Department of Anesthesia Techniques

Patient Monitoring in ICU

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Monitoring definition

- Interpreting تفسير available clinical data to help recognize يشخص present or future mishaps حوادث or unfavorable system conditions

Monitoring goals

- **Enhances** (but not replaces) the vigilance اليقظة of the intensivist.
- **Provides means** to assess physiological function.
- **Provides information** that improves the safety of patient.

Monitoring guidelines

- **Qualified personnel** should be present in the ICU
- **Physical examination**, **Assessment** & Diagnosis remain the most important tools available to the intensivist

Basic Monitoring :

1) **Oxygenation**

2) **Ventilation**

3) **Circulation**

4) **Temperature**

1) Oxygenation monitoring

- Objective: To ensure adequate oxygen concentration in the delivered gas and in the blood.

Methods

1) Clinical: color, respiratory pattern (rate, rhythm, depth, etc.), equal air entry, wheezing, crackles.

2) Delivered gas: the concentration of oxygen in the patient breathing system shall be measured by an oxygen analyzer.

3) Blood oxygenation: a quantitative method of assessing oxygenation such as pulse oximetry and ABGs show PaO2.

2) Ventilation monitoring

A. Every patient should have the adequacy of ventilation continually evaluated.

1) Clinical signs such as chest movement and auscultation of breath sounds

2) ABGs show $PaCO_2$ Continues end-tidal carbon dioxide analysis

* Monitoring of the volume of expired gas is strongly encouraged in mechanically ventilated patients.

B. In mechanical ventilator, there shall be in continuous use a device that is capable of detecting disconnection of components of the breathing system.

The device must give an audible signal.

3) Circulation

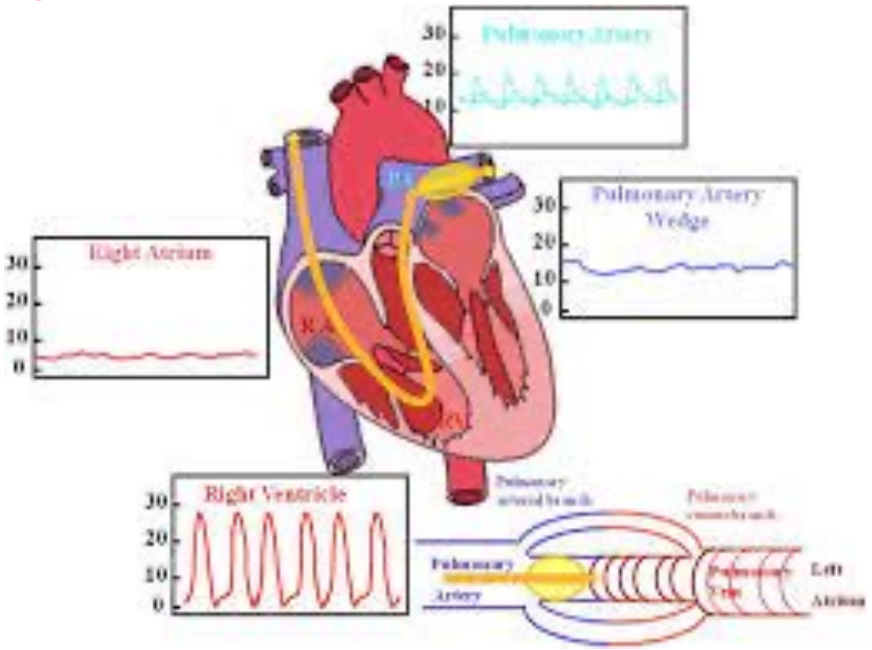
- clinical evaluation methods like
  - Palpation of a pulse
  - Auscultation of heart sounds
- Oximetry
- ECG continuously.
- BP and HR determined and evaluated at close intervals.

Other used monitors:

- Temperature [pharyngeal, axillary, esophageal]
- Urine output
- Central venous line: measuring CVP
- Arterial line:
  - Continuous BP monitoring
  - Easy access allowing for frequent ABGs

Less frequently used monitors:

- Swan-Ganz catheter, PCWP(pulmonary artery capillary wedge pressue) : pulmonary artery pressures, cardiac output
- ICP(intracranial pressure) monitoring
- EEG (electroencephalograph)
- Transesophageal echocardiography (TEE)



