UNIVERSITY OF SOUTH CAROLINA

American Physiological Society

Teaching Physiology with Ultrasound

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USC School of Medicine

IAMSE

Ultrasound in Pre-Clinical Curriculum

MEDICAL EDUCATION 1996, 30, 296-298

Ultrasound anatomy: a practical teaching system in human gross anatomy

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Perspectives in Radiologic Education

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Gross Anatomy Instruction with Diagnostic Images

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Why Physiology Also?

1) Help the student learn and understand important physiologic principles.

2) Teachable moments: Remind/review physiologic concepts and how these change when pathology/dysfunction occurs.

3) Working with the machine keeps it “fresh” in their minds.

Four Physiology Ultrasound Labs

1. Vascular US—Arterial: Doppler flow
2. Heart: Normal heart function (4 chamber apical view)
3. Cardiac Cycle/Heart Sounds: Synch together wall motion, hearts sounds, and electrical activity
4. Shock: Gross ventricular function; pericardial effusion; RV strain with a PE

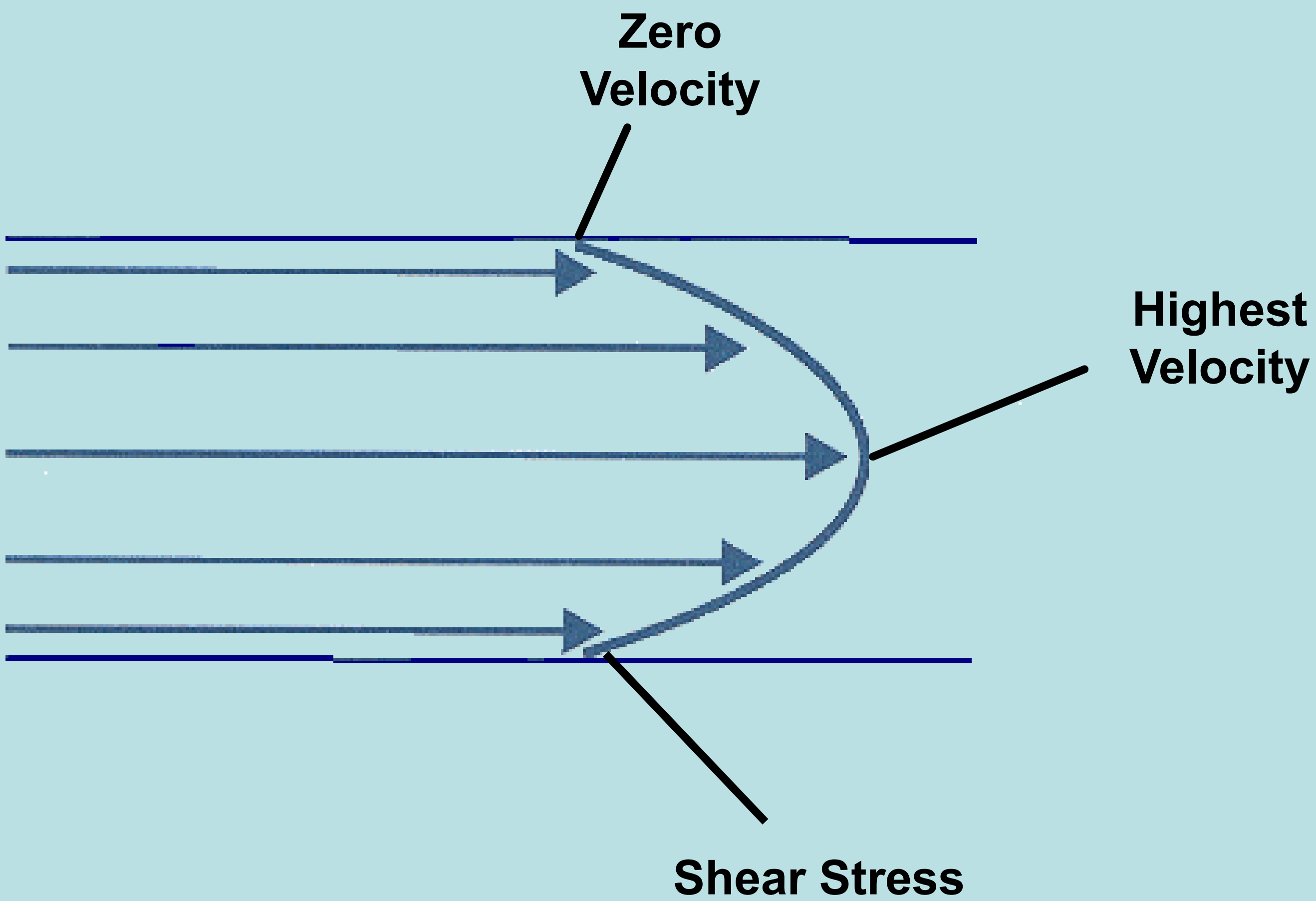
Basic Hemodynamics

$$Q = \frac{\Delta P}{R}$$

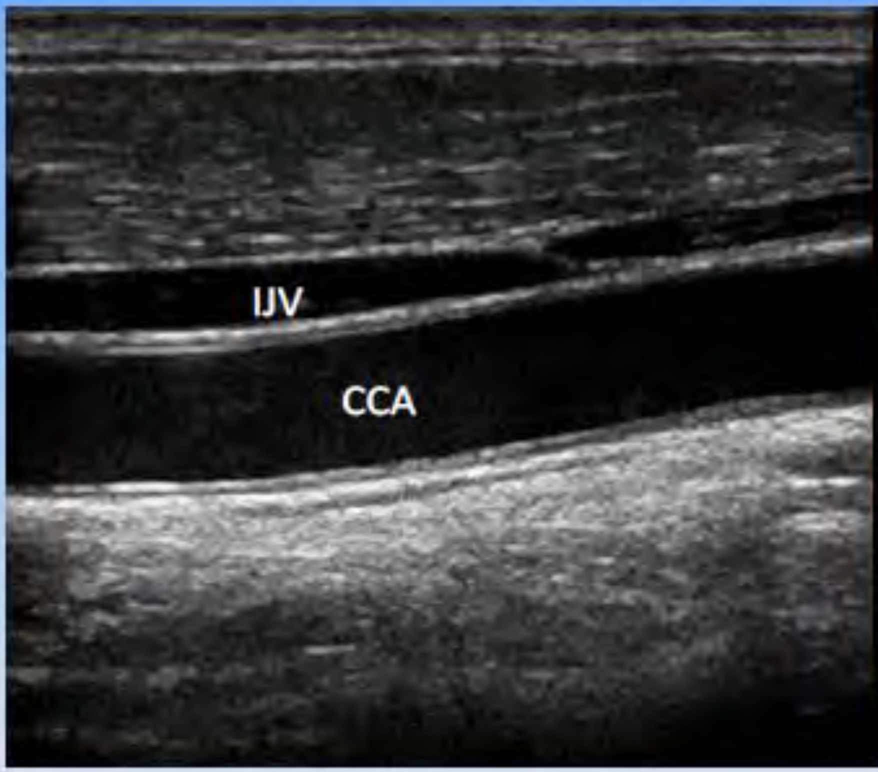
Fundamental Principles

Parabolic Velocity Profile

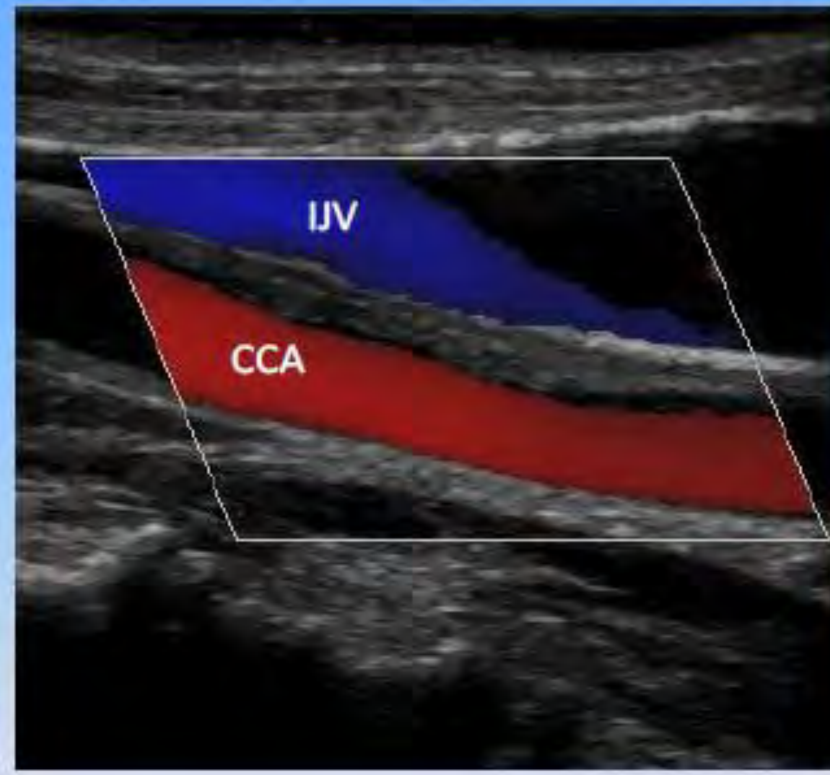
The mean linear velocity (v) is related to flow: v = Q/CSA (cross-sectional area)



