Take it to the Limits: Strategies to Fine-Tune Your Donor (*an 'interactive' presentation')*

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Persistence…

Give it up, man...no matter how hard you try, you still can't dance!

Questions to run on:

- *How can I use the monitoring 'tools' at my disposal to optimize my donor?*
- *How can I apply the basic science of oxygen delivery and consumption to increase organ yield?*

Imagine you are on referral call:

- 32 y/o female presented to outside hospital with c/o headaches increasing in past 3 weeks10 mo post partum.
- Diagnosed with Sagittal Sinus Thrombosis and transferred to the neurosurgeon at tertiary referral center
- Arrested in flight on transfer; intubated en-route and presents to ED hypothermic, hypotensive, hyperglycemic and anuric with fixed, dilated pupils.
- 3 pressors to get SBP to 90
- Family has not yet arrived. (They last saw her walking and talking and are driving to the facility).

First labs

- ABG (100%): 6.96/30/9/-13/**78**
- Na – 164; K – 5.4; **BS – 623**
- Cr – 2.7
- H/H – 16/48, plt – 528, INR – 2.7
- Vitals: (on w/o neo, 15 u/kg/min DA, Levo started) T- 93.1(r), B/P-100/52; HR – 122 (ST)
- The ED ward clerk is calling the OPO with this information because the GCS of 3 triggers their protocol for early notification from the ED.

Questions

- *What are your thoughts on the possibility of this lady being an organ donor?*
- *Do you rule her out because she is unstable?*
- *Do you rule out because the situation is too disastrous and the family has '…been through too much already?'*
- *Is this lady in shock? If so, what type?*

Comments

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Definition of Shock

- *Shock occurs when the supply of oxygen and nutrients are inadequate to meet cellular metabolic demands*

Types of Shock

- Hypovolemic
- Cardiogenic
- Distributive
  - Neurogenic
  - Septic
  - Anaphylactic

Jail Warden Exercise

- Warden of a Jail
- 'Bad Benny' Barrymore sent to solitary confinement for 2 months.
- Only access is through a slit window open on one side at a time.
- You are to determine how much to feed him and keep him reasonably healthy

How do you know when he's had enough?

What is in your 'toolbox?' (increasing level of 'invasiveness')

- History
- Physical Exam
- 'Static' Labs
- Non-invasive Vital signs
- Invasive vital signs (peripheral)
- Invasive vital signs (central)
- ***'Functional' labs***

History

- Age
- PMH (DM, COPD, CAD, Renal dz…)
- PSH (thoracic, abdominal, cardiac)
- Medications
- Allergies
- Mechanism of injury / event

Physical Exam (IPPA)

- Inspection: (Jaundice, deformities, scars, urine in the foley,color, JVD…)
- Palpation: (skin temp / turgor, edema, chest rise...)
- Percussion: (hyperressonance /dullness)
- Auscultation: (murmurs, rhonchi,wheezes bowel sounds)

Labs

- ABG: (Oxygenation, ventilation, acidosis)
- Electrolytes (Dehydration, dilution)
- Hemogram
- LFTs
- Coags

Non-invasive Vital Signs

- GCS
- Temperature
- Blood pressure
- Heart Rate
- [Respiratory Rate]
- ***Urine Output***
- * 'Pain is a 5th vital sign' (editorial)

Invasive Vital Signs:

- Peripheral:
  - Arterial line (SBP, DBP, MBP)
  - Flotrac, LiDCO, PiCCO, etc. (CO, SVR, **SVV,** GEDI, ITBVI, ETVI, GEF)
- Central:
  - CVL: CVP
  - Swan-Ganz catheter (CI / SVR / PA/ CVP/ SVO2)

'Functional' Labs'

- Oxygen Delivery (DO2)
- Oxygen consumption (VO2)
- Oxygen Extraction Ratio (O2ER)
- Serum lactate