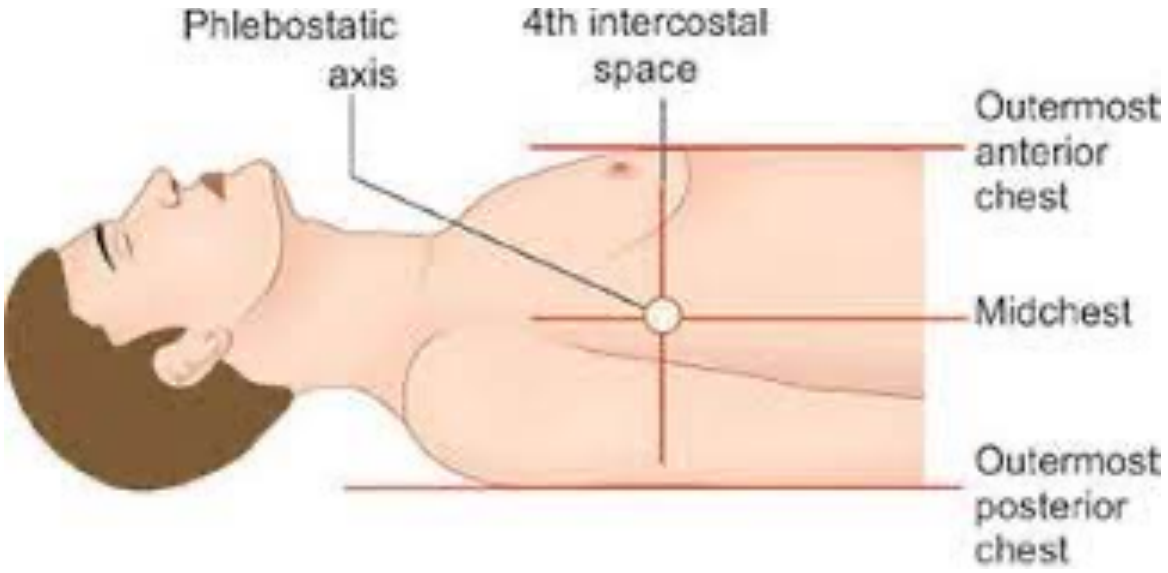

Transesophageal echocardiogram
Esophagus
Transducer

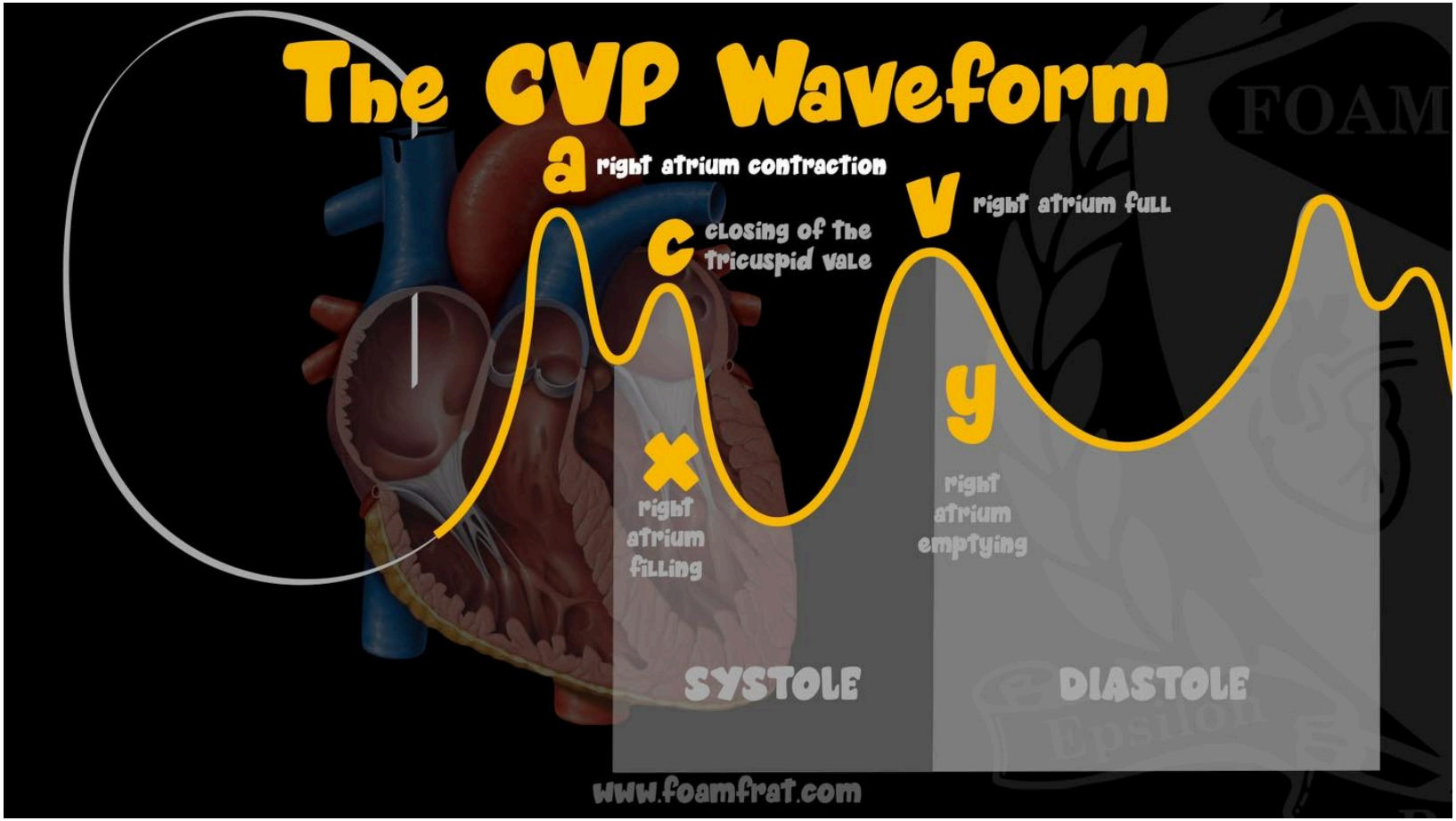
Central venous pressure (CVP)