US Lab—Doppler

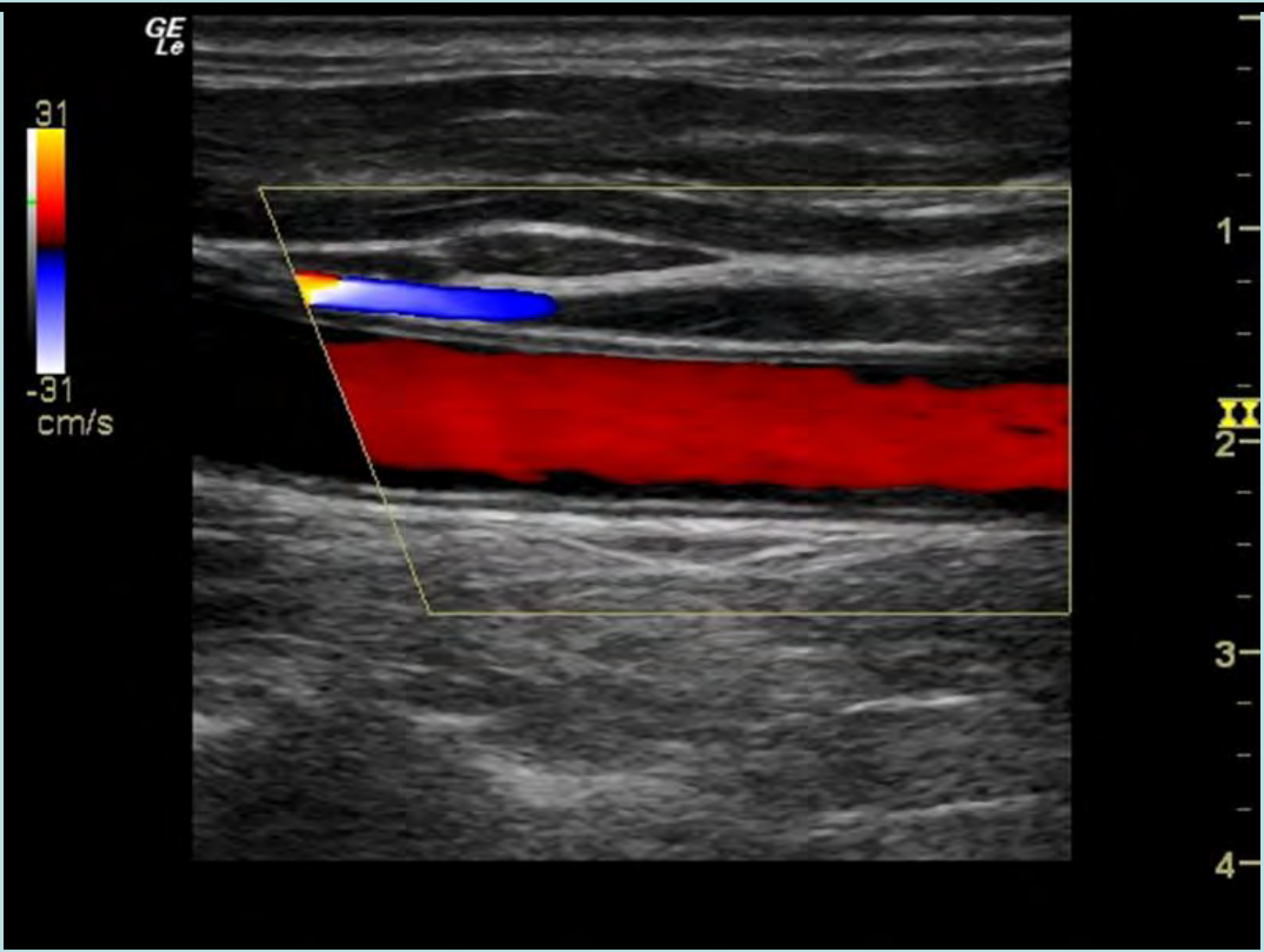


B-mode image of CCA

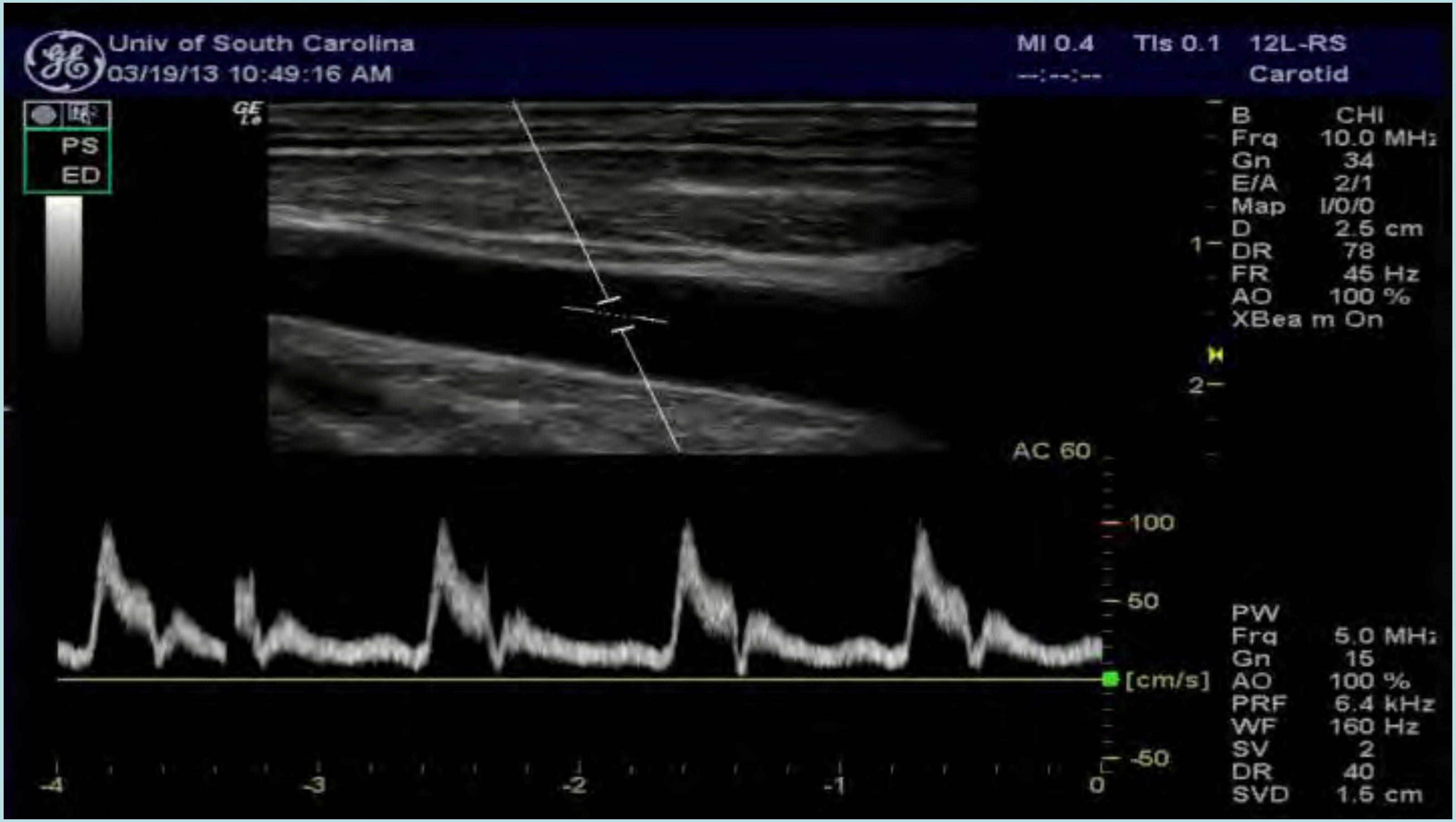


Color Flow Doppler image of CCA

US Lab—Doppler



US Lab—Doppler



Instructor: Now measure peak velocity and difference in sys/dia

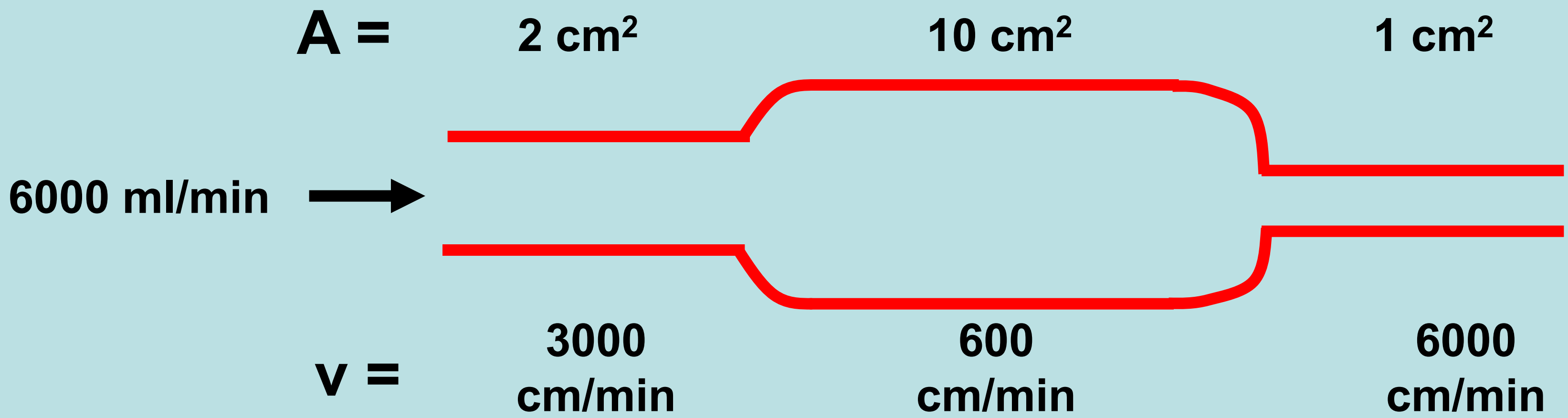
TM Instructor: Can you think of any instances in which velocity is changed?

Student: Why do I care about the actual velocity? I just like hearing the sound.

Student: (Pretends he/she didn't hear the question, because they can't think of anything)

Fundamental Principles

Velocity and Area



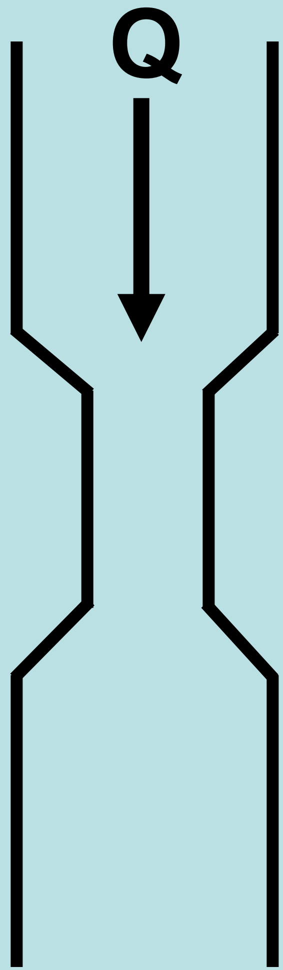
Fundamental Principles

Coarctation or Stenosis

Student: Ahhh, yes, now I recall this.

TM Instructor: What might happen if velocity becomes too high?

