

PASSION ACADEMIC TEAM

YU - MEDICINE

Cardiovascular System

Sheet# 5 (Part 3)

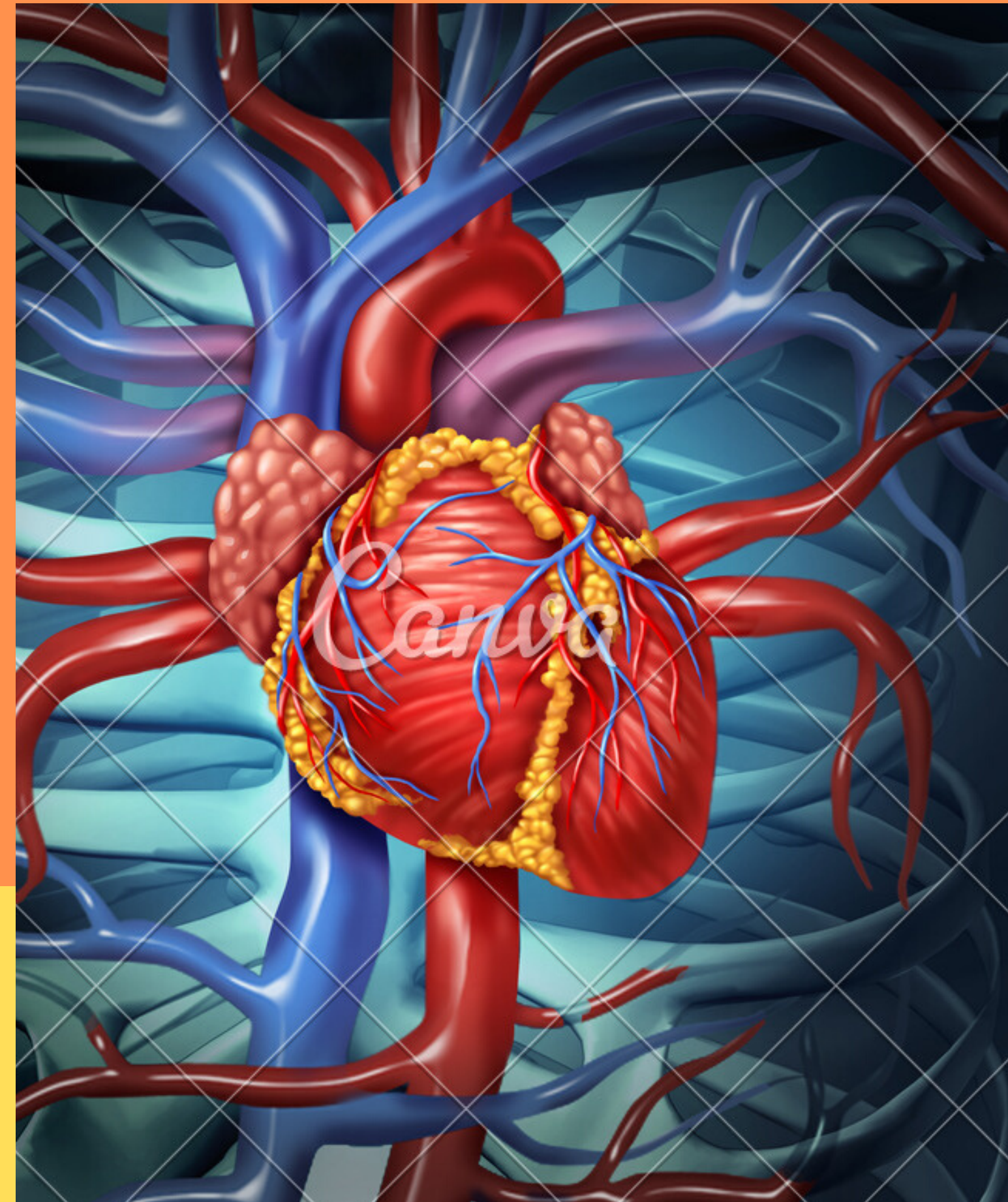
Lec. Date :

Lec. Title :

Written By : Bara'a Bashabsheh & Heba M.