Is the pressure recorded from the right atrium or superior vena cava and is representative of the filling pressure of the right side of the heart.

MEASUREMENT

- recorded at the end of expiration
- measured by transducing the waveform of a central venous line
- electronic transducer placed & zeroed at the level of the RA (the "hemostatic axis" phlebostatic axis – usually the 4th intercostal space in the mid-axillary line is used)


Phlebostatic axis
4th intercostal space
Outermost anterior chest
Midchest
Outermost posterior chest


The CVP Waveform
a
right atrium contraction
c
closing of the tricuspid vale
v
right atrium full
x
right atrium filling
y
right atrium emptying
SYSTOLE
DIASTOLE
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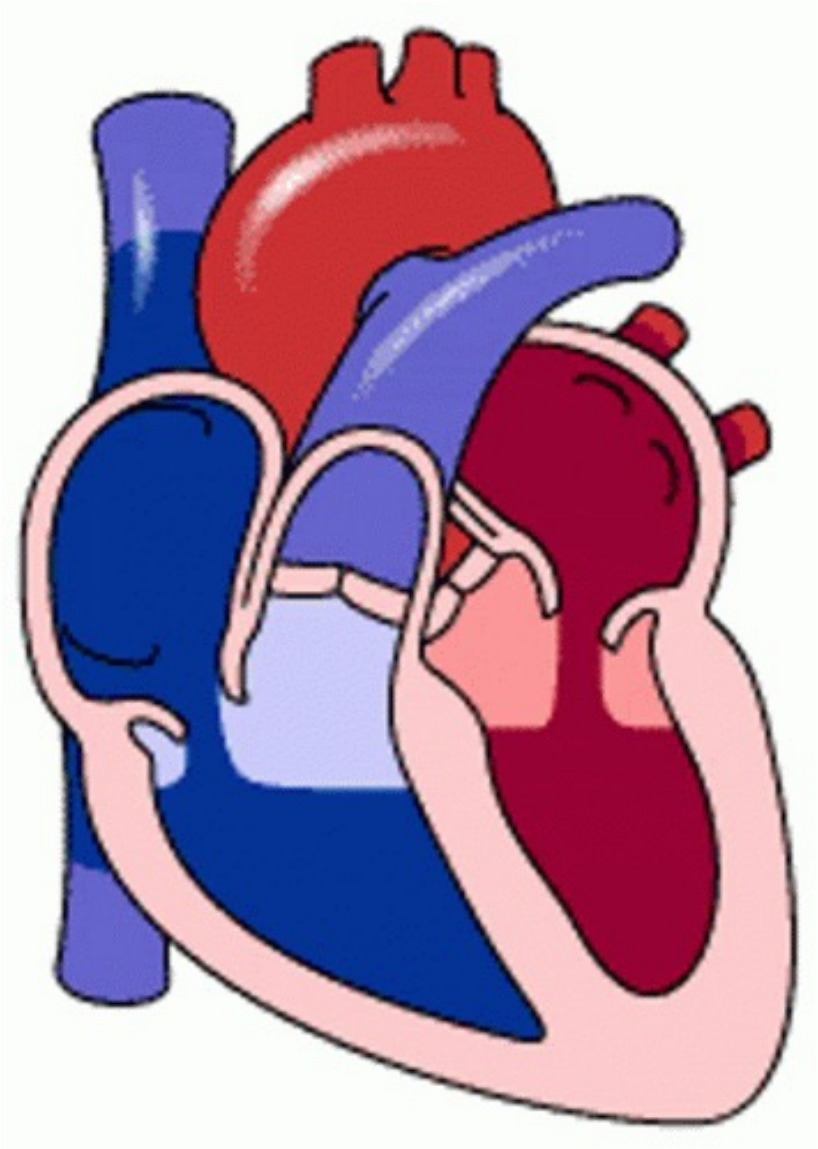
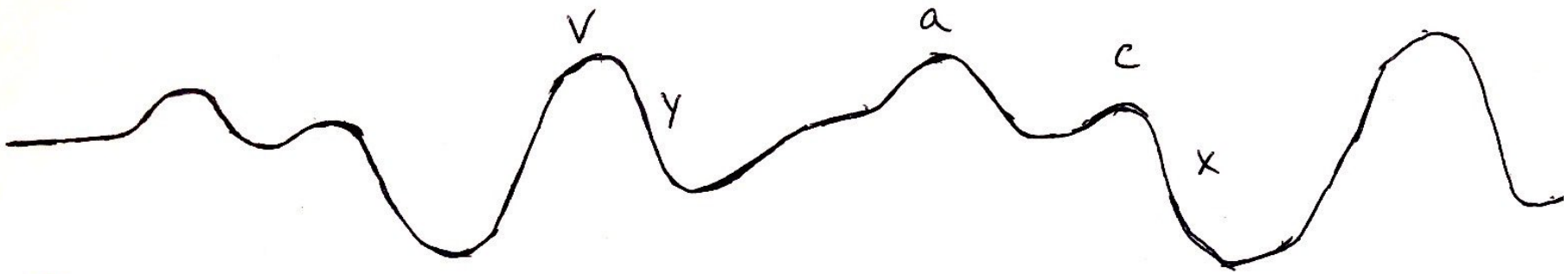
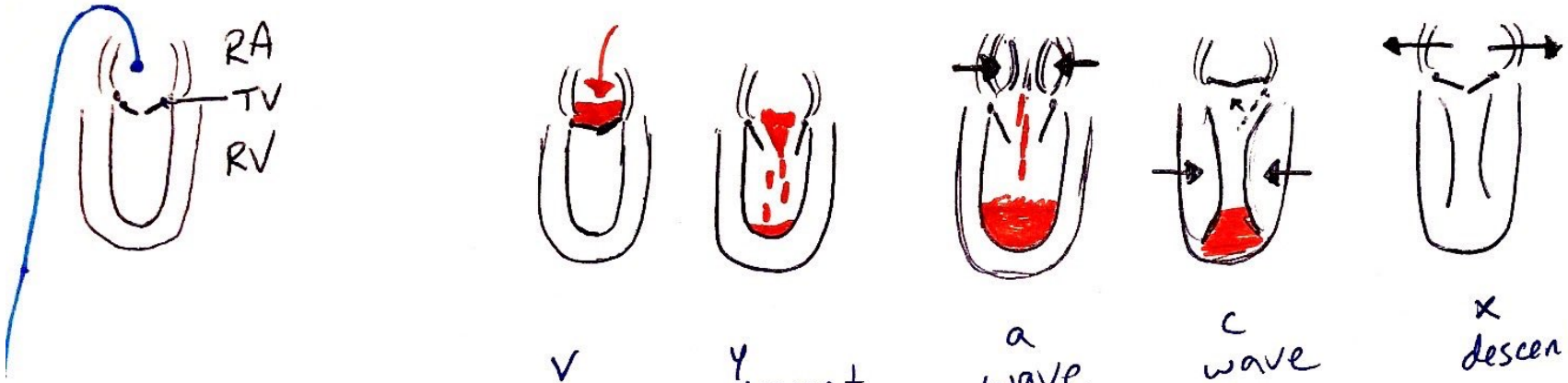






