

The *Bernoulli Effect* describes the relationship between changes in fluid flow and changes in pressure energy.

Q = V x A

(flow = velocity x area)

BERNOULLI EFFECT

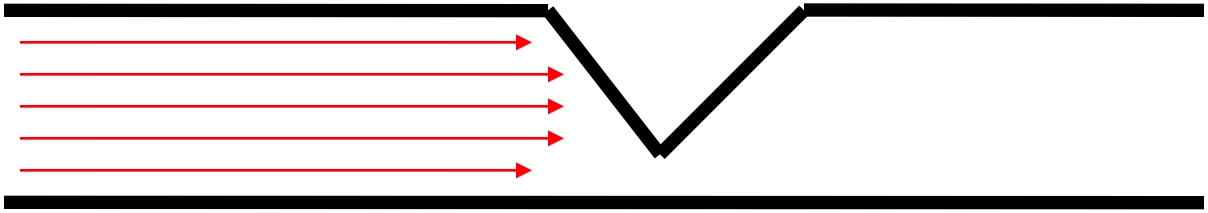
A reduction in pressure accompanies an increase in flow.

CRITICAL STENOSIS

- **causes a significant reduction in the amount of blood flow distal to the location of the stenosis**

CRITICAL STENOSIS

abdominal aorta ⇒ 90% area reduction



carotid artery ⇒ 75% area reduction

In the abdominal aorta, a 90% reduction (10% remaining) in area is required before the stenosis is critical, while in the carotid artery a 75% reduction (25% remaining) in area is characterized as critical. A 75% area reduction is equivalent to a 50% diameter reduction, often called a 50% stenosis.