1 Vascular Disorders of the Hand

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2 Outline

- Introduction
- Vascular Injuries
- Vascular Occlusive Disorders
- Vasospastic Disorders
- Extravasation Injuries
- Lymphedema
- Frostbite Injuries
- Vascular Tumors
- Use of Lidocaine w/Epinephrine
- Self-Assessment Q & A

3 Arterial Dominance

- Deep palmar arch (from radial artery) – Dominant in 57%
- Superficial palmar arch (from ulnar artery) – Dominant in 21.5%
- Co-dominant in 21.5%
- Persistent median or interosseous artery

4 Arterial Arch Anatomy

- Arches are defined as "complete" if connect to independent arterial limb
- Superficial palmar arch is complete in 78.5%
- Deep palmar arch is complete in 98.5%
- At least 3 palmar common digital arteries are present
- Classic pattern – princeps pollicis to thumb is fourth common digital artery

5 Flow Control Mechanisms

- Autonomic control mediated by peripheral nerves (n of Henle with ulnar artery)
- Microcirculatory factors such as nitric oxide (vasodilators), endothelin (vasoconstrictor)
- Local autoregulation, metabolic (oxygen demand) or myogenic (arterial pressure)

6 Vascular Insufficiency

- Vascular insufficiency – blood flow is inadequate for tissue viability
- "Critical" vascular event – tissue death and necrosis without intervention
- "Non-critical" vascular event – collateral circulation is sufficient for viability

7 Causes of Vascular Insufficiency

- Vascular injury (arterial laceration)
- Vascular occlusion (thrombosis or embolism)
- Iatrogenic injury (cannulation, vascular access)
- Congenital malformations (AV shunting)
- Genetic or autoimmune disease (Raynaud's)

8 Allen Test

- Wrist or digital
- Arterial perfusion
- Flow or no flow through artery

9 Doppler Ultrasound

- Dynamic flow information

- Arterial occlusion
- Collateral circulation

10 Isolated Cold Stress Testing

- Evaluates vasomotor response to cold stress
- Hands exposed to cool air (5-8 degrees C)
- Warm response pattern (men predominate) - little sympathetic change in vascular tone
- Cold response pattern (women predominate) - decrease in digital temperature and perfusion

11 Segmental Arterial Pressures

- RBI - radial / brachial arterial pressure ratio
- DBI - digital / brachial arterial pressure ratio
- Normal DBI = 1; abnormal DBI < 1
- DBI 0.7 to 1 implies compromised flow
- DBI < 0.7 implies inadequate flow for healing

12 Criteria for Vascular Reconstruction

- DBI < 0.7
- Patent distal vessels
- Favorable clinical risk-benefit

13 Vascular Diagnostic Testing

- Digital plethysmography (PVR)
- Color duplex imaging (CDI)
- Thermography
- Laser Doppler Fluxmetry (LDF)
- Laser Doppler Perfusion Imaging (LDPI)
- Magnetic Resonance Angiography (MRA)
- Contrast Angiography (gold standard)

14 Vascular Injury

- Penetrating trauma in 90%
- Crush injury or fracture
- Onset obvious or insidious

15 Clinical Assessment for Vascular Insufficiency

- Skin color, turgor, temperature, cap refill
- Peripheral pulse is not good indicator
- Use Allen test, Doppler exam
- Observe for compartment syndrome
- Beware pediatric supracondylar after CR

16 Indications for Arterial Repair or Reconstruction

- Axillary artery laceration
- Brachial artery proximal to profunda brachii
- Combined radial and ulnar artery lacerations
- Radial or ulnar artery w/poor collateral flow
- Combined vascular and neural injury (relative)

17 Arterial Repair Approach

- Arterial shunting to minimize ischemia
- Rigid skeletal fixation of fracture
- Well-trained surgical team, microscope

- Anticoagulation, debride zone of injury
- Repair under no tension, 8-0 or 9-0 nylon
- Expect 10-20% thrombosis rate

18 Arterial Reconstruction

- Arterial gaps after injury debridement
- Autogenous vein graft out of injury zone
- Reversed interposition vein grafts preferred
- Obtain graft 20% longer than defect
- Avoid twisting vein graft (turbulent flow)
- Avoid trauma, nicotine postoperatively

19 Ring Avulsion Injuries

- Young, working men
- 80% men, 20% women
- Ring finger nearly always
- Avoid rings in workplace

20 Ring Avulsion Biomechanics

- Ring edge angulates
- High stress at ring edge
- Skin is primary resistance
- Low load to failure (35#)

