

Vesalius SCALpel™ : Sepsis, MOF

SIRS: df: two or more of: T < 36C, >38, P > 90, RR > 20 or PCO₂ < 32, WBC > 12 or < 4 or >10% bands

systemic effects of locally released cytokines (TNF-> IL1, 2, 6)

infection, injury triggers cytokine release

TNF & IL1 pyrogens, increase vascular permeability, activate coagulation, diffuse endovascular injury -> organ failure

IL6 related to macrophage, WBC increase

MODS (multiple organ dysfunction syndrome): SIRS + organ dysfunction

Sepsis df: SIRS in response to documented infection

Severe sepsis: sepsis + organ dysfunction, hypoperfusion (lactic acidosis, oliguria, change mental status), 40% mort

Septic shock: severe sepsis, hypotension despite adequate resuscitation, perfusion abnormalities including lactic acidosis, oliguria, acute change in mental status

(activated protein C/drotrecogin alpha can moderate SIRS response and MODS if given before episode, but can't predict. Promotes fibrinolysis, inhibits thrombosis & inflammation. Can cause severe bleeding. Future potential?)

fluid shifts in shock

initial deficit is in extracellular fluid (ECF) by two mechanisms

transcapillary refill from ECF decreases Hct (not from blood loss)

hypoperfusion/hypoxia decreases cell membrane energy, Na pump fails allowing Na and water into cell, K out

Lactic acidosis (Cohen-Woods classification)

type A: hypoperfusion & tissue hypoxia

increased vascular permeability, left vent failure/decreased cardiac output (CO)

eg. carbon monoxide poisoning, PaO₂ < 35

hypoxia, anaerobic glycolysis causes oxidation of pyruvate to lactate, ATP and water

hydrolysis of ATP produces H⁺, acidosis, not lactate itself

lactate in Ringer's does not aggravate acidosis

must have perfusion to wash out lactate from tissues to result in measurable acidosis

lactic acidosis best objective determinant of presence and severity of circulatory shock, tissue ischemia

type B: non-hypoxic

liver disease, diabetes, drugs (ETOH, ASA)

nl. lactate 1-2mmol/L

MOF

leading cause of death in ICUs, sepsis not required, SIRS necessary precursor

2 or > organ systems remote from the injury site

SIRS is adaptive, MOF is maladaptive

risk factors: trauma/burns, overwhelming infection, ischemia, inflammation, transfusion, iatrogenic, DM, malignancy, hepatic, renal failure, AIDS, transplant, immunosuppression, radiation, age extremes, invasive devices, hyposplenism

acute lung injury/ALI (formerly ARDS)

etiology: Gm- sepsis, aspiration, pancreatitis, trauma, O₂ toxicity

mechanism: WBC & macrophages activated, injury to alveolar-capillary interface, endotoxemia, platelet aggregation

acute hypoxic respiratory failure, 40% mort

bilat diffuse infiltrates, PCWP < 18, static compliance < 50cc/cm, aA gradient < 0.25

increased cap perm earliest finding

earliest clinical manifestation: decreased functional lung capacity

interstitial infiltrates precede clinical abnormalities

(interstitial edema, decreased compliance)

further lung injury from repair process: fibrosis, hyaline deposits

inhomogeneous, more dependent

nitric oxide (NO) selective pulmonary vasodilatation, improved RV function, oxygenation

no influence on ventilator duration or mortality

short-term use for critical pts.

intratracheal surfactant (pediatric, neonate, not effective for adult)

Rx: mechanical ventilation, PEEP, albumin, lasix

stents terminal bronchioles and alveoli, recruits additional alveolar units

increases FRC, compliance, decreased pulmonary alveolar water

artificially raises left atrial (wedge) PA cath. pressure

limit PIP < 35 (barotrauma)

improve PaO₂/FIO₂ ratio

pressure regulated volume control (PRVC) vent

mainstay of resp. support

adjusts pressure to maintain stable tidal volume

allows variation in spontaneous tidal vol

comfortable for awake pt

airway pressure release ventilation

intermittent release for lung emptying

reverse I:E vent 2:1 or higher

normal I:E 1:2

increase intrathoracic pressure, decreased venous return

anxiety, discomfort, requires paralysis, sedation

stacking breaths -> auto-PEEP

permissive hypercapnea (pH no lower than 7.2)
improves, but no change in mortality