Student (puzzled look): Hhhhmmm

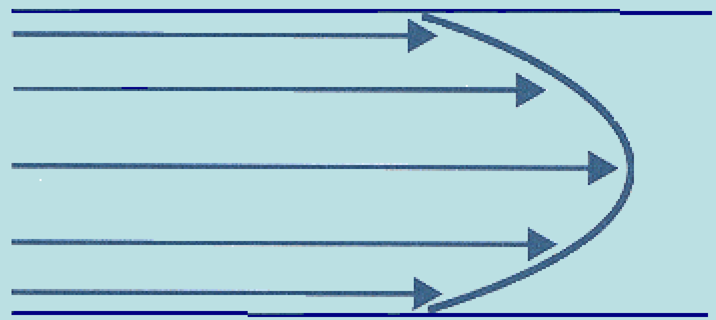


CSA goes $\downarrow$ so v $\uparrow$

Fundamental Principles

Transition to Turbulent Flow

Laminar Flow



When Reynold's number exceeds 2000

$$\text{Reynold's} = \frac{v D \rho}{\eta}$$

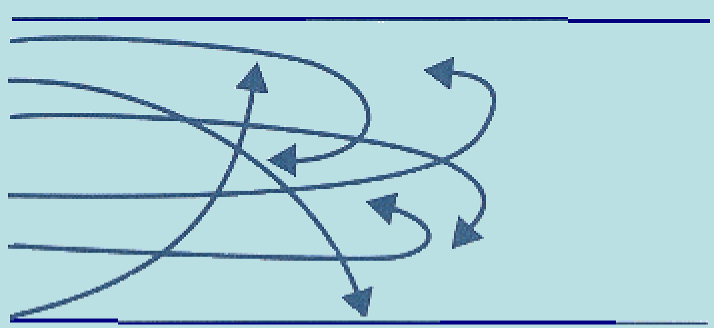
v = velocity

D = diameter

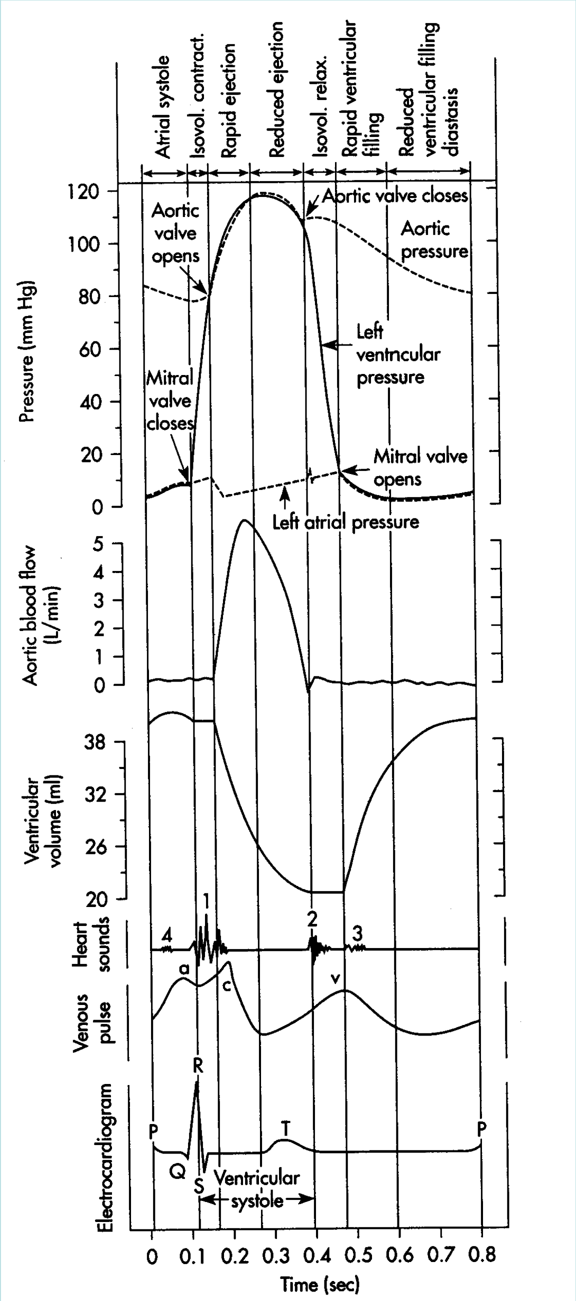
ρ = density

η = viscosity

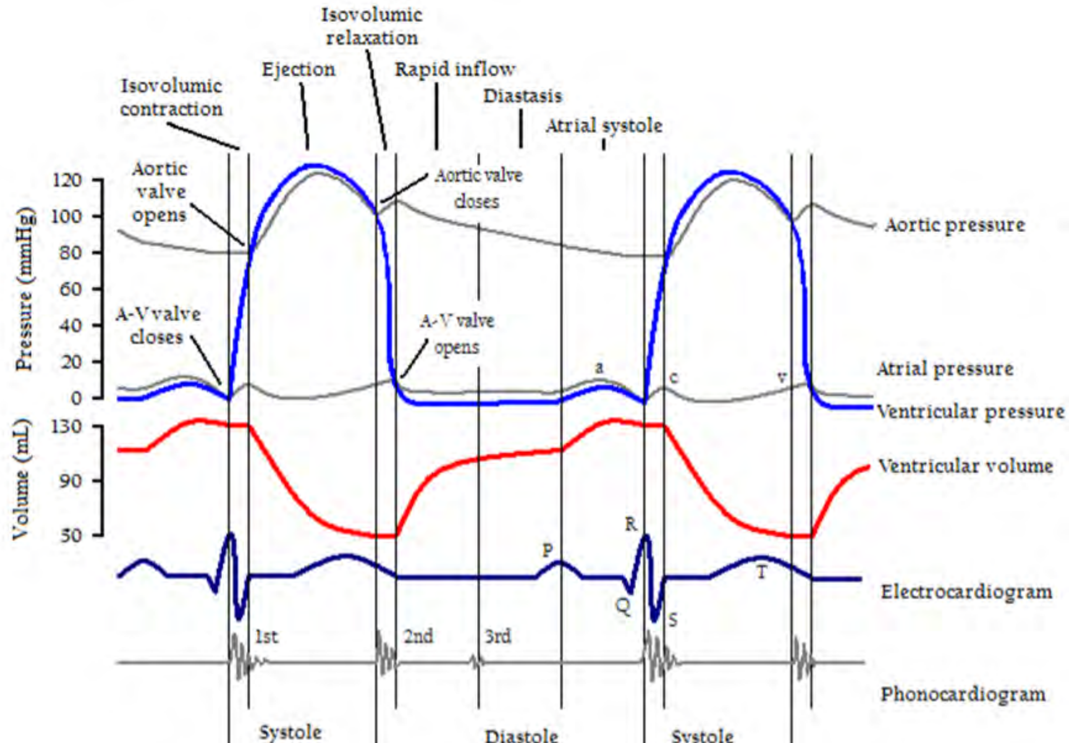
Turbulent Flow

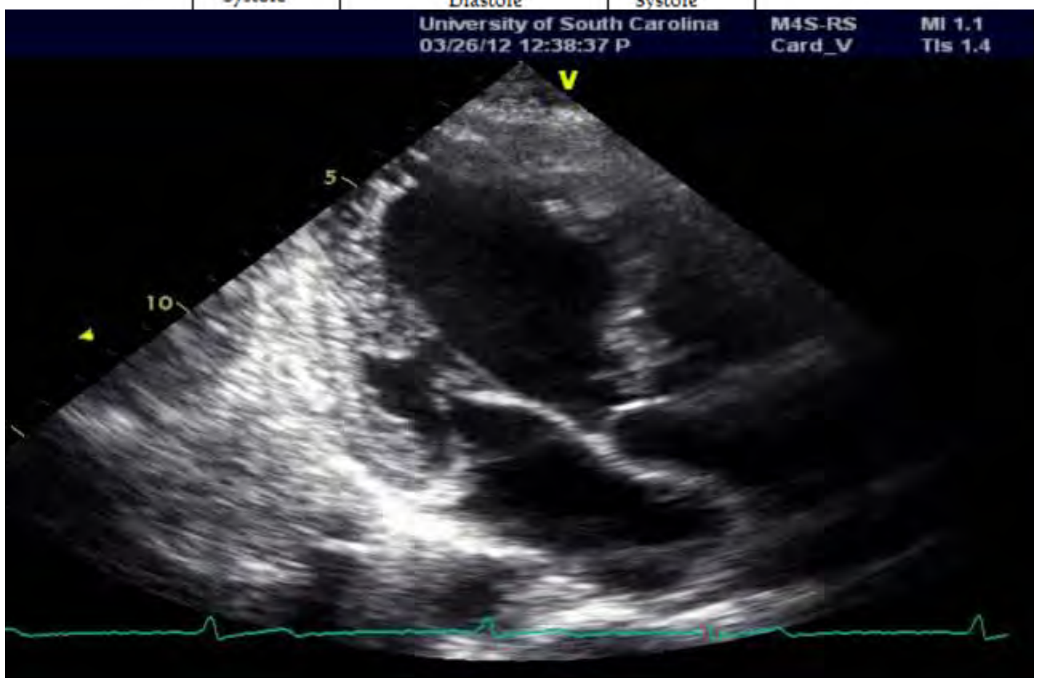


Wiggers Diagram of the Cardiac Cycle

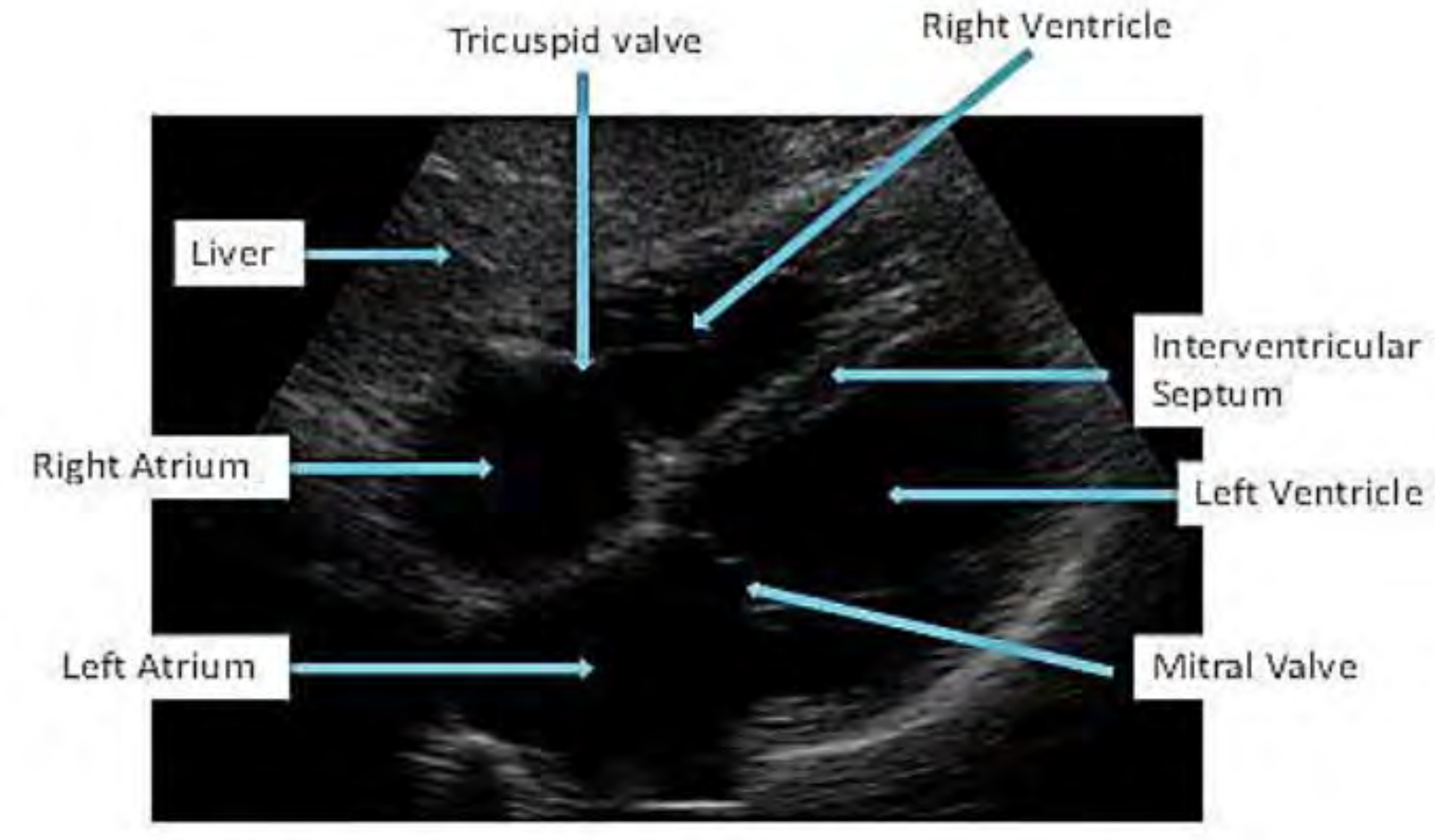