v wave

- venous filling of RA

y descent

- TV opens
- RA empties into RV

a wave

- atrial contraction

c wave

- ventricular contraction with closure of TV

x descent

- atrial relaxation

CVP WAVEFORM

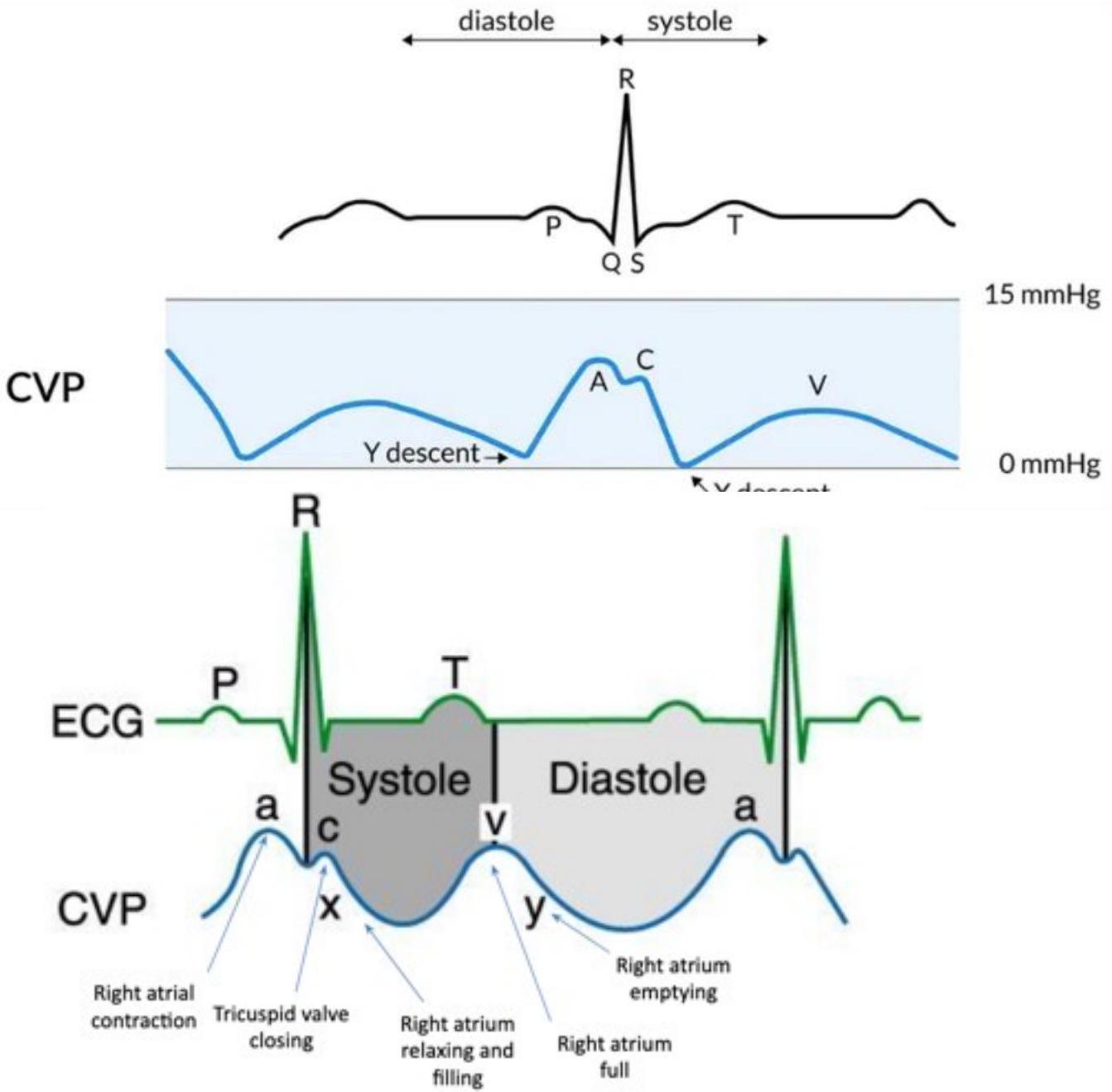
a = atrial contraction

c = closing and bulging of the tricuspid valve

x = atrial relaxation, with downward movement of the tricuspid valve during ventricular contraction

v = passive filling of atrium (tricuspid valve still closed)

y = ventricular filling with opening of the tricuspid valve


diastole
systole
R
P
T
Q S
15 mmHg
CVP
A
C
V
Y descent
0 mmHg
R
ECG
P
T
Systole
Diastole
a
c
v
a
CVP
x
y
Right atrial contraction
Tricuspid valve closing
Right atrium relaxing and filling
Right atrium full
Right atrium emptying