CPAP

fixed pressure throughout
non-intubated pt

NIV, non-invasive ventilation

PE: early findings elevated diaphragm, atelectasis, effusion
helical CT excellent specificity

renal dysfunction

kidney extracts only 10% of arterial O₂

can tolerate 1/3 normal flow for up to 1h

early dysfunction due to decreased BP, hypoperfusion

late multifactorial

prerenal: decreased cardiac output, hypovolemia

nephrotoxic: radiology contrast, immune meds

renal support: dopamine (1-3mcg/Kg/m) increases renal blood flow, cardiac output

multiple causes of BUN elevation: hi protein diet, tissue breakdown, catabolism,
steroids

less reliable than Cr as measure of renal function

Creatinine production constant, better reflection of GFR

nl. GFR 180L/d, nl. creatinine clearance > 125 ml/m

lasix, loop diuretics contribute to hypovolemia, ultimate renal injury

contrast nephropathy: saline pre-expansion only effective preventive measure

hepatic dysfunction

early, ischemic/shock liver

hypotension, increased transaminases, increased pro time, decreased glucose
resolves after resuscitation

late, ICU jaundice, multifactorial

hypotension, drugs, TPN, transfusion

very high Bilirubin

increased or normal transaminases and protime

cholestasis, steatosis, Kupfer cell hypoplasia

acalculus cholecystitis

cystic duct edema

may perforate within 48h

cardiovascular

4 factors determine cardiac output (CO)

preload (proportional to RV end diastolic volume)

pulmonary capillary wedge pressure (PCWP) index of L atrial pressure,
pre-load

PA catheter with LBBB have pacemaker standby for arrhythmia/arrest
arrhythmia during RA pressure recording = catheter knot
hemoptysis sign of PA rupture: deflate balloon, pull catheter back,
double lumen ET tube to prevent blood from entering uninjured
lung

contractility
heart rate
afterload

heart extracts 70% of O₂ from blood
during hypoxia blood is shunted to heart and brain

EKG abnormalities

1st step in interpreting = atrial activity (P waves) inferior leads
3R arrhythmias: rate, rhythm, QRS duration
multifocal atrial tach. associated with lung disease
atrial flutter initiated by local reentry outside A-V node
AF & A flutter eliminate atrial contribution to CO
AF digitalis to slow vent. rate, quinidine or pronestyl to convert
V tach & flutter: three or more consecutive vent beats > 100 BPM
hallmark A-V dissociation
may be initiated by PVCs
no narrowing QRS as in supraventricular tachycardia (SVT)
SVT rapid, regular, narrow QRS: adenosine
adenosine, amiodarone

antiarrhythmic drugs

amiodarone: prolongs repolarization, increases Q-T interval
SVT and ventricular arrhythmias
digitalis: prolongs A-V conduction, peripheral vasoconstriction
maintenance for A-fib and flutter
excreted by kidneys, toxicity in renal failure
contraindicated in A-V block, hypertrophic cardiomyopathy, severe
hypokalemia, hypomagnesemia
esmolol: cardioselective beta blocker, prolongs A-V, peripheral vasodilation
control ventricular rate in PAT, A-fib, A-flutter
bronchospasm in asthmatic
same contraindications as dig + hypotension
verapamil: Ca channel blocker, prolongs A-V
negative inotropic effect, vasodilatation
PAT, AF, AFL, multifocal atrial tachycardia (with nl. BP)

inotropic agents: increase contractility by increasing the concentration and availability
of intracellular calcium