21 Results of Replantation of 33 Ring Avulsion Amputations Adani et al, JHS 2013; in press

- 33 patients w/Type IV avulsions were replanted
- 29 patients were followed average of 7.4 years
- Vessel reconstruction, DIPJ fusion
- Outcome - good PIPJ motion, fair static 2PD
- Complete resection injured artery/vein is key
- Vessel transfers from middle finger is reliable

22 Ulnar Artery Thrombosis "Hypothenar Hammer Syndrome"

- Most common arterial occlusion in arm
- Male laborer, 40's, smoker, uses hand as club
- Impact in sports - baseball, golf, wrestling
- Sx - pain, cold intolerance, ulnar paresthesia
- PE - mass, + Allen test, ischemic changes
- Arteriogram is definitive diagnostic test

23 Treatment Options to Improve Collateral Flow

- Eliminate tobacco
- Vasodilators (tolazoline, chlorpromazine)
- Calcium channel blockers (nifedipine)
- Continuous sympathectic block
- Temperature biofeedback

24 Treatment Options to Restore Primary Arterial Flow

- Thrombolytic agent (Retavase, tPA)
- Periarterial sympathectomy (adventitial)
- Ligation/resection thrombosis (Leriche)
- Resection and interpositional vein graft

- Arterial bypass (long segment)

25 Post-Traumatic Ulnar Artery Thrombosis:
Arterial Reconstruction with Reverse Interpositional Vein Grafting
Chloros et al, JHS 2008; 33A: 932-40

- 12 patients (13 hands) from 1990 to 2005
- 10 of 13 grafts patent (73%) min 2-yr F/U
- If graft patent at F/U, ICST same as controls
- RIVG for UAT improves function, quality of life

26 Preferred Treatment

- If DBI > 0.7, then resection/ligation particularly in high-risk patients
- If DBI < 0.7, then resection and reconstruction with RIVG
- Reconstruction improves pain & function, promotes healing, prevents gangrene

27 True Aneurysm

- True aneurysm occurs with repeated blunt trauma leading to gradual vessel dilation
- Wall of true aneurym has endothelial lining
- Natural history is progression to thrombosis, then embolization
- Aneurysm resection, arterial reconstruction

28 Cannulation Injuries

- Brachial or radial artery thrombosis, potential distal embolization
- Brachial thrombosis most likely to embolize
- Radial artery occluded 25% of time, but often recanalizes
- Pseudoaneurysm (false aneuryms)
- Arteriovenous fistula

29 False Aneurysm

- Pseudoaneurym due to penetrating trauma, hematoma formation, recanalization
- Wall of false aneurym - no endothelial lining
- Progresses to thrombosis, then embolization
- Aneurysm resection, arterial reconstruction

30 Radial Artery Aneurysm

- Heparinazation
- Resection & ligation
- Arterial reconstruction
- Thrombectomy & embolectomy

31 Embolism

- Acute pain, pallor, pulselessness
- Multiple terminal vessels affected
- "Blue finger" > white > black
- 70% cardiac origin, atrial fib or post-MI
- Arterial emboli most commonly subclavian
- Rx with heparinization, embolectomy

32 Arterial Injection Injury

- Work place, medical procedure, drug abuse
- Vasospasm, endarteritis, thrombosis
- Rx w/thrombolytics, vasodilators
- Increased interstitial pressure, then fasciotomy
- Revascularization difficult due to small vessel occlusion

33 Buerger's Disease

- Thromboangiitis obliterans (inflammatory occlusive disease)
- Disease of small- to medium-sized arteries
- Young, male smoker is typical patient
- Smoking cessation decreases amputation rate
- Revascularization usually not feasible

34 Vasospastic Conditions

- Inappropriate arterial or venous tone
- Cold sensitivity most common symptom
- Affects 5-10% general population
- 20-30% premenopausal women
- Work up to exclude surgical lesion

35 Raynaud's Disease

- Triphasic digital color changes
- Bilateral hand involvement
- No occlusive disease
- No trophic changes or gangrene
- No systemic disease (primary)
- Symptoms for minimum 2 years
- Female preponderance

36 Three Stages (Triphasic)

- White or blanched - vasospasm interrupts arterial flow
- Blue or cyanotic - blood deoxygenated and pools
- Red or rubrous - rebound vasodilation, reactive hyperemia, dysesthesia

37 Wake Forest Classification of Vasospastic/occlusive Disease

- I - Raynaud's disease (primary, idiopathic)
- II - Raynaud's phen from collagen vascular dz (A - normal flow, B - abnormal flow)
- III - Vasospasm due to vascular injury (A - good collateral flow, B - abnormal flow)
- IV - Vasospasm from non-vascular injury