Wigger's Diagram





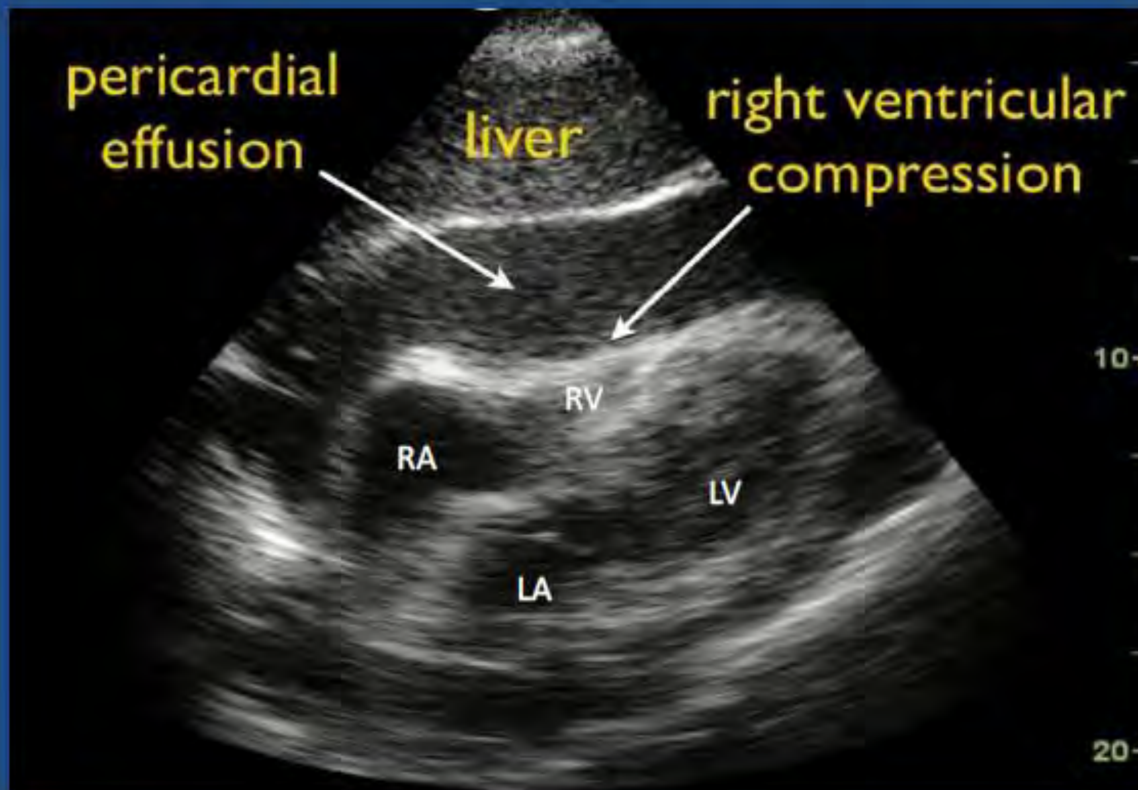
US Lab—Shock



Subcostal 4-chamber view

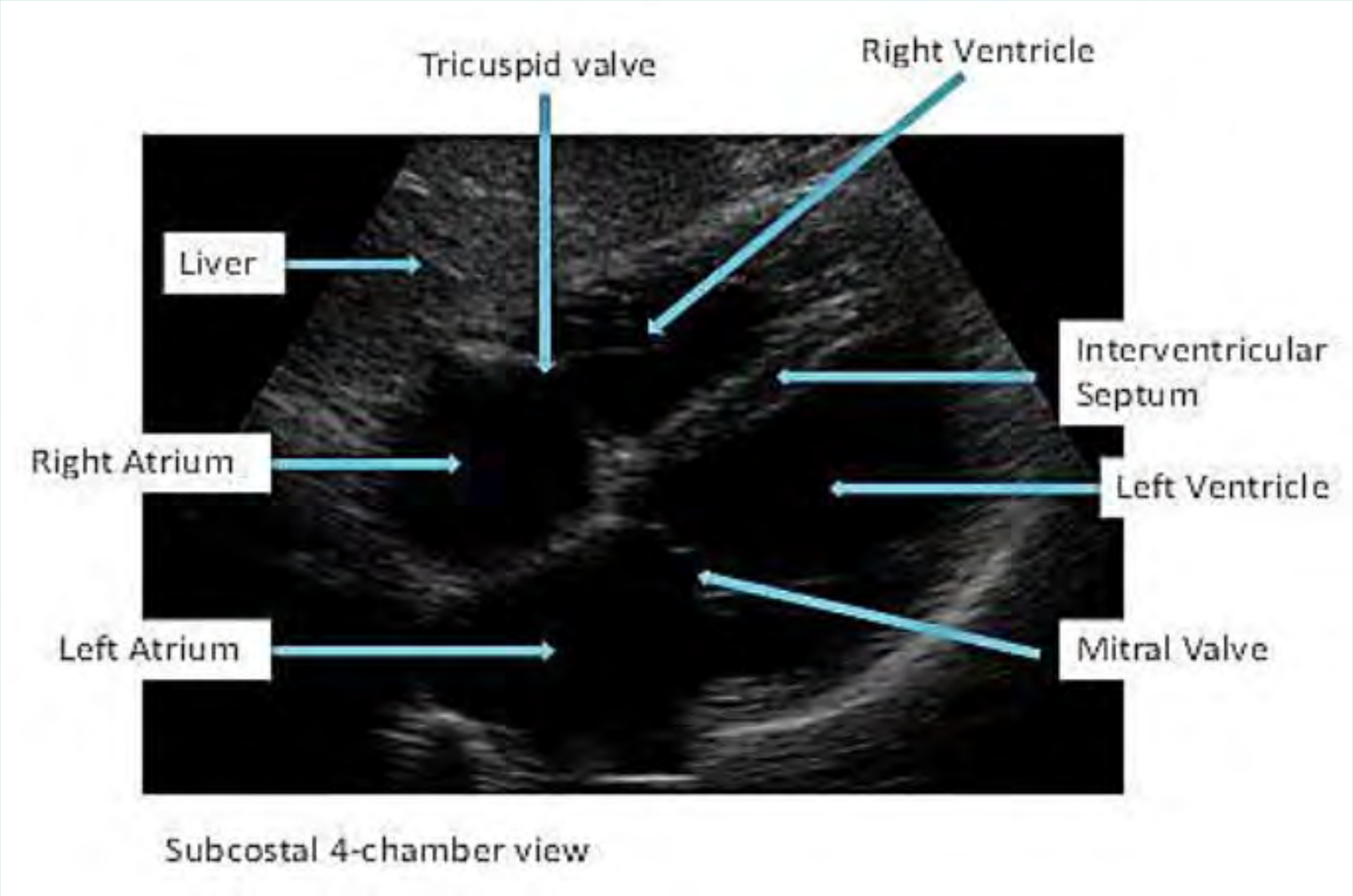
Question: If fluid builds up in the pericardial sac (pericardial effusion), how would it alter the structures seen in this view?