USES:

Value and waveform assist with diagnosis of:

1. Right ventricular infarction
2. Right heart failure and cor pulmonale
3. Tamponade
4. Tricuspid regurgitation or stenosis
5. Complete heart block
6. Constrictive pericarditis

CAUSES OF RAISED CVP

1. Right ventricular failure
2. Tricuspid stenosis or regurgitation
3. Pericardial effusion or constrictive pericarditis
4. Superior vena cava obstruction
5. Fluid overload
6. Hyperdynamic circulation
7. High PEEP settings

CAUSES OF low CVP

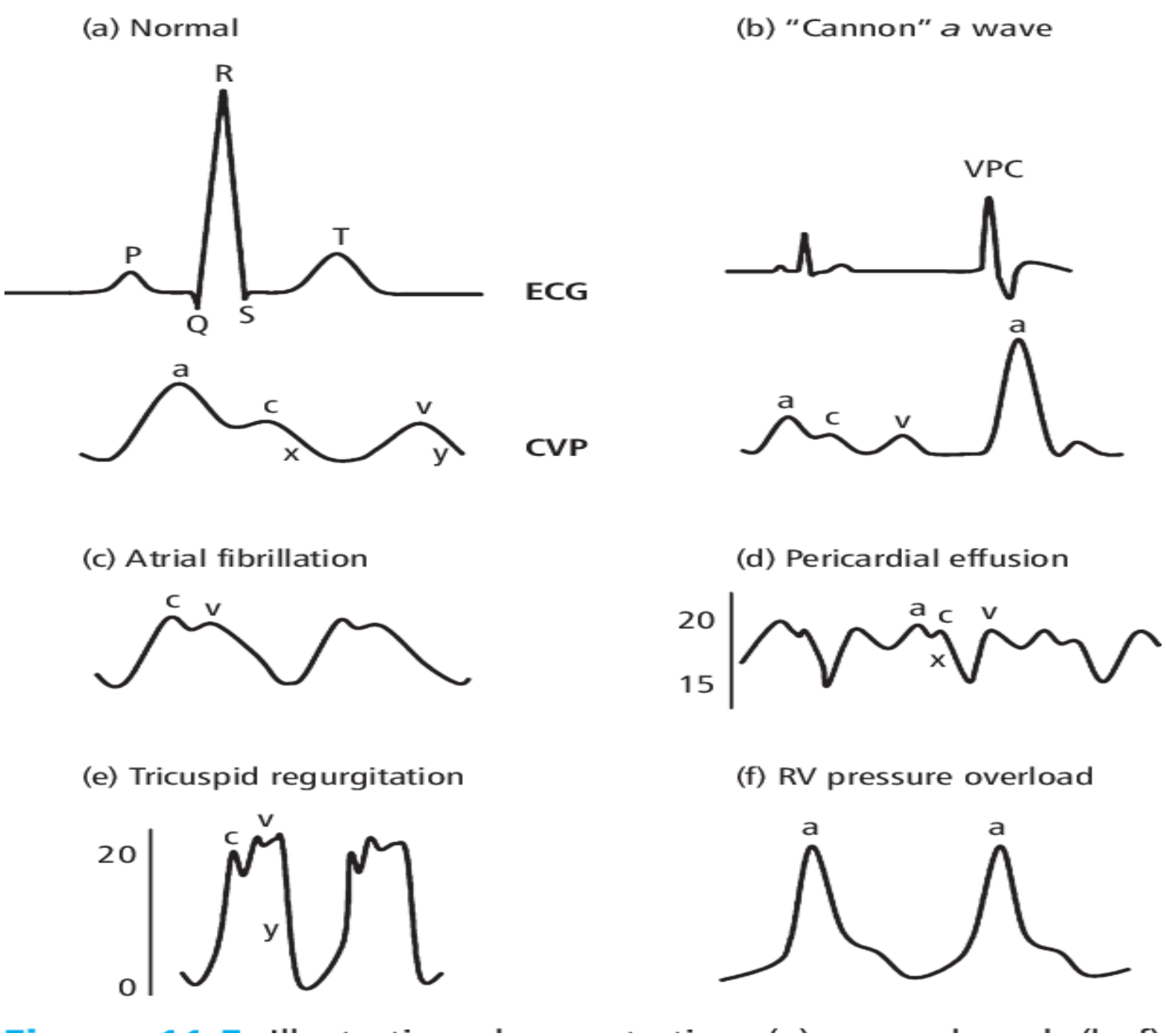
1- hypovolemia or vasodilation. Either of these would decrease venous return and thus decrease the CVP