Amayrah

**If you come by any mistake , please
kindly report it to
shaghafbatch@gmail.com**

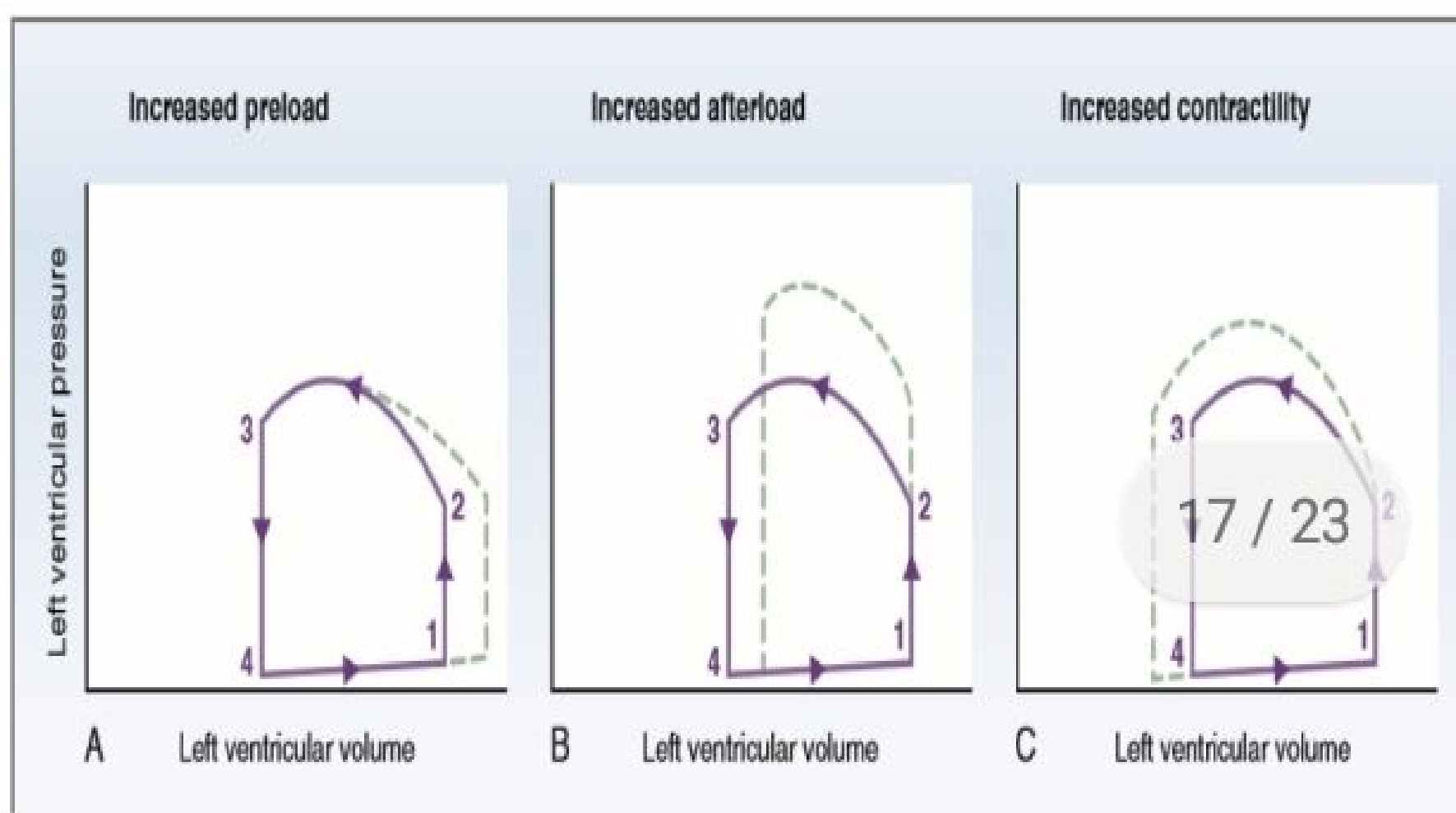


Factors that regulate cardiac pumping power. preload .. afterload & contractility

Ventricular pressure – volume loop*

the solid lines represent normal single ventricular cycle while the dashed -- lines represent the effect of preload ..afterload &contractility changes on ventricular cycle

Factors Regulating the cardiac pumping power



17

: figure A

زيادة في Preload لذلك الـ change في الـ cardiac cycle هو عبارة عن increased preload