Comments

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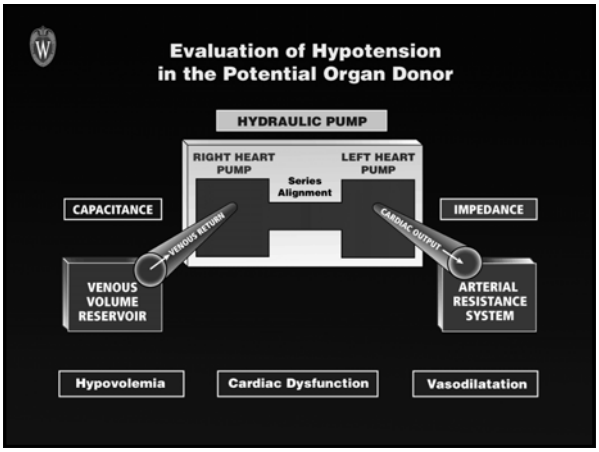
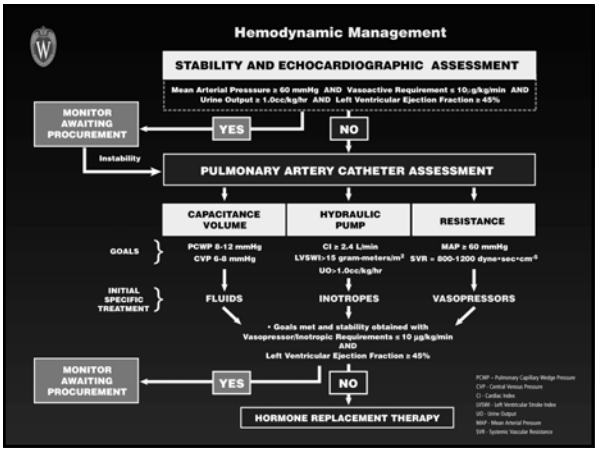
Evaluation of the Hemodynamically Unstable Donor





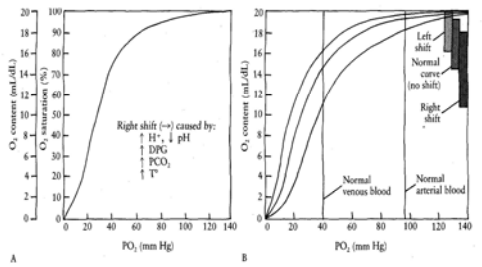
Determinants of O_2 Delivery

- Cardiac Output
  - HR X S.V.
- Arterial O_2 Content = CaO_2
  - [Hb x 1.39 x SaO_2] + [PaO_2 x 0.0031]
- DO_2 (O_2 Delivery)
  - C.O. x CaO_2 x 10

Determinants of O_2 Delivery

- Pulmonary Status
  - COPD, pneumonia, ARDS, contusion
- Cardiac Status
  - CAD, myopathy, post-CAB, contusion
- Anemia
  - Acute, chronic
- Poisons (Hb•O_2 dissociation curve…)
  - Smoking, cyanide, CO poisoning
- Atmospheric conditions
  - Mountain hiking, deep sea diving

Hb•O_2 Dissociation Curve



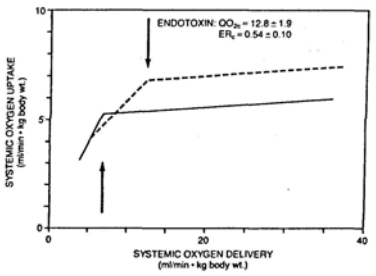
Determinants of O_2 Consumption

- Cardiac output
  - HR x S.V.
- Venous O_2 content = CvO_2
  - [Hb x 1.39 x SVO_2] + [PvO_2 X 0.0031]
- VO_2 (O_2 consumption)
  - C.O. X [C(a-v)O_2] x 10

Determinants of O_2 Consumption (Cont'd)

