Vesalius SCALpel™ : Sepsis, MOF

SIRS: df: two or more of: T < 36C, >38, P > 90, RR > 20 or PCO_2 < 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 defecit 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, PaO_2 < 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, O_2 toxicity
mechanism: WBC & macrophages activated, injury to alveolar-capillary interface, endotoxemia, platelet agregation
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 manifectation: 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 PaO_2/FIO_2 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 catherter 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 ventriclar 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 splanchinc
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 O_2 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 O_2 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% O_2, no respiratory movement, PCO_2 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.