الزيادة في preload سببها الـ **venous return** او زيادة في **blood volume** صار مثلاً transfusion of blood

The increase venous return .. increase the preload of the EDV _point 1--

To eject the blood .. the pressure must raise to this new value ; to a greater--
(level during the isovolumic contraction (point 1 to point2

As a consequence of this increase in the afterload ; the blood that is--
????? ejected is less . why

because most of the contractile energy is consumed in raising ventricular _-_
pressure to a greater than normal pressure during isovolumic contraction &
and the pressure remains for ejection is very low ; this lead to a reduction in
ejection Decrease SV

The loop is shifted .. the width of the loop decrease & SV decrease & more--
. blood remains in the ventricle at the end of systole ; more ESV

Point 4 is the ESV & it is shifted to the right ; the ESV increase BUT the--
. width of the loop decrease & SV also reduced

. the ventricular pressure increase--

**بدل ما يكون بنهاية isovolumic يساوي 80 صار 100mmHg .. هذه الزيادة في afterload
أدت إلى نقصان في SV وبالتالي زيادة ESV

*****يعني ESV بدل ما كان 60 صار 80

Figure C

; Increase contractility--

When contractility increase .. the ventricle can generate greater tension &
pressure during systole and it can therefore eject a larger volume of blood
. than normal

NO effect of frank-starling mechanism--

Point 1 is the EDV ; there is an increased contractility due to a positive--
inotropic agent , leading to that ventricular muscle develops a higher tension
, higher velocity of shortening , therefore the ventricle can eject a larger
. volume of blood than normal

The curve is shifted , the width of the loop increase & the cardiac output--
. increase

However; more force of contraction .. more ejection of SV , lead to a^^
. reduction in the ESV

. Point 4 C is the ESV is shifted to the left , because of increased SV--
; The contractility also increased--

. Point 2 to 3 is the contractility or systole & is shifted upward

Slide 18

Factors Affecting Stroke Volume

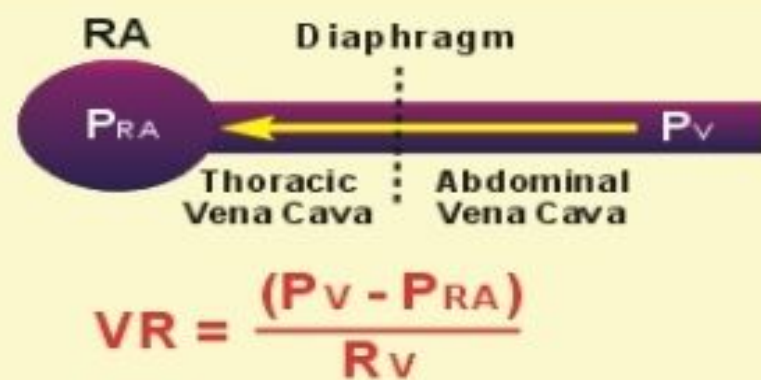
(2) THE VENOUS RETURN (VR)

is a basic determinant of the SV and CO. It acts by affecting the EDV through the Starling law, and its volume is affected by the following hemodynamic factors:

(a) **Venous pressure** (central venous pressure): the VR is directly proportional to it.

(b) **The right atrial pressure (RAP)**: This is normally about 0-2 mmHg and the VR is inversely proportional to it.

(c) **The resistance to the VR (Rv)**: Normally, this is about 1.4 mmHg/liter of blood flow, and the VR is inversely proportional to it.



Hemodynamic factors determining venous return (VR) from peripheral veins to the right atrium (RA). P_v, venous pressure; P_{RA}, right atrial pressure, R_v, venous resistance.

18

. The second factor affecting SV is **venous return**

Venous return : the volume of blood that returns to the heart from different
. parts of the body

Venous return depend on hemodynamic factors which are the physical--
:factors that regulate blood flow or venous return

The pressure & resistance

: We have 2 types of pressure

(venous or central venous pressure (PV --1

Venous return is directly proportioned to this pressure . as venous pressure
. increase , venous return increase

(Right atrial pressure (PRA—2

This pressure is normally 0 up to 2

Venous return is inversely proportionated to this pressure , as RAP increase ,
. venous return decrease

Venous pressure is directly proportional to central venous pressure ,as
. venous pressure increased venous return increased too