38 Nonoperative Treatment

- Smoking cessation
- Cold avoidance, protective garments
- Temperature biofeedback
- Calcium channel blockers (nifedipine)
- Tricyclic anti-depressants (amitriptyline)
- Serotonin reuptake inhibitors (Prozac, Zoloft, Paxil)

39 Operative Treatment

- Proximal (cervicothoracic) sympathectomy
- Peripheral sympathectomy (Leriche)
- Palmar/hand sympathectomy (Koman)
- Digital sympathectomy (Flatt/Wilgis)
- Repair, reconstruct, bypass occluded vessels

40 Long-Term Results of Periarterial Sympathectomy Hartzell et al, JHS 2009; 34A: 1454-60

- 26 patients (20 autoimmune, 8 atherosclerosis)
- Targeted periarterial sympathectomy for ulcers
- Average follow up 8 years

- 15/20 in autoimmune group improved vs 1/8 in atherosclerosis group
- 26% (autoimmune) vs 59% (atherosclerosis) required amputation

41 Botulinum Toxin A for Raynaud's Phenomenon

- Blocks neurotransmitter release at synapses, improves flow, reduces pain
- Off-label use of botox (experimental)
- Efficacious for 4-6 months
- Cost is $500-600 per vial
- Intrinsic weakness is adverse effect

42 BTX-A for Digital Ischemia in Patients with Raynaud's Phenomenon Fregene et al, JHS 2009; 34A: 446-52

- 26 patients, 55 encounters, 2003 to 2007
- Used for painful, nonhealing fingertip ulcers
- Improved pain and digital oxygen saturation
- 11 of 23 digital ulcers healed in 9.5 weeks
- Few complications - injection pain, transient intrinsic weakness

43 Extravasation Injuries

- Intravenous agents may extravasate
- Iatrogenic injuries, preventable
- Irritants cause inflammation
- Vesicants are toxic, cause necrosis
- Early recognition and treatment

44 Factors Determining Extent Soft Tissue Injury

- Osmolarity (parenteral nutrition)
- Cytotoxity (chemotherapeutic agents)
- Infusion pressure (radiocontrast media)
- Vasocontrictive (vasopressors)

45 Treatment Principles

- Early recognition
- Stop infusion
- Aspirate residual drug
- Further treatment drug-specific
- Saline flush (Gault technique)

46 Saline Flush-Out (Gault)

- Local anesthesia
- Hyaluronidase subcutaneous injection
- Four stab incisions at periphery
- Saline lavage (500 cc)
- Leave wounds open

47 Lymphedema & Hand Surgery

- Incidence 6-70% S/P breast cancer treatment
- Radical mastectomy & lymph node dissection
- Modified radical mastectomy, node dissection
- Simple mastectomy, no node dissection
- Mass excision or lumpectomy, node biopsy

48 Precautions After Lymph Node Dissection

- Avoid trauma
- Prevent infection

- Avoid constriction
- Exercise the arm

49 Safety of Upper Extremity Surgery After Rx for Breast Cancer: ASSH Survey
Gharbaoui et al, JASSH 2005; 5: 232-38

- 606 of 1200 surgeons responded
- 95% offer surgery; 85% if chronic lymphedema
- 94% use tourniquet; 74% if chronic swelling
- Complications - delayed healing, infection, worsening lymphema
- No contraindication to elective hand surgery

50 Elective Hand Surgery After Breast Cancer Rx

- Supported by the hand literature
- Regional anesthesia is safe
- Tourniquet may be used
- Low rate of increased lymphedema
- General surgeons disagee

51 Frostbite

- Exposure to low temperature (28 deg F)
- Crystal formation in exposed tissues
- Severity depends on temperature, wind chill, altitude, duration, vascular status, prior injury
- Superficial frostbite results in minimal loss
- Deep frostbite results in significant loss
- Men more commonly affected (10:1)
- Mentally ill, indigents, intoxicated

52 Degree of Injury

- 1st - Pallor, erythema
- 2nd - Clear blisters
- 3rd - Hemorrhagic blisters
- 4th - Deep tissue necrosis

53 Pathophysiology

- Phase I - Cooling & Freezing - intra-cellular ice crystals, small vessel endothelial damage
- Phase II - Rewarming - increased endothelial permeability, fluid extravasation, edema
- Phase III - Progressive Tissue Injury - vascular stasis and thrombosis, ischemia, inflammation
- Phase IV - Resolution - tissue necrosis, gangrene, late sequelae

