

Hemodynamics

Critical Thinking
and the
NBRC Exams

And maybe some other stuff too...

Critical Thinking (NOT)

Thinking Critically

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“Carefully exploring the thinking process to clarify our understanding and make more intelligent decisions.”

Thinking Critically About Problems

1. What is the *problem*?
2. What are the *alternatives*?
3. What are the *advantages/disadvantages* of each alternative?
4. What is the *solution*?
5. How well is the solution *working*?

Thinking Critically About Problems (in NBRC Speak)

1. What is the *problem (Item)*?
2. What are the *alternatives (Options)*?
3. What are the *advantages/disadvantages* of each alternative (*Key vs Distractors*)?
4. What is the *solution (Key)*?
5. How well is the solution *working*?

Thinking Critically About Problems

1. What is the *problem*
 - *What EXACTLY do they want to know?*
 - *Look for keywords:* First, Best, Except
 - Evaluate the data for “normalcy”
 - Evaluate the variations from normal – patterns?
 - Try to answer the question before you look at the options
2. What are the *advantages/disadvantages* of each alternative?
 - How do the options fit, or not fit, the identified patterns?
3. What is the *solution*?
 - OK, OK, maybe you don't like any of the options, too bad, pick one!
4. How well is the solution *working*?
 - Do a quick “reality check”.

Types of NBRC Questions

- **Recall**
 - Something you (better have) memorized
- **Application**
 - Interpret a limited data set
- **Analysis**
 - Evaluating a variety of data to determine best response

Recall

Cardiac index is calculated from cardiac output and

1. Mean arterial pressure
2. Systemic vascular resistance
3. Body surface area
4. Pulmonary vascular resistance

Recall

Normal left ventricular preload pressure is

1. 0 – 6 mm Hg
2. 4 – 12 mm Hg
3. 18 – 22 mm Hg
4. 80 – 120 mm Hg

Recall

Cardiogenic pulmonary edema is typically associated with

1. CVP < 5 mm Hg
2. PCWP > 18 mm Hg
3. Heart Rate < 60 beats/min
4. Cardiac Index > 4.0 L/min/m²

Recall

Normal mixed venous oxygen saturation is

1. 20-25%
2. 45-50%
3. 70-75%
4. 95-100%

Application

Now we need a bit of critical thinking...

Application

An adult patient with a cardiac output of 6 L/min, a heart rate of 100 beats/min and a body surface area of 2 m² has a cardiac index of

1. 3 L/min/m²
2. 12 L/min/m²
3. 21 L/min/m²
4. 60 L/min/m²

Formula?

Reality Check?

Normal Range:

- 2.5 to 4.0 L/min/m²

Application

An adult patient with a systolic blood pressure of 120 mm Hg and a diastolic blood pressure of 80 mm Hg has a mean blood pressure of

1. 80 mm Hg
2. 90 mm Hg
3. 100 mm Hg
4. 120 mm Hg

1. Formula?

[Systolic + (2 x diastolic)] / 3

2. Math skills

Application

Hemodynamic assessment of an adult ICU patient reveals the following data

- PA – 42/26 mm Hg
- PCWP – 14 mm Hg

Based on this data, the patient has an increased

- | | |
|----------------------------------|--------------------------|
| 1. Systemic vascular resistance | PA = Very High |
| 2. Intrapulmonary shunt | PCWP = Schooch High |
| 3. Pulmonary vascular resistance | Normal: PCWP ~ PA Diast. |
| 4. Alveolar minute ventilation | ↑ Gradient = ↑ SVR |

Assessment

Analysis

Now we really need some of that critical thinking mojo!

For example...

Analysis

Assessment of an adult ICU patient ventilated for respiratory failure reveals the following data:

- HR – 124
- BP – 82/64
- CVP - 5
- PCWP – 24
- PA – 42 / 25
- SvO₂ – 80%
- CI – 1.8 l/min/m²

Question:

Which data point should be re-assessed?

What is the problem?

- “Which data point should be re-assessed?”
 - Code for “one of these things is not like the other”
 - Why?
 - Acquisition error
 - Transcription error
 - Device malfunction
 - Calibration, etc.
 - So, let’s see if we can figure it out BEFORE we look at the options...

The Data: Normal or Abnormal?