milrinone: phosphodiesterase inhibitor
blocks conversion of cAMP to 5-AMP, increasing conc. of cAMP
increases Ca⁺⁺ flux & uptake by endoplasmic reticulum (ER), improves
contractility and relaxation
vasodilatation limits use in shock
catechols: epi., norepi., dopamine

alpha-1 arterial vasoconstriction, alpha-2 venous capacitance constr.
 beta-1 myocardial contractility, beta-2 relaxation bronchial SM and
 relaxation vascular smooth muscle in skeletal muscle
 dopamine receptors relax vascular smooth muscle
 D-1 renal and splanchnic
 D-2 inhibit uptake of norepi., prolongs action
 catechol receptors upregulated and downregulated in critical illness
 lo dose dopamine: 2-5 mic/kg/m stimulates dopamine and alpha-2
 5-10mic selective beta stimulation
 > 10 progressive alpha stimulation
 dobutamine: synthetic catechol
 5-15mic. beta-1 stimulation
 > 15 beta-2 tachycardia and skeletal muscle vasodilation
 increases cardiac output and O₂ delivery in septic shock
 epi: lo dose < 0.02mic alpha and beta-2
 > 0.02 alpha-1 and 2
 increases cardiac ectopic pacemaker activity, dysrhythmia,
 increases cardiac O₂ demand
 increases renin, glucose, free fatty acid production
 norepi: lo dose beta-1 and 2 chronotropic effect
 hi dose alpha-1 and 2 predominate, decreased chronotropic
 peripheral hypotension (decreased peripheral vascular resistance), edema
 increased microvascular permeability
 tachyarrhythmias, biventricular dilatation, decreased ejection fraction (R>L)
 mechanical factors, cytokines?

CNS

up to 70% of ICU pts, non-localized altered level of consciousness
 brain death
 eliminate reversible causes of brain dysfunction: uremia, T < 32C, hepatic
 encephalopathy, severe electrolyte disorders, hyperglycemia, hypotension
 (MAP < 60)
 critical illness polyneuropathy: sepsis with encephalopathy can result in
 failure to wean
 symmetrical quadriplegia, decreased DTR's, facial sparing (v
 myasthenia)
 trial off vent: 100% O₂, no respiratory movement, PCO₂ elevation to 60, MAP
 drop to < 60, desaturation = positive test
 30% of brain dead have normal plantar pain response

peripheral NS (old term: ICU polyneuropathy)

up to 70% of ICU pts,
 generalized (esp limb) weakness, absent DTRs, failure to wean

relative sparing of cranial Ns

hematologic

thrombocytopenia: decreased production, sequestration, consumption

HIT: antibodies to heparin plus platelet factor 4 complex

DIC: decr platelets, increased clotting time, increased fibrin split products

anemia: blood draws, acute phase response (IL1)

lymphopenia, common, cause unknown, (poor nutrition?)

metabolic dysfunction

hyperglycemia: insulin resistance

sick euthyroid: decreased T3, normal T4, decreased thyrotropin

nutritional support:

enteral if possible

glutamine protects gut mucosa

arginine, fish oils, nucleotides enhance immunity, decrease sepsis

stress ulcer/stress related mucosal disorder

mucosal ischemia

coagulopathy: pl. < 50, INR > 1.5, PTT 2X nl.

prophylaxis must keep pH > 4

3% of pts bleed on prophylaxis

causes by frequency: respiratory failure > shock > sepsis > neuro

other predisposing factors: renal insufficiency, hepatic failure, enteral feed, steroids,
heparin, coumidin

coagulopathy and respiratory failure are the two independent predictive factors

decubitus

if within 6w of hospitalization, 3X mortality

I erythema, II partial thickness, III full thick skin, intact fascia, IV bone, muscle

increased incidence > 7d in ICU, emergency ICU admission strongest correlation

References:

Hashmi S. Current concepts in critical care. JACS, 200(1), Jan. '05: 88-94.