The venous resistance or vessel resistance .. this resistance is 1.4 mmHg 1--
, per liter of blood flow

. Venous return is inversely proportional to resistance

.....: Mathematically

VR: venous return

PV: venous or central venous pressure

PRA: Right atrial pressure

RV: venous resistance

$$VR=(PV-PRA)\RV$$

نلاحظ أن هناك علاقة طردية بين P والـ Venous return

كلما كانت p أكثر، كلما كان Venous return أعلى مع ثبات الـ Resistance

▲ More RAP , less P & less Venous return at constant resistance

▲ . More PV ,, more P ,,more VR ,, at constant resistance

More VR ,, more SV ,, more filling & more contraction (more SV & cardiac
(output

factors that increase resistance leads to reduction in venous return and lss
.CO

▲ أي عامل يؤدي إلى زيادة في RAP سيؤدي إلى نقصان في Venous return لان P أقل .
SO; less venous return to right atrium ,, less right ventricle filling ,, less right
ventricle output ,, less pulmonary venous return to left atrium ,, less atrium
filling ,, less ventricular filling ,, less ventricular output ,, less systemic
. return

بعض العوامل التي تؤثر على venous return وهذه العوامل في العادة تؤثر على PV

Slide 19

More blood volume increase venous return So; more EDV & more forceful
. contraction & more SV

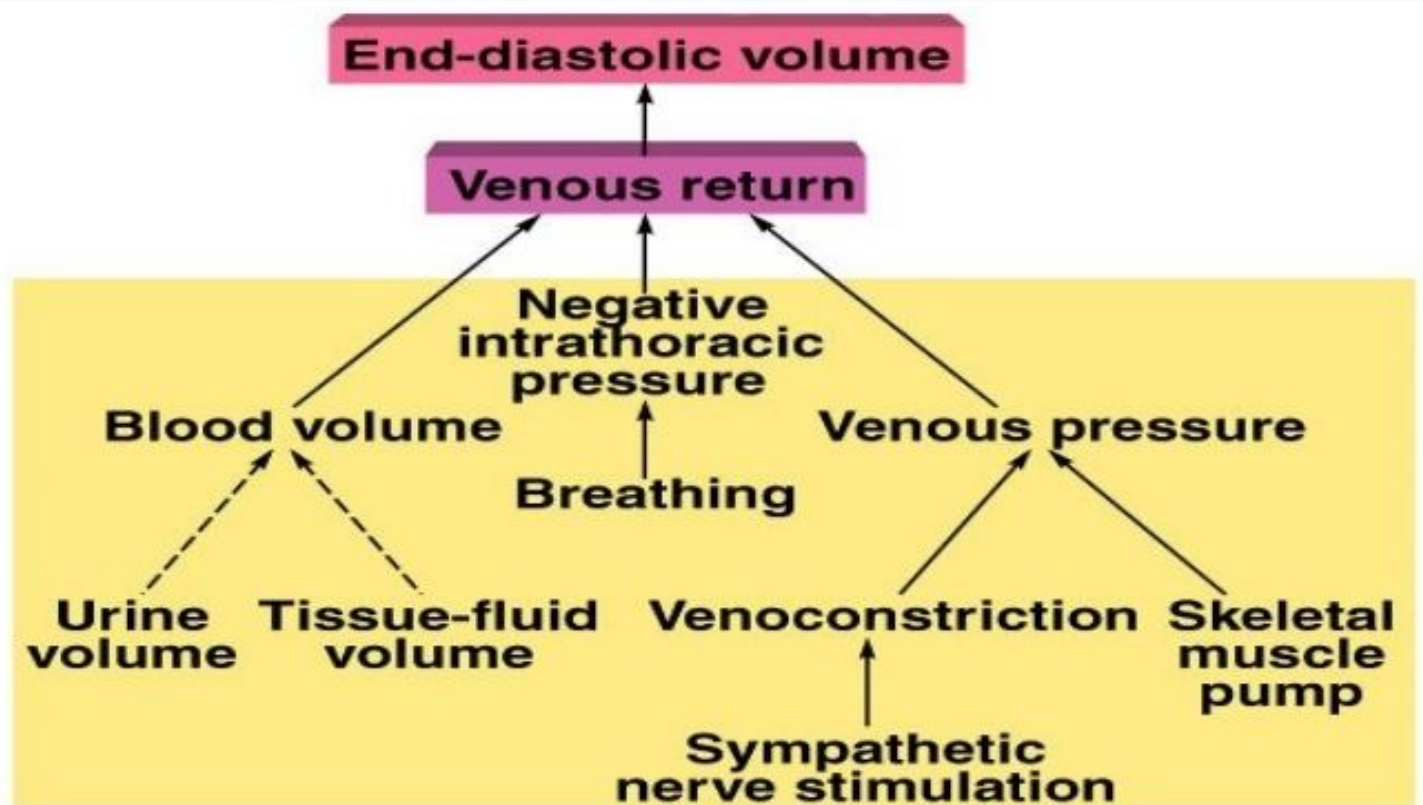
)) ----- Negative intrathoracic pressure