Recall

- HR – 124
- BP – 82/64
- CVP - 5
- PCWP – 24
- PA – 42 / 25
- SvO2 – 80%
- CI – 1.8 l/min/m2
- Abnormal, High
- Abnormal, Low
- Normal
- Abnormal, High
- Abnormal, High
- Abnormal, High
- Abnormal, LOW

The Data: Assessment of Variance

Application

- HR – 124
- BP – 82/64
- CVP - 5
- PCWP – 24
- PA – 42 / 25
- SvO2 – 80%
- CI – 1.8 L/min/m2
- Bad heart
- Bad heart
- OK
- Yikes! BAD HEART
- Bad heart
- Good heart????
- Double yikes!
- Cardiac shock

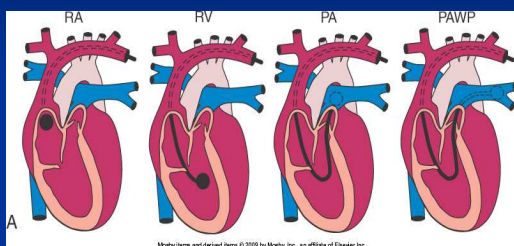
SvO2

- Reveals the *balance between oxygen consumption and oxygen delivery*
- Normal value ~ 70 – 75%
 - Deliver 1,000 ml/min; consume 250; 750 remains
- Cut CO by 50%, SvO2 drops to 50%
 - Deliver 500 ml/min; consume 250; 250 remains
- So, how can I have a value of 80% when all other indicators say poor cardiac output???

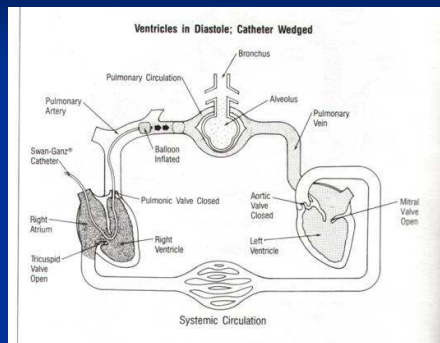
SvO2

- By definition: blood from the pulmonary artery
 - If I want to know the average oxygen usage of the whole body I need to see blood from all sites mixed together (by RV).
- Therefore, a PA catheter (Swan-Ganz) is required for sampling.

Pulmonary Artery Catheters



PA Catheter Diagram



Sampling from PA Catheter

- Insure the catheter is in the proper position and is not wedged
 - If the catheter is “wedged”, oxygenated blood will be aspirated backward from the gas exchange portions of the lung!
- Slowly aspirate the sample from the distal port
 - If the catheter is “almost” wedged, rapid aspiration will vacuum oxygenated blood from the gas exchange portion of the lung!

Big Picture

- We needed to identify a data point that should be re-assessed (doesn't fit).
- Evaluation of the data revealed the SvO2 measurement indicates high CO versus low CO for most other data points.
- High SvO2 measurements are possible in a low CO situation if a sampling error occurs.
 - Therefore, SvO2 should be “re-assessed” (more carefully this time)

Now we can peek at the options!

Assessment of an adult ICU patient ventilated for respiratory failure reveals the following data:

- HR – 124
- BP – 82/64
- CVP – 5
- PCWP – 24
- PA – 42 / 25
- SvO2 – 80%
- CI – 1.8 l/min/m2

Which data point should be re-assessed?

1. HR
2. PCWP
3. CI
4. SvO2

Hemodynamic Assessment

Is essential to management of mechanical ventilation

You are asked to perform an optimal PEEP study on an adult, mechanically ventilated patient with ARDS. Results of the study are below.

PEEP	FiO2	SpO2	BP	SvO2	CO
5	0.6	89	130/91	58	5
10	0.6	92	129/88	64	5.0
15	0.6	96	127/86	73	5
20	0.6	98	110/75	68	4

Goals of PEEP

- Alveolar recruitment
 - Reduces intrapulmonary shunt fraction
 - Improve Oxygen Delivery (PaO2/SaO2/CO)
 - Avoid toxic levels of O2
 - BUT, there are potential hemodynamic complications
- Airway “Stenting” (in ARDS)
 - Reduces early closure of airways
 - Identified with a pressure-volume loop
 - Low inflection point sets minimum target

Our statement only has oxygen delivery data so that's the goal we should shoot for

PEEP	FiO2	SpO2	BP	SvO2	CO
5	0.6	89	130/91	58	5
10	0.6	92	129/88	64	5.0
15	0.6	96	127/86	73	5
20	0.6	98	110/75	68	4

Oxygen Delivery

- O2 Delivery = O2 Content x CO
 - Oxygen Content
 - PaO2 / SaO2
 - Hemoglobin
 - Cardiac Output
 - Heart Rate
 - Stroke Volume

PEEP Management

- Increase the PEEP until maximal oxygen delivery is obtained.
- Or, in plain language:

Crank it until something bad happens!

Then go back a step

Assessment

PEEP	FiO2	SpO2	BP	SvO2	CO
5	0.6	89	130/91	58	5.0
10	0.6	92	129/88	64	4.9
15	0.6	96	127/86	73	5.0
20	0.6	98	110/75	68	4.1

Assessment

PEEP	FiO2	SpO2	BP	SvO2	CO
5	0.6	89	130/91	58	5.0
10	0.6	92	129/88	64	4.9
15	0.6	96	127/86	73	5.0
20	0.6	98	110/75	68	4.1

Assessment

PEEP	FiO2	SpO2	BP	SvO2	CO
5	0.6	89	130/91	58	5.0
10	0.6	92	129/88	64	4.9
15	0.6	96	127/86	73	5.0
20	0.6	98	110/75	68	4.1

Assessment

PEEP	FiO2	SpO2	BP	SvO2	CO
5	0.6	89	130/91	58	5.0
10	0.6	92	129/88	64	4.9
15	0.6	96	127/86	73	5.0
20	0.6	98	110/75	68	4.1

Bad things happened at a PEEP of 20 cm H2O

Therefore, a PEEP of 15 cm H2O would be optimal

Not all hemodynamic questions

Are directly about hemodynamics...

