Vascular Disorders of the Hand

Bernard F. Hearon, M.D.
Clinical Assistant Professor, Department of Surgery
University of Kansas School of Medicine – Wichita
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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

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

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

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)

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

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)

Allen Test

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

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 sympathetic 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 aneurysm 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 aneurysms)
• Arteriovenous fistula

29 False Aneurysm
• Pseudoaneurysm due to penetrating trauma, hematoma formation, recanalization
• Wall of false aneurysm – 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
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

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

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

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

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

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

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

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)
- Cytotoxicity (chemotherapeutic agents)
- Infusion pressure (radiocontrast media)
- Vasoconstrictive (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

### Safety of Upper Extremity Surgery After Rx for Breast Cancer: ASSH Survey

- 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

### 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 disagree

### 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

### Degree of Injury

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

### 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

### 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
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

Surgical Rx Protocol
- Debridement
- Escharotomy
- Fasciotomy
- Amputation

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

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

Symptom Triad
- Cold hypersensitivity
- Paroxysmal pain
- Pinpoint pain

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

Preoperative Evaluation
- Radiographs – Bone deformation
- MRI – High signal on T2-weighted image

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
Critical Look at the Evidence For and Against Elective Epinephrine Use in the Finger
• 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

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

How Long Does It Take Phentolamine to Reverse Adrenaline-Induced Vasoconstriction in the Finger & Hand?
• 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

Multicenter Prospective Study of 3110 Cases of Elective Epinephrine Use in Fingers & Hand
• 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

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

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