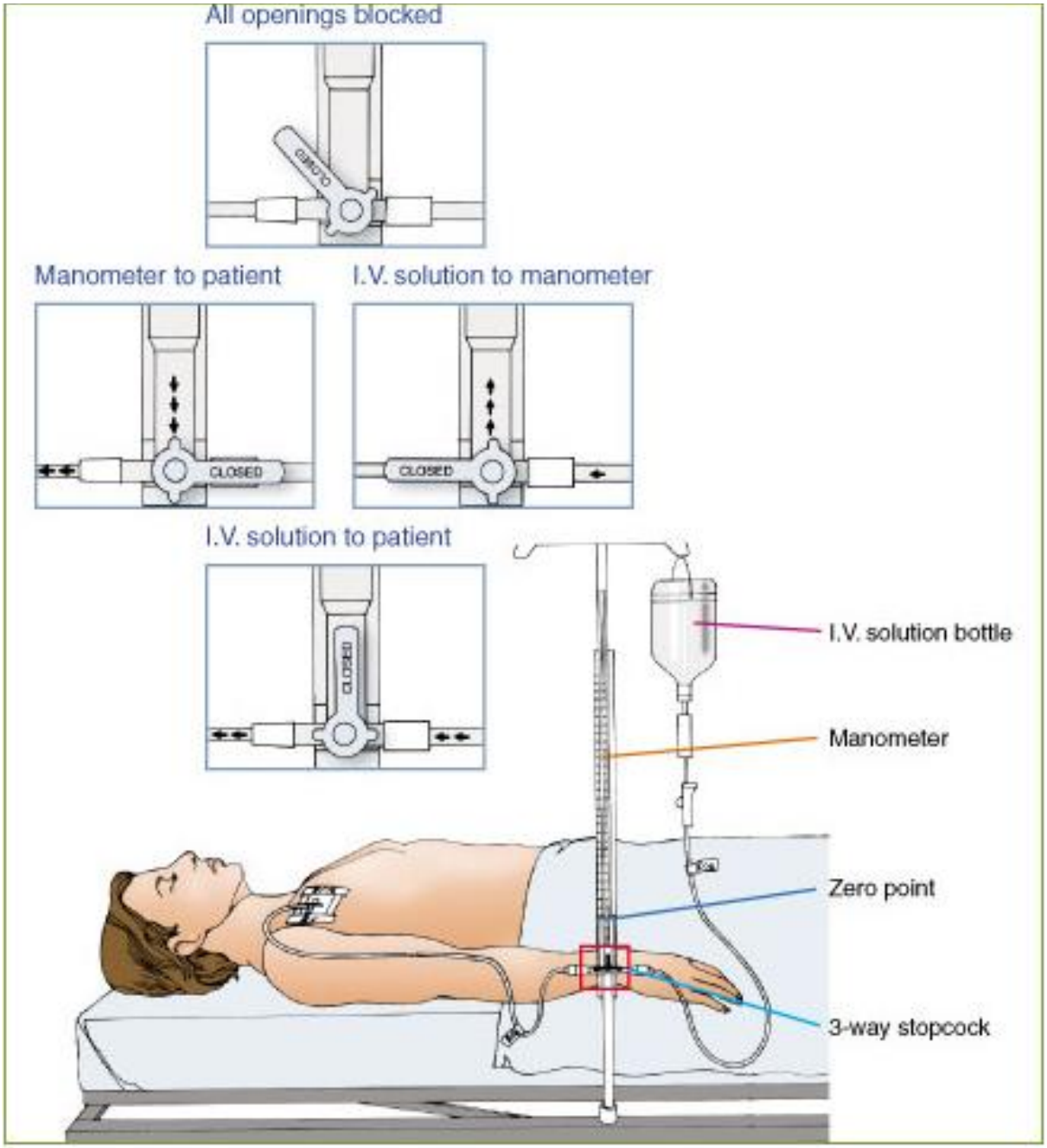
- A decrease in CVP is noted when there is more than 10% of blood loss or shift of blood volume.