Hemodynamics in Analysis

- ABG results from an adult patient are
 - pH – 7.35
 - PaCO₂ – 46 torr
 - PaO₂ – 41 torr
 - Bicarb – 24 mmol/L
- Other data available are:
 - HR – 72
 - BP – 118 / 78
 - RR – 18 breaths/min
 - 28% air entrainment mask
- The therapist should recommend:
 - Not yet! Remember, evaluate the data first!

Synthesis: Normal or Not?

- ABG results from an adult patient are

■ pH – 7.35	Normal
■ PaCO ₂ – 46 torr	Abnormal, High
■ PaO ₂ – 41 torr	Abnormal, Low
■ Bicarb – 24 mmol/L	Normal
- Other data available are:

■ HR – 72	Normal
■ BP – 118 / 78	Normal
■ RR – 18 breaths/min	Normal
■ 28% air entrainment mask	Max PAO ₂ ~ 160 torr, A-a gradient @ 120 torr, anyone for a P/F ratio?

Synthesis: Analysis

- Admit it, you looked at the ABG and freaked.
- OMG, non-rebreather STAT!
- This is why I didn't want you to look at the options too soon; the first two are:
 - Increase the FiO₂ to 50%
 - Change to a non-rebreather
 - Don't fall for the trap!

Now you should look at the options...

Options

■ The therapist should recommend:

- Increase the FiO₂ to 50%
- Change to a non-rebreather
- Intubation and ventilation
- Redraw the ABG

Hemodynamics as Obfuscation

An adult patient undergoing a cardiac cath presents the following data

- Hemodynamics
 - CVP – 8 mm Hg
 - PA – 37/24 mm Hg
 - PCWP – 8 mm Hg
 - BP – 110 / 72 mm Hg
- AGB's on 21% O₂
 - pH – 7.45
 - PaCO₂ – 36 torr
 - PaO₂ – 51 torr
 - Bicarb – 23 mmol/L

Based on this information, the therapist should initiate

1. Inhaled Nitric Oxide
2. Nebulized Prostacyclin
3. Intravenous Sildenafil
4. Supplemental Oxygen

Data Assessment

An adult patient undergoing a cardiac cath presents the following data

- Hemodynamics
 - CVP – 8 mm Hg
 - PA – 37/24 mm Hg
 - PCWP – 8 mm Hg
 - BP – 110 / 72 mm Hg
- AGB's on 21% O₂
 - pH – 7.45
 - PaCO₂ – 36 torr
 - PaO₂ – 51 torr
 - Bicarb – 23 mmol/L

- High, Mild
- High, Moderate
- Normal
- Normal, lowish
- Normal
- Normal
- Low, moderate
- Normal

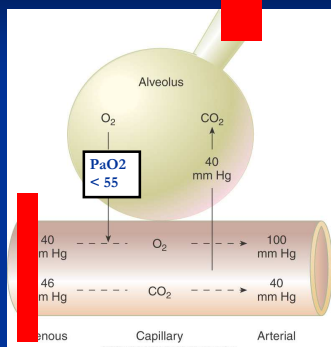
Data Analysis

An adult patient undergoing a cardiac cath presents the following data

- Hemodynamics
 - CVP – 8 mm Hg
 - PA – 37/24 mm Hg
 - PCWP – 8 mm Hg
 - BP – 110 / 72 mm Hg
- AGB's on 21% O₂
 - pH – 7.45
 - PaCO₂ – 36 torr
 - PaO₂ – 51 torr
 - Bicarb – 23 mmol/L

- A little extra fluid
- Pulmonary Hypertension
- Normal – no CHF - ↑ **SVR**
- Normal
- Normal
- Normal
- **Hypoxemia**
- Normal

Hypoxic Pulmonary Vasoconstriction

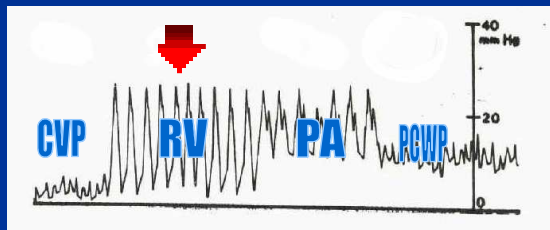


The Treatment for Hypoxemia is?

Based on this information, the therapist should initiate

- Inhaled Nitric Oxide
- Nebulized Prostacyclin
- Intravenous Sildenafil
- Supplemental Oxygen

Know your PA Pressures!



Questions?