Vesalius SCALpel™ : Burns

Mortality risk

3 major factors: age > 60yo, > 40%, smoke injury
- 0 factors 0.3% mortality
- 1 3%
- 2 33%
- 3 90%

Transfer to burn center

2^{nd} degree > 10%
any 3^{rd} degree
hands/face, functional/cosmetic
electric, chemical, inhalation
pre-existing disease, concurrent trauma

Pathophysiology

coagulation: dead cells, irreversible
stasis penumbra: can progress to cell death or heal
- surrounding thromboxane inhibitors, antioxidants, leukocyte adherence

hyperemia: vasodilatation, inflammation, will heal
factors affecting outcome: edema (decreases perfusion, allows to worsen), perfusion, dessication, infection
systemic effects
- generalized edema: histamine, bradykinin, prostaglandins, leukotrienes, activated complement, catechols, cytokines
- IL-1, 6 increased
- cardiac: hypovolemia, increased peripheral vascular resistance, decreased cardiac output (myocardial depressant factor?)
- renal: decreased renal blood flow and GFR
- GI: mucosal atrophy, increased permeability, decreased uptake of glucose, amino acids, fatty acids
- immune: decreased cellular immunity
- hypermetabolism: increased energy expenditure, increased O2 consumption, proteolysis, lipolysis; remains up to 9 mo
- burn causes decrease in T_3 and T_4

Severity

2 factors: depth and body surface area
- depth:
  - 2^{nd} degree partial
    - moist, blister, sensate

3rd degree full thickness
dry, leathery, insensate
4th degree
into muscle
surface: Lund and Browder chart; rule of 9s, palm of examiner's hand = 1%

Fluid resuscitation

Parkland formula:
isotonic crystalloid/LR followed by colloid when capillary leak seals @ 24h
4cc/kg/% burn: half first 8h, half next 16h
5% albumin @ 24h: 0.5ml/Kg/% burn continuous
goal: urine output 30-50cc/h (except electric 100cc/h)
pediatric: Galvaston formula
5000cc/M^2 burned + 1500ml/M^2 total body area
increased requirement with smoke inhalation, large component of full thicknes
traditional endpoint of resuscitation = tissue perfusion reflected by urine output
also lactate, O_2 delivery/consumption

Electrical injury

4 categories: lo and hi voltage (less and more than 1000V); arc; lightning
hi voltage associated w other injuries in 60% of cases
if thrown, secondary injuries
lo voltage: AC household current great damage from muscle contraction, longer contact
lightning very high voltage: respiratory and cardiac arrest, 5% cataracts up to 2y out
Ohm variables: resistance of contact point, amps, time, type and amount of current
damage more related to current than voltage
skin and bone greatest resistance, greatest damage extremities
smaller the contact area the greater the damage
volume injury, electric current travels along nerves and vessels
normal appearing skin with great muscle damage, coagulation necrosis
myonecrosis, especially origins and insertions
creatinine kinase should rise 24-48h then decrease;
reevaluate if remains high, may need fasciotomies for muscle compartments
pain, numbness, decreased pulse late signs, don't wait, then too late to save M
carpal tunnel release if symptomatic
arrhythmia, v-fib most common cause of death at scene and soon after injury
lo voltage: if no initial EKG changes and no cardiac Hx, no need to monitor further
massive muscle contraction, fracture
Parkland formula not applicable, need urine output > 100cc/h to clear myoglobinuria from myonecrosis and prevent renal tubule shutdown
50% of neuropathies resolve with time
cataracts weeks to months

Chemical injury

hydrofluoric acid forms Ca salts, decreases Ca; give gel, injection, infusion
ingestion
alkalai more injury to esophagus, late stricture
acid longer time, greater exposure in stomach, late outlet obstruction

Complications

pulmonary: edema, chest constriction by eschar (escharotomy)
abdominal compartment syndrome/intraabdominal hypertension:
20-30% of patients with > 40% burn will develop abd. compartment syndrome
more likely if fluid resuscitation exceeds 25% of body weight
decreased venous return, decreased cardiac output, decreased organ perfusion & O_2 delivery, decreased urine output, respiratory compromise
pressure-control ventilation dangerous: abd pressure can exceed vent pressure dangerously decreasing tidal volume
bladder pressure > 30mm Hg, airway pressure > 45cm H2O
instill 50cc saline into bladder, transduce
CVP normal or increased, PA catheter not helpful
laparotomy (increase fluid losses?)
decrease fluids if stable