أثناء ال inspiration رح يكون في زيادة في venous return ((

Changes in PV

أي زيادة في PV تؤدي إلى زيادة في venous return وزيادة في venous pressure قد يكون بسببها
sympathetic stimulation which affect veins by veno constriction ,, more
venous pressure also skeletal pump leads to increasing in venous pressure

Other factors that control the venous return



Slide 20

:Skeletal muscle pump

More skeletal pump , more contraction , increase venous return , increase .EDV & force of ventricular contraction & more cardiac output

?????Why

Vein vessels are highly compliant & it has a large capacity , 65% of blood . volume in your body at rest is inside the veins

Most of large veins are surrounded by skeletal muscle , muscle contraction-- ejects the blood from veins toward the heart , more filling & more cardiac . output

. Large veins have valves , distal valves&proximal valve--

When muscle contracts , proximal valves **open** & distal valve **close** ; the-- . blood moves from veins to the heart

. more muscle contraction ,,,, more blood flow,,,,more venous return**

In people who keep long studying during the day , there will reduction in--
venous return because of gravity , the blood is pooling in peripheral tissues
.(veins

the pooling lead to increase in the venous pressure , this excessive venous--
pressure stretches veins especially the veins of the leg & increase the
diameter of the veins , venous valve become incompetent (leakage) , as a
. result of that there will be reduction in venous return

: Torcous veins, bulbs veins--

Vircosed veins .. peripheral pooling of blood , increases venous pressure ,
stretching of veins , accompanied by damage to venous valve so enlargement
.(of veins (varicose vein

Normally; during muscle contraction , the proximal valve opens ; distal valve
. closes , the blood move to the heart

During relaxation ,proximal valve closes; distal valve opens , the blood
. moves to the veins in skeletal region

**من العوامل المؤثرة على venous return هو intrathoracic pressure الذي يحدث نتيجة الـ
breathing خاصة inspiration .

:Respiratory pump--

Inspiration , contraction of diaphragm (the major res. Muscle) ,, increases the
intraabdominal pressure , this will increase the pressure inside the
. abdominal veins & increase in the venous return

.AS we know ; inspiration increase the negatively inside the thorax

This will increase the transmural the pressure & expand the lung &--
. thoracic cage

the negative pressure in the thoracic lead to a reduction in the--
. pressure of the right atrium & vena cava