US Lab—Shock



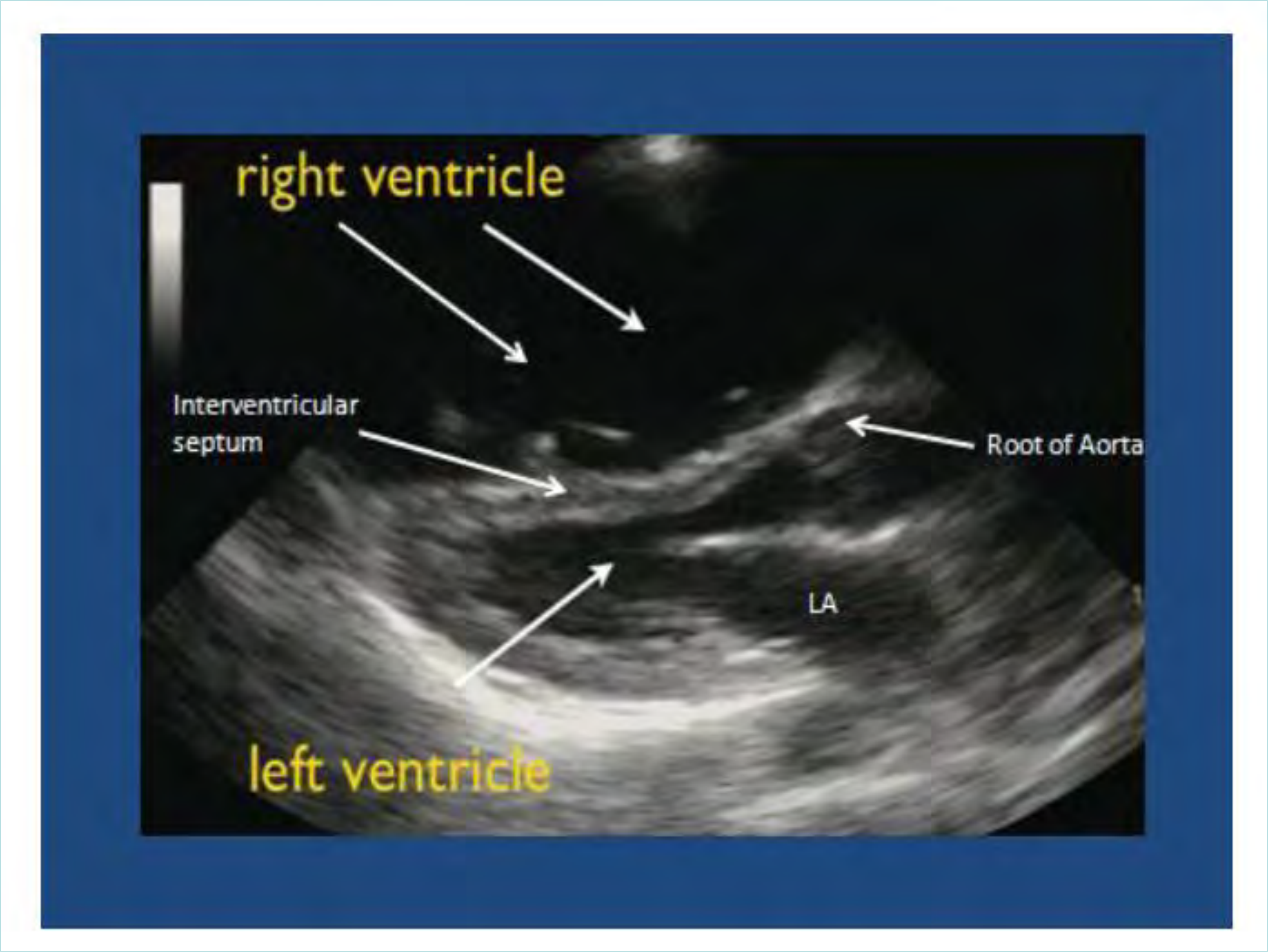
RA = RIGHT ATRIUM, LA = LEFT ATRIUM, RV = RIGHT VENTRICLE, LV = LEFT VENTRICLE

US Lab—Shock



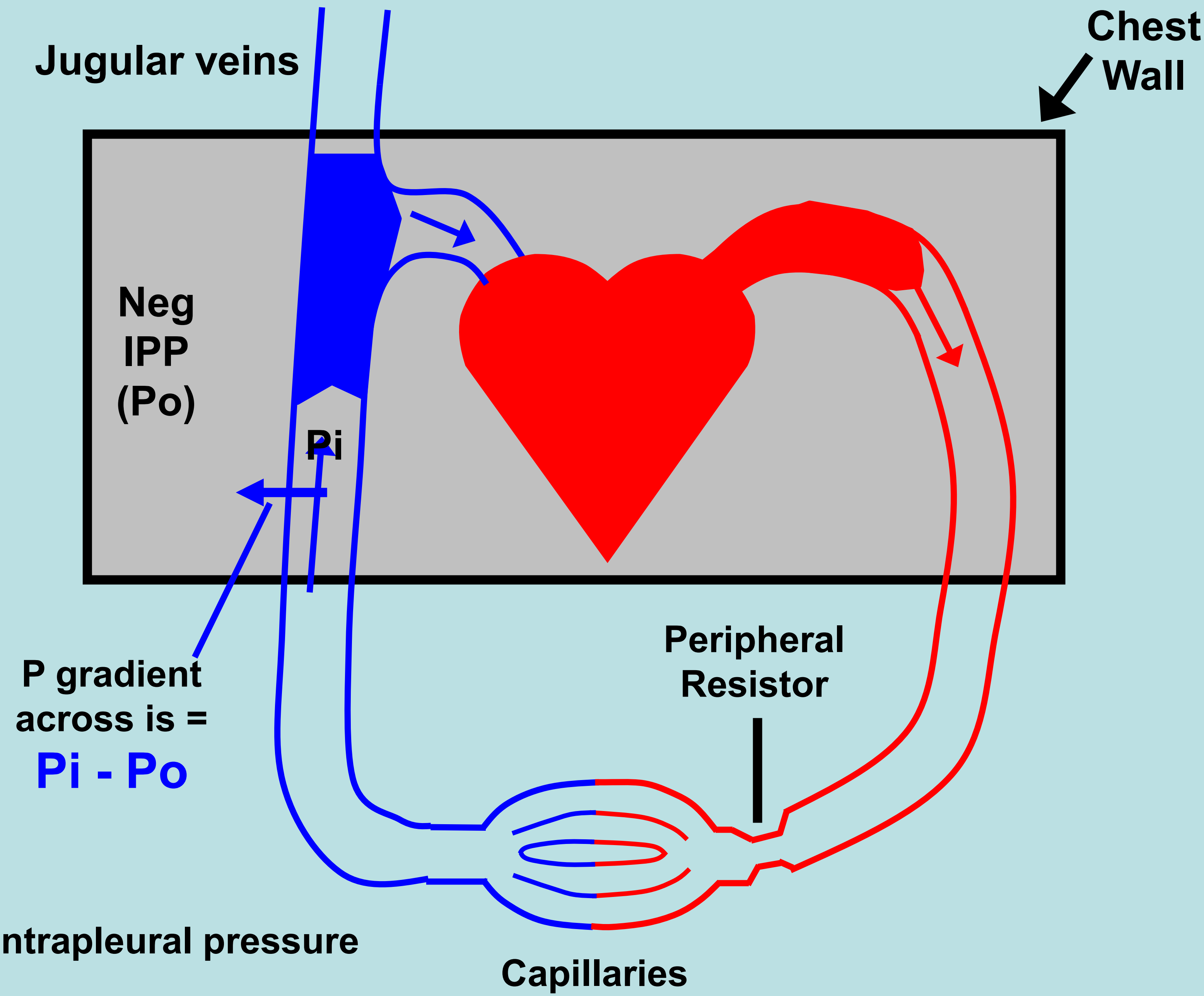
Question: If afterload to the right heart suddenly increases, how would it alter the structures seen in this view?