Inhalation injury

significant impact on mortality
chemical injury
airway very efficient in dissipating heat, thermal injury less critical than chemical except for steam (4,000X heat carrying capacity)
increased blood flow & cap permeability
neutrophils release proteases, oxygen free radicals
fibrin casts, plugging
carbon monoxide poisoning (hyperbaric to increse oxyHb)
upper airway obstruction, lower airway injury
late bronchopneumonia (60%)
ventilator: avoid barotrauma: PEEP, hi frequency ventilation, permissive hypercapnea
keep pressure < 40, pH > 7.20
steroids and prophylactic antibiotics no benefit

Chemical burns

hydrofluoric acid: topical and intraarterial Ca++
phenol: irrigate with glycerol, not water soluble

Nutritional support

early enteral feeding: 6h, reglan and erythromycin for motility
calculate energy expenditure and N balance, adjust caloric intake
glutamine: decrease gut mucosal atrophy, bacterial translocation

Hypermetabolism

beta block: decrease energy expenditure, improve protein synthesis
insulin: maintain glucose 100-140; less muscle atrophy, shorter length of stay
anabolic steroids: oxandrolone; maintain muscle mass, slightly faster healing, better rehab

Wound care

1st degree: no dressing, moisturizing
2nd degree: prevent infection, dessication
    topical antibiotic or adherent synthetic/biological dressing
        decreases pain, prevent conversion to 3rd degree
3rd degree: decrease bacterial count until go to OR (all 3rd degree)
escharotomy: all circumferential full thickness extremities and trunk, medial and lateral

Topical agents

silvadine: broad spectrum, no penetration, transient leucopenia, occasional decrease platelets
mafenide acetate/sulfamylon cream/solution: better penetration of eschar
    carbonic anhydrase inhibition metabolic acidosis, increases CO2
        not a problem unless pulmonary insufficiency and can't blow off
    painful
0.5% silver nitrate: stains, leaches Na, rarely used

Synthetic dressing

bio-brane: silicone, nylon, stiff sheet
    adheres to 2nd degree, peel off
transcyte (bio-brane +): cultured human fibroblasts, stimulate healing?, decrease pain
    usefull infant, child
    attach with steri-strips
acticoat: silver-based, antibacterial
    helpful in sulfa allergy, moist wound environment

Surgery

as early as possible, decrease sepsis
    serial excision, tangential (10-20% at a time)
        bloodiest, can lose several units, use fibrin sealant
        early excision less blood loss (@ 5-10 days more inflammation)

fascial: one piece with cautery
most devastating cosmetically
life-saving when blood loss is a concern

Skin replacement

autograft: mesh except unmeshed face, hand
reuse healed previously used donor sites when run out of fresh
beta strep wound culture contraindication to skin graft
allograft: frozen, tissue-banked cadaver skin
temporary coverage large areas
integra: outer silicone, inner glucosamino-glycan layer (like dermis)
capillary ingrowth, peel off silicone
expensive, prone to infection
alloderm: freeze-dried decellularized cadaver dermis
cultured epithelial autografts: 3 weeks to grow
send 2X4cm skin for culture
fragile, expensive, subject to infection
dermal matrix under cultured skin: allograft (epidermis removed) or alloderm (non-antigenic)
acticoat, bilirubin light (pediatric) dries, decreases bacteria

Long-term complications

Marjolin's ulcer (squamous carcinoma in burn wd) ~ 35y

Improved survival factors:

early excision: remove inflammatory and septic focus
aggressive fluid resuscitation
infection control protocols
early enteral feeding: preserve mucosal integrity, decrease hypermetabolic response

Future directions

bioengineered skin, cultured skin substitute, recombinant growth hormone
growth factors: KGF, FGf, TGFB

References:

Cone J. What's new in general surgery: burns and metabolism. JACS, 200(4), April '05: 607-614.