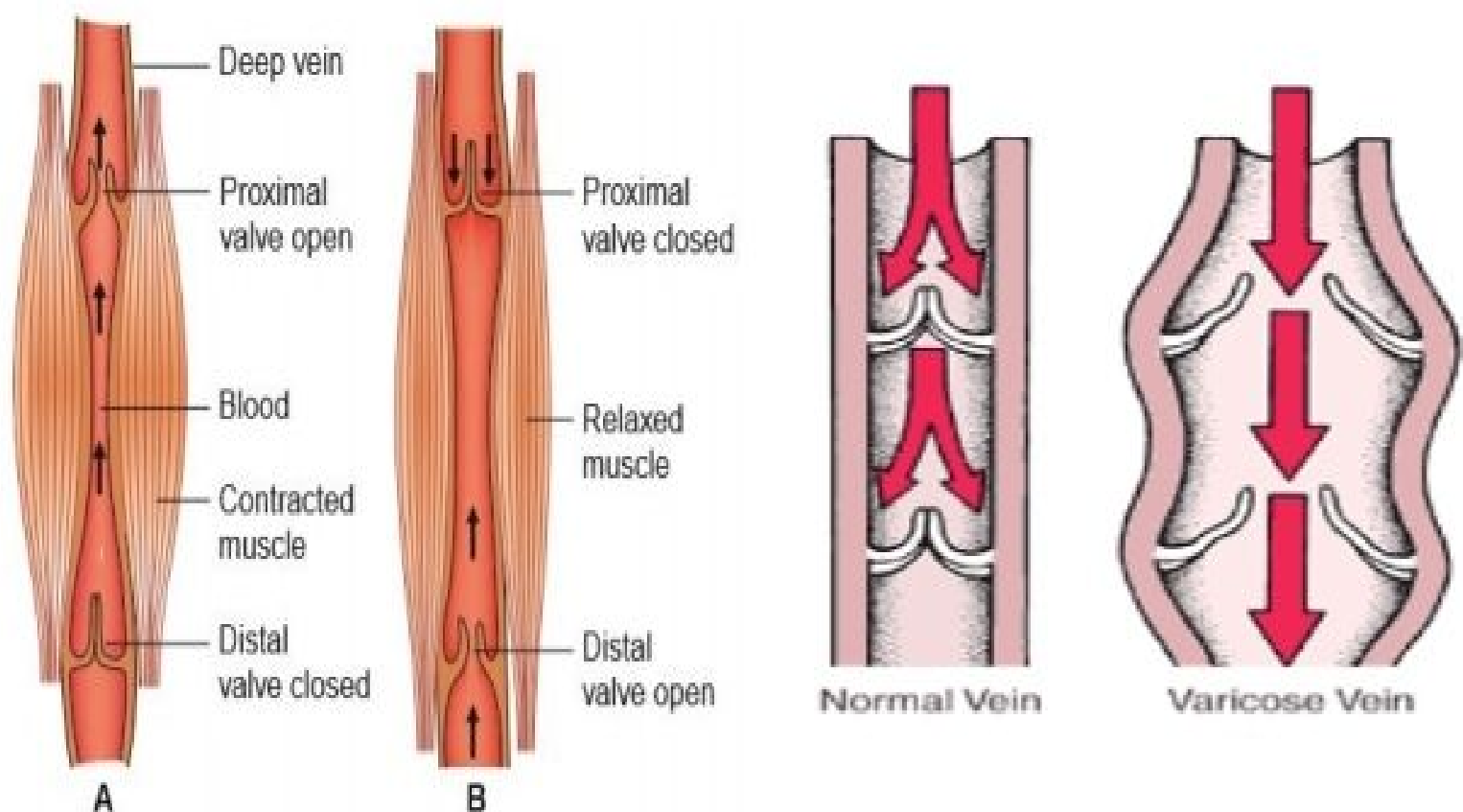
thoracic pressure *حكيما قبل انه اذا كان الـ pleural pressure سالب , رح تكون برضه باقي*
 . zero *ضغطها*

NOW, right atrial pressure & vena cava have negative pressure , P will
increase & venous return increase (venous return depends on P)
(venous pressure minus atrial pressure

Inspiration increases venous return

Factors that control the venous return

Muscle Pump



: Other factors

: Atrial pumping activity

Ventricular filling usually occur passively 15% of ventricular filling at occurs
. by atrial contraction or atrial pump activity

. Atrial pump activity does not contribute significantly to SV

When there is **increase in blood demand** (ex:during exercise) here atrial--
.systole contribute significantly to diastolic volume & SV & cardiac output