54 Nonsurgical Rx Protocol

- No re-warming until core temp > 95 deg F
- Prevent thaw-refreeze cycles
- Rapid re-warming water bath 104-107.6 deg F
- Tetanus prophylaxis, antibiotics, analgesics
- Topical aloe, silver sulfadiazine
- Daily hydrotherapy, elevation, splinting

55 Safety & Efficacy of Tissue Plasminogen Activator in Treatment of Severe Frostbite
Twomey et al, JTrauma 2005; 59: 1350-55

- 19 frostbite patients from 1989-2003
- 6 patients rx intra-arterial, 13 patients rx IV
- Technetium bone scan indicated 174 digits at risk
- Results - 33 digits in 18 patients were amputated
- Not effective if > 24 hrs cold exposure or > 6 hrs warm ischemia time

56 Surgical Rx Protocol

- Debridement
- Escharotomy
- Fasciotomy
- Amputation

57 Late Sequelae

- Vasomotor dysfunction - cold sensitivity, color changes, susceptibility to future cold injury
- Neurologic dysfunction - persistent pain, hypesthesia, paresthesia, phantom pain
- Musculoskeletal problems - joint contractures, osteopenia, subchondral bone loss (frostbite arthropathy), premature physeal closure

58 Glomus Tumors

- Benign vascular hamartomas
- 75% are hand lesions, 65% in fingertip
- Subungual or subcutaneous location
- Bluish discoloration in nail bed
- Sharp pain with cold exposure, light touch
- Lesions may be single or multiple

59 Symptom Triad

- Cold hypersensitivity
- Paroxysmal pain
- Pinpoint pain

60 Glomus Tumours of the Hand: Retrospective Review of 51 Cases
Van Geertruyden et al, JHS 1996; 21B: 257-60

- 44 women, 7 men; 30 tumours subungual, 21 tuft
- Average duration sx before dx 10 years (1-40 yrs)
- Pinpoint pain 100%, temperature sensitivity 63%
- Nail deformity 47%, bluish discoloration 43%
- Bony defect distal phalanx 36%, bone scan positive in 4/4

61 Preoperative Evaluation

- Radiographs - Bone deformation
- MRI - High signal on T2-weighted image

62 Use Local w/Epinephrine and No Tourniquet

- Popularized by Don Lalonde (President of AASH)
- Used for wide variety of hand cases
- Permits active motion (tendon repair, transfer)
- Avoids tourniquet pain, need for sedation
- 1% lidocaine w/epi 1:100,000 (< 7mg/kg)
- Injection using the tumescent concept

63 Critical Look at the Evidence For and Against Elective Epinephrine Use in the Finger
Thomson et al, Plast Recon Surg 2007; 119: 260-66

- 48 cases of digital infarction w/local anesthesia
- All but 6 cases occurred before 1950
- 31 cases injected with procaine (expired?)
- 27 cases w/o epinephrine, 21 cases w/epinephrine
- Tissue necrosis from expired, acidic procaine

64 Finger Injection with High-Dose Epinephrine: Does It Cause Necrosis & Should It Be Treated?
Fitzcharles-Bowe et al, Hand 2007; 2: 5-11

- Accidental injections epinephrine (1:1000)
- 59 cases in world literature 1900-2005
- 32 cases were untreated
- 27 cases rx phentolamine, nitropaste, nifedipine
- No injection resulted in finger necrosis

65 How Long Does It Take Phentolamine to Reverse Adrenaline-Induced Vasoconstriction in the Finger & Hand?
Nodwell & Lalonde, Can J Plast Surg 2003; 11: 187-90

- 22 subjects injected 2% lidocaine w/epi, 3 places in one finger of each hand
- 1 hour later injected w/phentolamine 1 mg at same sites one hand, other hand w/ saline
- Normal color returned in 85 min vs 320 min

66 Multicenter Prospective Study of 3110 Cases of Elective Epinephrine Use in Fingers & Hand
Lalonde et al, JHS 2005; 30A: 1061-67

- 9 surgeons, 6 cities, 3110 consecutive hand cases
- Local anesthetic w/epinephrine (1:100,000 or less)
- No incidence of digital tissue loss
- No requirement for phentolamine rescue

67 Contraindications to Epinephrine in the Finger

- Finger must be nice and pink before surgery
- Scleroderma - check capillary refill first
- Raynaud's dz - lidocaine > causes vasodilation
- Advanced diabetics - no if finger is dusky
- Smokers - no problem if good refill to start

68 Future Use of Epinephrine

- "No use of epinephrine in the hand" myth has been exposed
- Evidence for safety is compelling
- Testimonials by hand surgeons
- More education is required
- Will be standard of care in future