- Metabolic rate
- Stress
- Sepsis
- Poisoning
- ARDS

Supply Dependence vs. Independence



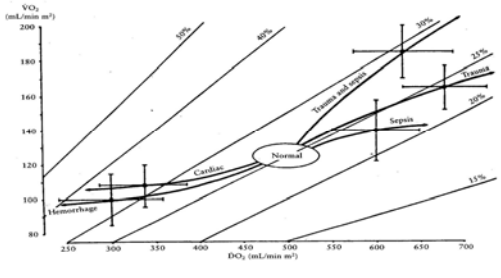
Abnormalities of O_2 Utilization With Illness

Table 6-2. Disease-related alterations of oxygen utilization

Disorder	Cardiac output	Hb	PaO_2	PvO_2	DO_2	$\bar{V}O_2$	Extraction ratio	Abn. Q	Abn. CaO_2	Abn. O_2 use
Pulmonary disease[a]	N	N, ↑	↓	N, ↓	↓	N	↑	No	Yes	No
CHF/cardiogenic shock	↓ ↓	N	N, ↓	↓, ↓ ↓	↓	N, ↓	↑	Yes, macro	±	No
Hypovolemic shock[b]	↓	N	N	↓	↓	N, ↓	↑	No	No	No
Hemorrhagic shock[a]	↓	↓ ↓	N	↓	↓	N, ↓	↑	No	Yes	No
Anemia[a]	N, ↑	↓ ↓	N	↓	↓	N	↑	No	Yes	No
Cyanide toxicity[b]	↑	N	N	↑	↑	↓ ↓	↓	No	No	Yes
CO poisoning[c]	N, ↑	N	N	↑	↓ ↓	↓	↓	No	Yes	Yes
Arterial occlusion[d]	N	N	N	N	N ↓ ↓	N ↓	N (G) ↑ (L)	No G, yes L	No G, yes L	No G, yes L
ARDS/sepsis[e]	↑	N	N	↑	N, ↑	↓ ↓	↓	Yes, micro	No	Yes

Key: Hb = hemoglobin; CHF = congestive heart failure; CO = carbon monoxide; ARDS = adult respiratory distress syndrome; N = normal; G = global; L = local; ↑ = increased; ↓ = decreased; macro = in the systemic circulation; micro = in the microcirculation.
[a] VO_2 maintained by an increased extraction of O_2 until the maximum extraction ratio is exceeded, then $\bar{V}O_2$ becomes flow limited.
[b] VO_2 is limited by cytochrome block at cell level.
[c] VO_2 is decreased by both a decrease in DO_2 and an extraction defect.
[d] Unique pathophysiologic state when usual laboratory and hemodynamic measurements often do not reflect local defects.
[e] VO_2 decreased secondary to an extraction defect in the face of normal to elevated DO_2—based on both abnormal flow and use.

Abnormalities of O_2 Utilization With Illness (Graphic)



Let's go back to our referral

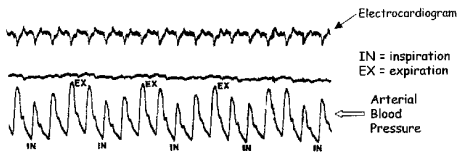
- ER nurse convinces Neurosurgeon to consult critical care
- Intensivist come to the ED [*curses*] and starts NS wide open and gets patient to the unit.
- Uses the 'tools':

Tools:

- Already has the first four: Hx, PE, Labs, NIVS
- Peripheral invasive vital signs:
  - Arterial line

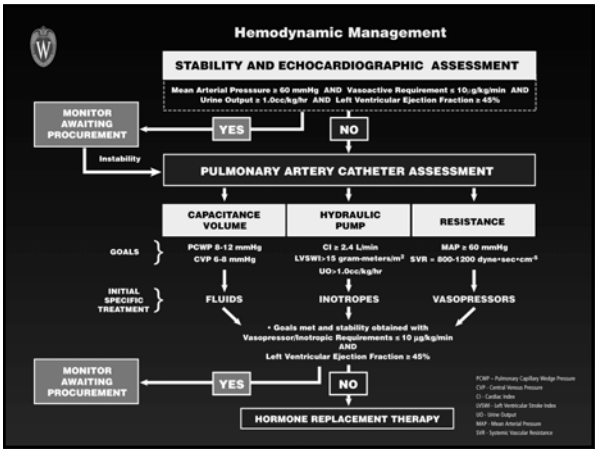
What besides the absolute numbers on the peripheral arterial line can tip you off to the intravascular volume status?

