Vesalius SCALpel™ : Trauma (non-abdominal)

blunt trauma

no vital signs in the field, 0% survivors, ER thoracotomy futile

hemorrhage

duration of hypotension major predictor of mortality
permissive hypotension: maintain mean arterial pressure (MAP) ~90 to prevent pressure-induced rebleeding from sealed vessels
class of hemorrhage (70Kg ~ 5L circulation blood volume)
- I 15% = 750cc
- II 15-30% = 750 to 1500cc (increased pulse, diastolic/narrowed pulse pressure)
- III 30-40% > 1500 to 2000cc (hypotension)
- IV > 40% > 2000cc

urine output diminishes from class II onward
transfusion: trauma pts < 55 without heart disease Hb 7-9 is adequate

shock

Df: inadequate tissue perfusion to maintain normal metabolic and nutritional functions
cellular hypoperfusion/hypoxia/injury
release of cytokines, superoxide radicals, prostaglandins, adhesion molecules
extensive injuries can lead to SIRS, MOF

normal systemic parameters

cardiac index (CI): > 4.5L/m/M2
mixed venous O2 saturation: > 70%
O2 delivery: > 600 mL/m/M2
O2 consumption: > 170 mL/M2
right ventricular end diastolic volume index (RVEDVi) > 100mL/M2
gastric mucosal pH > 7.35
- enteral feeding as effective as H2 block and ppi's in lowering gastric pH

radiation

whole body gamma, neutron, high energy X-ray
- hi sensitivity tissues: WBCs, hematopoetic, GI epithelium
- intermediate: vascular endothelium, pulmonary endothelium, hepatocytes
- resistant: myocytes, nerve

3 syndromes
- 1 hematopoetic (1-4 Gy): pancytopenia, opportunistic infection, thrombocytopenia (& bleeding)
- 2 GI (8-10 Gy): severe nauses/vomiting, watery diarrhea (acute onset, mucosal separation day 5), massive fluid loss, acute renal failure, death (in addition to type 1 changes)

3 neurovascular (15-50 Gy): extreme nervousness, confusion, massive vasodilatation, interval partial recovery @ 6h, then rapid mortality @ 72h

blast injury

primary injury: shock wave causes air embolus, pulmonary contusion, diffuse parenchymal hemorrhage
- often late manifestations 12-24h
- tympanic membrane most sensitive screening exam (retinal air embolus rarer)
- initial CXR may be clear; decreasing pulse ox sat may be 1st sign pulmonary injury

secondary injury (body thrown against solid objects)
- more likely causes of abdominal solid organ injury than primary shock wave

tertiary (flying debris)

neuro

traumatic brain injury (TBI)
- severe: GCS 8 or below (coma)
- control hypotension to minimize secondary injury, maintain oxygen saturation
- ventriculostomy to monitor ICP, drain CSF if necessary
  - multimodality monitoring to intervene before secondary injury occurrs
- if ICP exceeds 20, institute measureas to decrease, maintain cerebral perfusion pressure (CPP=MAP-ICP) >60
  - pressors OK in volume resuscitated patients
- sedation and analgesia decrease metabolic demands
- elevate head of bed 35-40 degrees
- mannitol: osmotic diuresis, increases serum osmolality, draws fluid from brain
- saline resuscitation increases vascular volume, cerebral perfusion and decreases blood viscosity improving cerebral circulation
- hyperventilation to decrease pCO2 no lower than 35, causes mild cerebral vasospasm, decreased cranial blood volume
  - further drop leads to ischemia
- preexisting warfarin anticoagulation increases mortality of intracranial injury 4-5X
  - emergency reversal with rFVIIa in9h (v 32h FFP and vit K)
- Cushing's response: hypertension, bradycardia

definition of death
- traditional cardiorespiratory criterion indicating loss of brain stem integrating function: ceases and does not resume communication, movement or breathing
- '68 criteria:
  - presence of a cause compatible with brain death
  - absence of complicating medical condition
  - absence of drug intoxication, poison
  - no voluntary or involuntary movement except spinal reflexes
  - apnea with high pCO2 without toxic or drug etiology
    - apnea test: hypercapnea (pCO2 60) with normal p02 should stimulate respiration
  - body temperature at least 36 degrees centigrade

below core temp of 32 lose brain stem reflexes
systemic blood pressure > 90
positive fluid balance > 6h
(EEG not sufficient, nuclear scan measure of cerebral blood flow not studied yet)

spinal cord injury
- M 4:1, age 20-35
- CT superior to multiplanar views for C-spine Dx
- most contusion, compression, stretch, not transection
- secondary injury: mitocondrial dysfunction, cyclooxygenase, lipooxygenase, nitric oxide synthetase activity, reactive oxygen species damage of cell membrane by lipid peroxidation
- methyl prednisolone unlikely to improve function

neurogenic shock
- complete cord transection, loss of sympathetic tone, hypotension
- persistent bradycardia, absence of reflexes lasting days to weeks
- complete transection above T6 20-70% incidence of autonomic dysreflexia (6% in 1st mo)
  - stimulus below the level of injury can provoke BP variability, hypertension, intracranial hemorrhage, seizure, death
  - afferent impulses result in generalized sympathetic response, vasoconstriction below the level of injury
  - stimuli: removal of hardware, bowel/bladder distention, pressure sores, menstruation, meds
  - Rx: remove trigger, short acting antihypertensive meds, phosphodiesterase inhibitor (silenadil)
- XS parasympathetic response after injury causes vasodilation, flushing, piloerection, nasal congestion, sweating, headache