US Lab—Shock



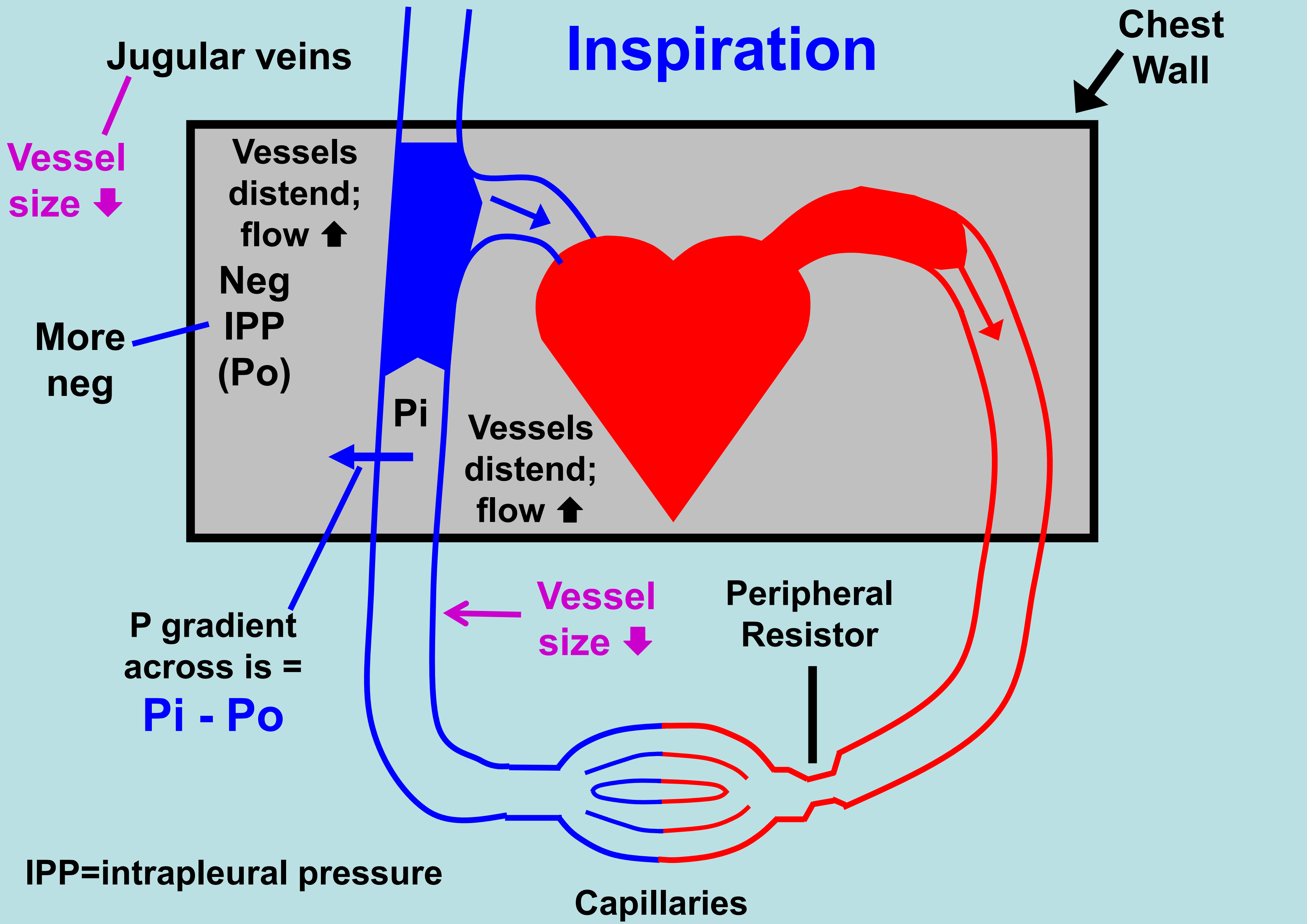
Question: What could cause this?