2- decrease in intrathoracic pressure caused by forced inspiration causes the vena cava to collapse which decreases the venous return and, in turn, decreases the CVP

CVP WAVEFORM ANALYSIS

- Dominant a wave – pulmonary hypertension, tricuspid stenosis, pulmonary stenosis
- Cannon a wave – complete heart block, ventricular tachycardia with atrio- ventricular dissociation
- Dominant v wave – tricuspid regurgitation
- Absent x descent – atrial fibrillation
- Exaggerated x descent – pericardial tamponade, constrictive pericarditis
- Sharp y descent – severe tricuspid regurgitation, constrictive pericarditis
- Slow y descent – tricuspid stenosis, atrial myxoma
- Prominent x and y descent – right ventricular infarction


(a) Normal
R
P
T
Q
S
ECG
a
c
v
x
y
CVP
(b) "Cannon" a wave
VPC
a
a
c
v
(c) Atrial fibrillation
c
v
(d) Pericardial effusion
20
15
a
c
v
x
(e) Tricuspid regurgitation
20
0
c
v
y
(f) RV pressure overload
a
a


All openings blocked
CLOSED
Manometer to patient
CLOSED
I.V. solution to manometer
CLOSED
I.V. solution to patient
CLOSED
I.V. solution bottle
Manometer
Zero point
3-way stopcock

Airway / Respiratory Axis

1. Oxygenation
2. Ventilation
3. Correct ETT placement
4. ETT cuff pressure (keep between 20-30 cm H2O)
5. Airway pressure

Respiratory Monitoring

- Various alarms by the ventilator:
  - Low airway pressure: leakage, disconnection.
  - High airway pressure: kink, biting of the tube, blocked tube, bronchospasm.
  - Low expired tidal volume: leakage.
  - Apnea alarm: disconnection.
  - O2 sensor failure:
  - Flow sensor failure:
- NEVER ignore an alarm by the ventilator!

PEAK INSPIRATORY PRESSURE (PIP)

Depends on:

- Airway resistance (Raw)
- lung compliance (Cl).

During controlled ventilation look for

increase airway resistance (e.g. bronchospasm, kinked ETT)

decrease in pulmonary compliance (e.g., pulmonary congestion).

Oxygenation and ventilation

1-Pulse oximetry (vital sign for Oxygenation)

– Measures O2 saturation in blood

2- Capnography (vital sign for ventilation &perfusion)

– Measures CO2 in the airway

– Provides a breath-to-breath status of ventilation

Cardiovascular Axis

1. Arterial Blood Pressure
2. Electrocardiography (ECG)
3. Central Venous Catheterization
4. Pulmonary Artery Catheterization
5. Cardiac Output:
   - Thermodilution
   - Dye Dilution
   - Pulse Contour Devices
   - Esophageal Doppler
   - Fick Principle
   - Echocardiography
   - Thoracic Bioimpedance

Electrolyte / Metabolic Axis

1-Fluid balance

2- Sugar

3- Electrolytes

4- Acid-base balance

5- Nutritional status

Visual Monitoring

- Respiratory: patient color, respiratory pattern (accessory muscle use etc.)
- Patient monitor numbers and waveforms
- Bleeding/coagulation
- Diaphoresis / movements
- Line quality (is my IV reliable?)
- Positioning safety review

Clinical tips

- ALWAYS remember that your clinical sense & judgement is superior to any monitor.
- If a monitor gives an abnormal value, such as low oxygen saturation, Check the patient first then the equipment.
- Know where the defibrillator is kept in the unit and how it works
- All 1 ml ampoules look the same (check very carefully)
- Always label all syringes

Selects the best single choice

1- Alarms in ICU ventilator (all true except one)

a) Low airway pressure: leakage,
b) High airway pressure: disconnection.
c) Low expired tidal volume: leakage .
d) Apnea alarm: disconnection .
e) O2 sensor failure: (unfortunately common in many of our ventilators)

2- PEAK INSPIRATORY PRESSURE (PIP) (all true except one)

a. Depends on airway resistance(Raw)
b. Not affected by lung compliance (Cl) .
c. During controlled ventilation look for increase airway resistance
d. Increased by bronchospasm
e. Increased by kinked ETT

3- All the following are for circulation monitoring except one

a) Urine output

b) Central venous line: measuring CVP

c) Arterial line Invasive BP mentoring :

d) ECG

e) Glasgow coma scale

4- Causes of high CVP

a) Right ventricular failure

b) Pericardial effusion

c) Superior vena cava obstruction

d) Fluid overload

e) low PEEP settings

5- Waveform abnormalities of CVP and specific pathologies (all true except one)

a) Dominant a wave – pulmonary embolism

b) Cannon a wave – complete heart block

c) Dominant v wave – tricuspid regurgitation

d) Absent x descent – atrial fibrillation

e) Exaggerated x descent – pericardial tamponade