.The sympathetic stimulation increase atrial pump activity--

. Ventricular compliance also affect SV

Right figure

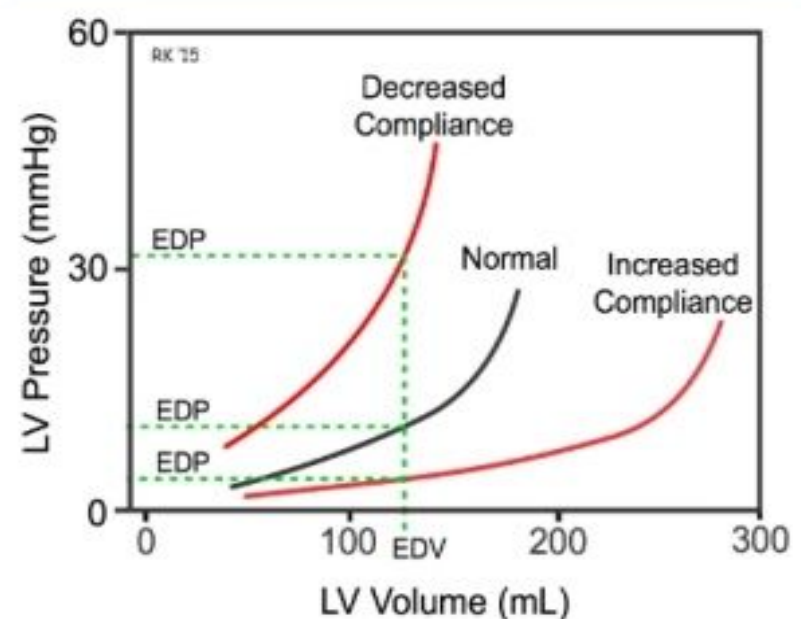
... Ventricular compliance of 3 situations

Other factors affect stroke volume

Atrial Pump Activity:

- The ventricular filling occurs mostly passively. About 15 to 20% of ventricular filling at rest occurs due fo atrial contraction (the atrial pump activity).

Ventricular Compliance



Black curve = normal , if shifted to the left & upward , reduction in compliance the upper curve is decreased compliance curve

If the normal curve is shifted to the right & downward , there will be-- . increase in compliance ,, the lower curve is increased compliance curve

Compliance is the stretchability**

In **RS** , compliance curve (normally) are plotted as the change in volume-- over the change in pressure

$(V \setminus P =$ in the slope (mathematically

lung is more compliance **عند** **معين** , **هذا يعني أن** **كلما كان هناك زيادة في V**

In **CVS** , the compliance curve of ventricle , it is common to plot the change in pressure over the change in volume

$P \setminus V =$ the slope is the reciprocal of compliance

****لأنه كلما زاد الحجم عند ضغط معين , معناها الـ compliance عالية , وهكذا تمثل في العادة الـ compliance curve ولكن في الـ ventricle :**

.. The compliance curve is the relationship between $P \setminus V$

يعني هون الـ slope هو معكوس الـ compliance يعني إذا كان الـ slope عالي معناها الـ compliance منخفضة والعكس .

: Normal curve

X axis is the volume

Y axis is the pressure

As the ventricle volume increase , the pressure within ventricular chambers . which is EDP : the end diastolic pressure ,, passively increase

. If there is increase EDV , the EDP passively increase----

BUT , the relationship is not linear particularly at higher volumes ,the .compliance decrease , the wall become more stiff

زيادة خفيفة في الـ volume تؤدي إلى زيادة عالية في الـ pressure وزيادة في slope وبالتالي نقصان في الـ compliance.

Therefore; ventricular and diastolic pressure EDP is higher at any given EDV if . compliance decreased

لو أخذنا EDV على الخط الأخضر المتقطع نلاحظ انه EDP تزداد إذا هناك نقصان في الـ compliance

عند EDP , الـ EDP ازداد معناها slope ازداد والـ compliance قلت , العكس تماما لما يكون نقصان في الـ EDP عند نفس الـ EDP صار هناك زيادة في الـ compliance لان $EDP \setminus EDV$ في الحالة الثانية الـ slope رح يكون قليل والتالي compliance is higher

The ventricular compliance is determined by structural properties of cardiac . muscle

Ex : muscle fibers , orientation of muscle fibers , connective tissue , compliance of ventricles is also determined by the stat of ventricular . contraction & relaxation

In ventricular hypertrophy , the compliance of ventricles decrease ,ventricle wall become stiff not stretchable , thickness of ventricular wall increases & compliance decreases , therefore ; ventricular end diastolic pressure is higher . at any given diastolic volume

Ventricular muscle maybe compliant, but if there is some restriction to the-- distention of ventricles due to external pressure EX: pericardial effusion .. tomponade , this leads to reduction in EDV compliance or stretch ability .decrease

Dilated cardiomyopathy , the ventricles are very dilated , No appreciable-- thickening of the wall ,, the wall is not thickened , the compliance here increase & EDV is high ,But EDP is not high because the contractility is very . weak

**العوامل التي تؤثر على Ventricular compliance هي : pericardial effusion ,
ventricular hypertrophy , dilated cardiomyopathy

A Summary of the Factors Affecting Cardiac Output