Fundamental Principles



IPP=intrapleural pressure

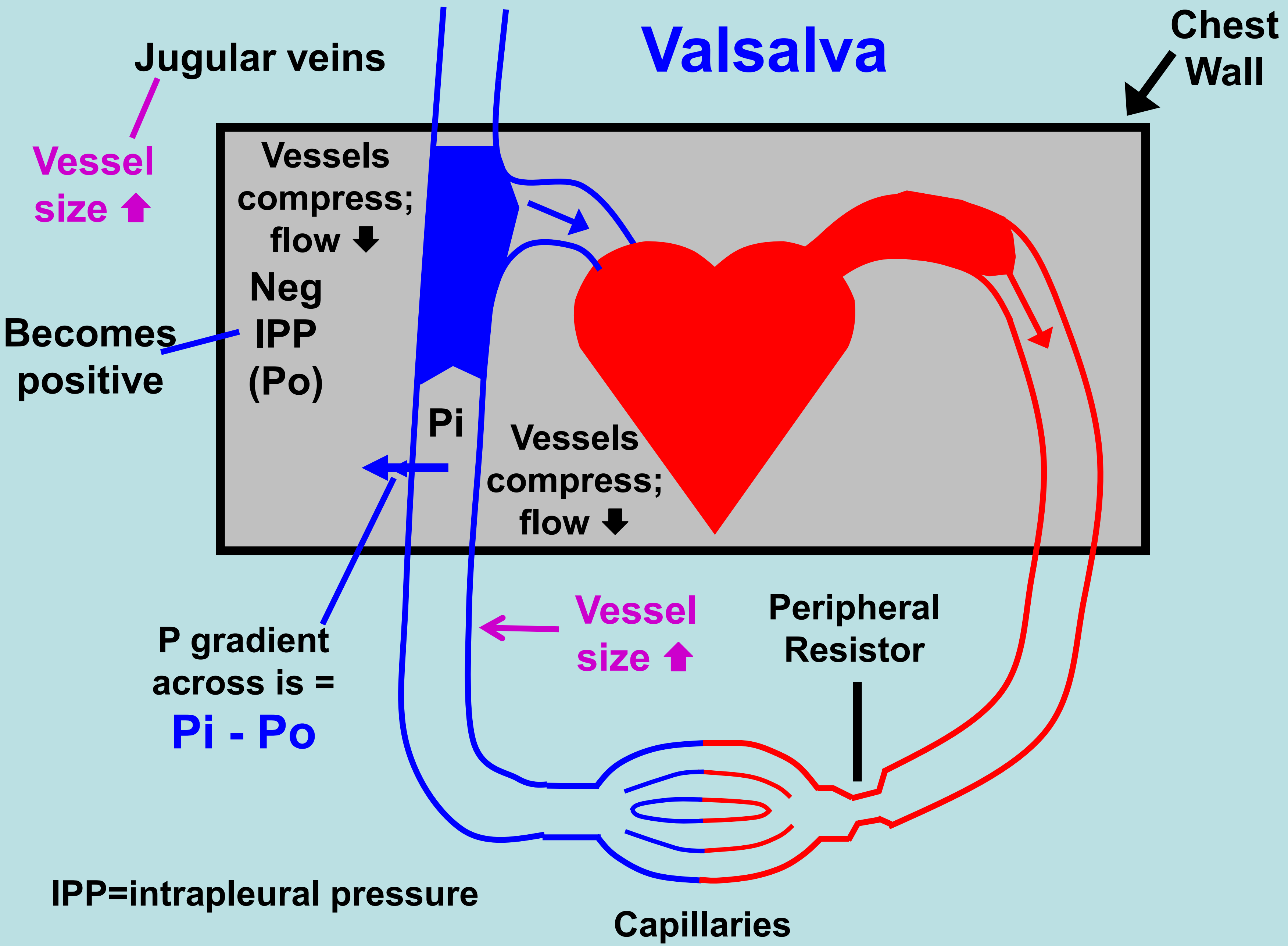
Fundamental Principles



Sniff

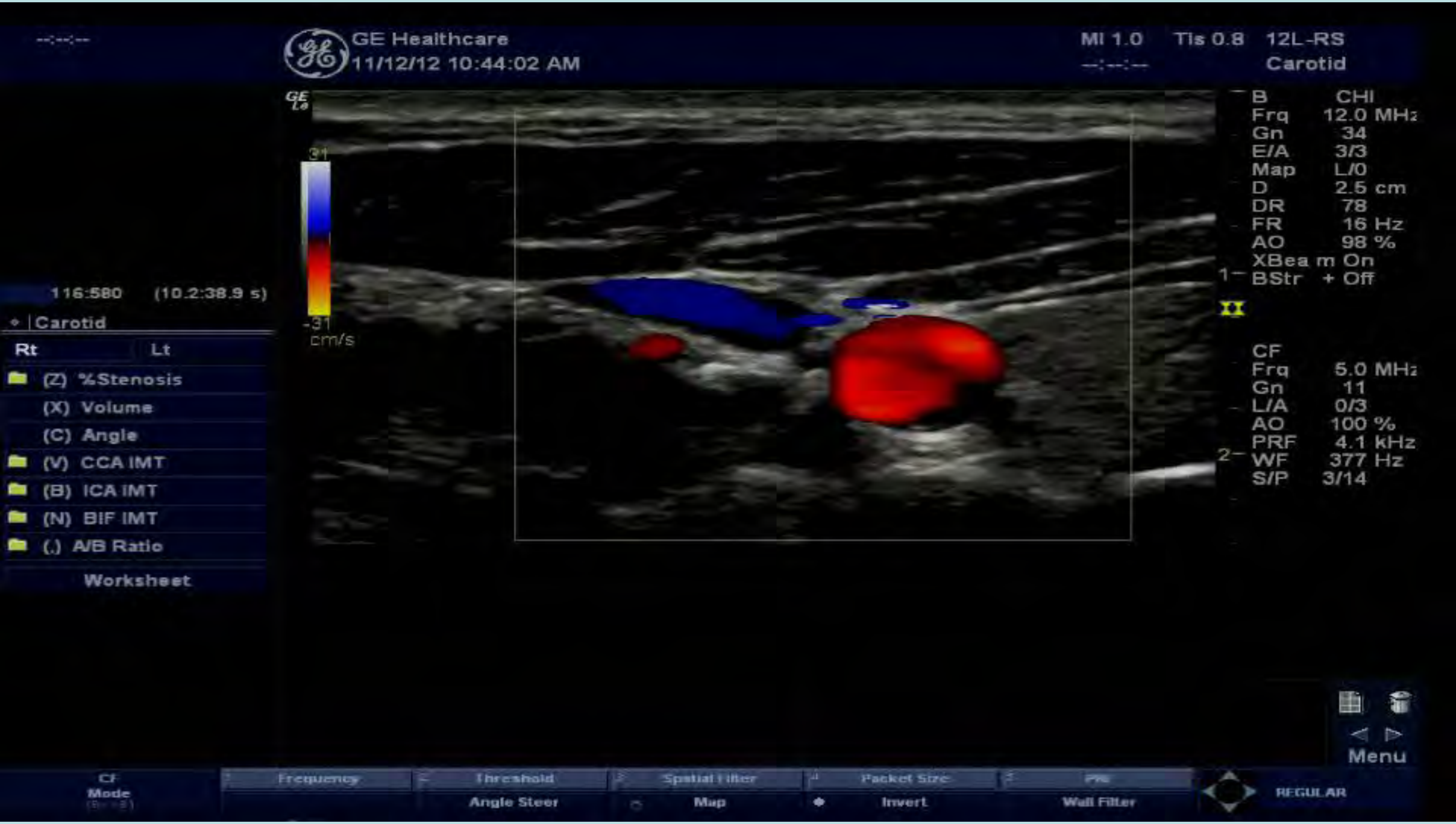

GE Healthcare
11/12/12 10:52:39 AM
MI 1.1
TIs 0.1
4C-RS
Abd2
B CHI
Frq 4.0 MHz
Gn 30
E/A 2/3
Map D/0
D 13.0 cm
DR 81
FR 25 Hz
AO 100 %
XBea m On
BStr + Off
0
5
10
512:512 (62.0:62.0 s)
Abdomen
Rt
Lt
(Z) Bladder
(X) Volume
(C) Renal Volume
(V) Renal Cortex
(B) Gall Bladder
(N) Emergency Medicin
(M) Renal Length
(,) Aorta
(.) Liver
(/) Spleen
Renal(0.49)
Worksheet
Menu
B Mode
Frequency
Edge Enhance
Colorize
Dynamic Range
Gray Map
Rotation
CrossXBeam
Focus Position
Focus Number
REGULAR

Fundamental Principles



IPP=intrapleural pressure

Valsalva


GE Healthcare
11/12/12 10:44:02 AM
MI 1.0
Tis 0.8
12L-RS
Carotid
116:580
(10.2:38.9 s)
Carotid
Rt
Lt
(Z) %Stenosis
(X) Volume
(C) Angle
(V) CCA IMT
(B) ICA IMT
(N) BIF IMT
(.) A/B Ratio
Worksheet
31
-31
cm/s
B CHI
Frq 12.0 MHz
Gn 34
E/A 3/3
Map L/0
D 2.5 cm
DR 78
FR 16 Hz
AO 98 %
XBeam On
BStr + Off
CF
Frq 5.0 MHz
Gn 11
L/A 0/3
AO 100 %
PRF 4.1 kHz
WF 377 Hz
S/P 3/14
Menu
CF
Mode
Frequency
Threshold
Angle Steer
Spatial Filter
Map
Packet Size
Invert
Wall Filter
REGULAR

Valsalva

GE Healthcare
11/12/12 10:48:36 AM
MI 1.3
TIs 1.5
12L-RS
Carotid
B CHI
Frq 12.0 MHz
Gn 48
E/A 3/3
Map L/0
D 2.5 cm
DR 78
FR 14 Hz
AO 98 %
XBeam On
BStr + Off
CF
Frq 5.0 MHz
Gn 0
L/A 0/3
AO 100 %
PRF 4.1 kHz
WF 377 Hz
S/P 3/14
31
-31
cm/s
517:587 (40.8:45.9 s)
Carotid
Rt
Lt
(Z) %Stenosis
(X) Volume
(C) Angle
(V) CCA IMT
(B) ICA IMT
(N) BIF IMT
(.) A/B Ratio
Worksheet
Menu
CF Mode
Frequency
Threshold
Spatial Filter
Packet Size
PRI
Angle Steer
Map
Invert
Wall Filter
REGULAR

Valsalva


GE Healthcare
11/12/12 10:47:23 AM
MI 0.5
TIs 0.5
12L-RS
Carotid
B CHI
Frq 12.0 MHz
Gn 48
E/A 3/3
Map L/0
D 2.5 cm
DR 78
FR 27 Hz
AO 98 %
XBea m On
BStr + Off
214:220 (26.2:26.2 s)
Carotid
Rt
Lt
(Z) %Stenosis
(X) Volume
(C) Angle
(V) CCA IMT
(B) ICA IMT
(N) BIF IMT
(,) A/B Ratio
Worksheet
Menu
B Mode
Frequency
Edge Enhance
Dynamic Range
Rotation
Focus Position
Virtual Convex
Colorize
Gray Map
CrossXBeam
Focus Number
REGULAR

US Lab—Physiology

Where do we go from here?