PULSUS PARADOXUS



Pulmonary Artery Monitoring

- Cardiac performance
  - C.O.
- Systemic resistance
  - SVR, PVR
- Filling pressures
  - CVP, PaOP
- **Mixed venous saturation!**
  - Delivery, consumption, extraction



Treatment Goals

- Identify the abnormality
- Treat the underlying abnormality
- Increase O_2 Delivery
  - Fluids, Blood, Inotropes
- Decrease O_2 Utilization
  - Thermal control
  - Treat sepsis

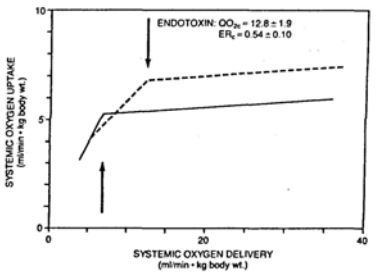
Initial Numbers:

- C.O. / C.I. – 2.6/1.4
- PA – 18/6
- Hgb – 16gms
- SaO2 – 96%
- SvO2 – 42%

Calculations

- CaO2 = (Hgb x 1.39 x SaO2) x 10
  –= (16 x 1.39 x .96) x 10 = 213.5
- CvO2 = (Hgb x 1.39 x SvO2) x 10
  –= (16 x 1.39 x .42) x 10 = 93.4
- DO2 = C.O. X CaO2 = 2.6 x 213.5 = **555.1**
- VO2 = C.O. x C(a-v)O2 = 2.6 x 120.1 = **312.26**
- O2ER = VO2/DO2 = **.56**

Supply Dependence vs. Independence



Comments

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Interventions over next 36 hours:

- Fluid: Total 22 liters crystalloid, 2 u PRBCs (started making urine in 4 hours…)
- Insulin gtt
- Weaned pressors
- ECHO (@ 16 hours) EF – 55%
- APRV (recruitment…)
- Bronchoscopy
- T4, Steroids, Narcan
- **NO HCO3**
- TIME…

Repeat Numbers:

- C.O. / C.I. – 6.2/3.35
- PA – 36/12
- Hgb – 11.5gms
- SaO2 – 100%
- SvO2 – 62%

Repeat Calculations

- CaO2 = (Hgb x 1.39 x SaO2) x 10
  –= (11.5 x 1.39 x 1.0) x 10 = 161.24
- CvO2 = (Hgb x 1.39 x SvO2) x 10
  –= (11.5 x 1.39 x ..62) x 10 = 99.1
- DO2 = C.O. X CaO2 = 6.2 x 161.24 = **999.7**
- VO2 = C.O. x C(a-v)O2 = 6.2 x 62.14 = **385.27**
- O2ER = VO2/DO2 = **.39**

Comparison

- PA - 19/6
- CO/CI – 2.6/1.4
- Hgb – 16
- SaO2 – 96%
- SvO2 – 42%
- **CaO2 – 213.5**
- CvO2 – 93.4
- DO2 – 555.1
- VO2 – 312.26
- **O2ER - .56**

- PA - 36/12
- CO/CI – 6.2/3.35
- Hgb – 11.5
- SaO2 – 100%
- SvO2 – 62%
- **CaO2 – 161.24**
- CvO2 – 99.10
- DO2 – 999.7
- VO2 – 385.27
- **O2ER - .39**

Outcome

- En bloc heart/lung retrieval
- Bilateral Kidney retrieval (Cr 1.1 at time of OR)
- Liver retrieval
- Patient found to have undiagnosed DM; pancreas ruled out
- ***6 organ donor!***