peripheral nerve: digital nerve repair has better prognosis than larger nerves

extremity

mangled extremity severity score components: injury, ischemia, shock, age
- score > 7 poor viability
- no system reliably predicts long term functional outcome
- energy imparted direcly correlates with height of amputation
- elderly may lack the energy to use prosthesis
- absolute indications for amputation
  - ischemic limb/unreconstructable vasculature
  - hypothermia, acidosis, coagulopathy
- massive crush
  - myoglobin & cytokine release lead to
  - SIRS, renal failure, ARDS
- damage control when emergency craniotomy, thoracotomy, laparotomy necessary
  - avoid prolonged salvage attempts at vascular repair, unstable fracture

crush injury
- exacerbated by reperfusion injury
- CK level proportional to rhabdomyolysis

increased capillary permeability after reperfusion, edema, exacerbates hypovolemia from other injuries
phosphate and potassium released from injured cells, arrhythmias, death
35% incidence renal failure, multifactorial
hypovolemia: pre-renal azotemia
vasoconstrictors
myoglobin precipitation in tubules, direct toxicity
acid urine exacerbabtes precipitation
Rx: vigorous volume resuscitation, dilutes myoglobin load
mannitol, osmotic diuresis
bicarbonate to alkalinize urine
(no loop diuretic/lasix: acidifies urine and decreases vascular volume)

extremity vascular

explore without a-gram: obvious hemorrhage, expanding hematoma, distal ischemia
pulse deficit, ABI < 1 associated with significant vascular injury
most popliteal injuries associated with pulse deficit, so no angio
angio penetrating shoulder because collaterals mask injuries

vascular

minor intimal injury: < 50% diameter, no flow limitation, allow spontaneous healing
spasm adjacent to soft tissue injury no Rx
intervention (most injuries):
occlusion causing ischemia: to OR unless adequate collaterals
persistent hemorrhage: OR orinterventional
AV fistula: coil or ligate, enlarge with time
large pseudoaneurysm: OR or US-guided compression, percutaneous thrombosis
blunt carotid injury
hyperextension (most common), rotation: neuro and vascular complications
stretch carotid over TV processes C1-2 causing dissection
hi risk for blunt carotid injury: Horners, basal skull fx, diffuse axonal injury, near hanging, LeFort II & III (not I), direct blow
hours to days: head/neckache, focal motor/sensory defecit
early Dx and Rx decreases stroke
delayed presentation up to 1y
4 vessel angio gold standard, duplex US
IV unfractionated heparin
LMWH at venous thrombosis levels inadequate
if heparin contraindicated: antiplatelet (ASA, plavix)
deterioration in neuro status to OR or interventional
f/u testing > 10d for progression/evolution
5-40% mortality, 12-80% neuro morbidity/sequellae
25% of stenoses recanalize, 75% of thromboses
aortic injury
endovascular repair option in the face of other life threating injuries
proximal subclavian injury stent avoids morbidity of trap door

popliteal trauma
- mechanisms: tibial plateau fx, posterior knee dislocation, hyperextension/stretch
- popliteal artery intimal tear, thrombosis; venous injury
- priorities: stabilization, prompt reperfusion
- if long delay temporary shunt, anticoagulate
- 31% amputation rate pulseless distal limb

thoracic

cause of 25% of trauma mortality
rib fx elderly: 2X risk morbidity and mortality; 19% increase for each rib
- most elderly not candidates for epidural

hemothorax: initial output > 1,500cc to OR
innominate artery most common vascular injury in blunt trauma: median sternotomy
tension pneumo: kink superior and inferior vena cava, circulatory collapse
aorta
- if cross clamp necessary limit to 30m to avoid spinal cord ischemia
  - 10-15% paraplegia

cardiac contusion: echocardiogram, enzymes
- more common than valvular damage
- troponin I specific for cardiac injury
  - rises by 4-10 hours, 50% sensitivity within 4h, 100% @12
  - confirmatory, too late for emergency screening
  - peaks 4-8d
  - peak correlates with subsequent cardiac events
- conservative Rx
- severe can go into CHF, need aortic balloon pump

thoracotomy
- R anterolateral rarely used
- double lumen tube prevent blood and secretions compromising non-involved side

penetrating, tamponade, usually R vent injury
- clinical or FAST Dx
- needle pericardiocentesis temporizing only, not necessary for diagnosis
- sternotomy for definitive repair of injury

flail chest: primary problem is pulmonary contusion
- pain control: intercostal block, epidural
- mechanincal ventilation if necessary

diaphragmatic rupture
- blunt 3X incidence of penetrating, usually (70%) L
- 80% present with dyspnea
- X-ray NG tube above diaphragm
- acute: explore through abdomen for associated abdominal injuries (85%), most spleen
- chronic/late: repair through thorax because of adhesions

musculoskeletal

hip dislocation

CT little useful information before reduction
15% nerve injury, most sciatic neuropraxia
timing of reduction (1st few hrs) influences late osteonecrosis femoral head (10-50%)

transfusion reaction

earliest sign of transfusion reaction in the OR is diffuse bleeding

References:

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