

Vascular Disorders of the Hand



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“Back of the Book” Segment

- Last hand topic alphabetically
- Last Chapter in Green’s textbook
- Last diagnostic consideration for ortho
- Last hand topic before graduation
- Last hand surgery topic in 5-year cycle

Hand Vascular Disorders

Outline

- Introduction
- Vascular Injuries
- Vascular Occlusive Disorders
- Vasospastic Disorders
- Extravasation Injuries
- Lymphedema
- Frostbite Injuries
- Vascular Tumors

Hand Vascular Disorders

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

Hand Vascular Disorders

Arterial Arch Anatomy

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

Hand Vascular Disorders

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)

Hand Vascular Disorders

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

Hand Vascular Disorders

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)

Hand Vascular Disorders

Allen Test

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

Hand Vascular Disorders

Doppler Ultrasound

- Dynamic flow information
- Arterial occlusion
- Collateral circulation

Hand Vascular Disorders

Isolated Cold Stress Testing

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

Hand Vascular Disorders

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*

Hand Vascular Disorders

Criteria for Vascular Reconstruction

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

Hand Vascular Disorders

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)

Hand Vascular Disorders

Vascular Injuries

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

Hand Vascular Disorders

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

Hand Vascular Disorders

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)

Hand Vascular Disorders

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**

Hand Vascular Disorders

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

Hand Vascular Disorders

Ring Avulsion Injuries

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

Hand Vascular Disorders

Ring Avulsion Biomechanics

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

Hand Vascular Disorders

Urbaniak Classification of Ring Avulsion Injuries

I	Incomplete injury, adequate flow	Wound care
II	Incomplete injury, inadequate flow	Revascularization
III	Complete avulsion	Amputation

Hand Vascular Disorders

Key Classification, Adani Modification

I	Adequate circulation	Wound care
II a, v	Inadequate, w/o fx	Revascularization
III a, v	Inadequate w/fx	Fx care, revascularization
IV d	Amputation distal FDS	Replantation
IV p	Amputation prox FDS	Amputation

Types I, II and III are incomplete injuries

Hand Vascular Disorders

Results of Replantation of 33 Ring Avulsion Amputations Adani et al, JHS 2013; 38A: 947-56

- 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

Hand Vascular Disorders

Reading List

Vascular Occlusive Disorders

Hand Vascular Disorders

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

Hand Vascular Disorders

Treatment Options Improve Collateral Flow

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

Hand Vascular Disorders

Treatment Options Restore Primary Arterial Flow

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

Hand Vascular Disorders

Contraindications to Thrombolysis

ABSOLUTE

Active bleeding
Severe clotting disorder
Intracranial neoplasm
Severe hypertension
Recent CNS surgery
CNS trauma
Recent CVA

RELATIVE

Recent surgery (< 10 days)
GI bleed
Advanced liver disease
Advanced kidney disease
Trauma

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

Hypothenar Hammer Syndrome: Long-Term Results of Vascular Reconstruction Endress et al, JHS 2015; 40A: 650-55

- 18 patients from 1994 to 2013
- 4 of 18 grafts patent (22%) at 9.8-yr F/U
- If graft patent at F/U, pain & cold intolerance were better than if occluded
- High satisfaction, low functional impairment

Preferred Treatment

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

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

Hand Vascular Disorders

Cannulation Injuries

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

Hand Vascular Disorders

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

Hand Vascular Disorders

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

Hand Vascular Disorders

Arterial Injection Injury

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

Hand Vascular Disorders

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

Hand Vascular Disorders

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

Hand Vascular Disorders

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

Hand Vascular Disorders

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

Hand Vascular Disorders

Raynaud's Disease or Phenomenon

Triphasic color	Yes	Yes
Age > 40 years	No	Yes
Rapid progression	No	Yes
Underlying disease	No	Yes
Female	Frequent	Infrequent
Trophic findings	Infrequent	Frequent
Allen test	Normal	Abnormal
Angiography	Normal	Abnormal

Hand Vascular Disorders

Wake Forest Classification 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

Hand Vascular Disorders

Nonoperative Treatment

- Smoking cessation
- Cold avoidance, protective garments
- Temperature biofeedback
- Calcium channel blockers (nifedipine)
- Tricyclic anti-depressants (amitriptyline)
- Serotonin reuptake inhibitors (fluoxetine)
- cGMP-specific phosphodiesterase inhibitor (sildenafil)

Hand Vascular Disorders

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

Hand Vascular Disorders

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

Hand Vascular Disorders

Reading List

Operative Treatment

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

Hand Vascular Disorders

Wake Forest Classification Preferred Treatment

I - Raynaud' Dz	Nonop rx, sympath
IIA - Collagen Vasc Dz	Nonop rx, sympath
IIB - w/poor flow	Arterial resection
IIIA - Vascular Injury	Arterial repair
IIIB - w/poor flow	Arterial reconstruction
IV - Nonvascular injury	Nonop rx, sympath

Hand Vascular Disorders

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 autoimmune improved vs 1/8 in athero
- 26% vs 59% required amputation

Hand Vascular Disorders

Reading List

Extravasation Injuries

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

Hand Vascular Disorders

Factors Determining Extent Soft Tissue Injury

- Osmolarity (parenteral nutrition)
- Cytotoxicity (chemotherapeutic agents)
- Infusion pressure (radiocontrast media)
- Vasoconstrictive (vasopressors)

Hand Vascular Disorders

Treatment Principles

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

Hannon & Lee, JHS 2011

Hand Vascular Disorders

Early Intervention May Improve Outcome

Extravasate	Necrosis Interval
Vasopressors	4 - 6 hrs
Radiographic contrast	6 hrs
Chemotherapeutic agents	72 hrs

Hand Vascular Disorders

Saline Flush-Out (Gault)

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

Hand Vascular Disorders

Vesicant Extravasates & Treatment

Parenteral nutrition	Saline flush
Phenytoin (Dilantin)	Saline flush, NTG
Dopamine	Phentolamine SQ, NTG
Radiocontrast media	Squeeze, liposuction
Mechlorethamine	Sodium thiosulfate SQ
Vinblastine, vincristine	Saline flush
Daunorubicin, doxorubicin	Ice, Saline, Dexrazoxane IV

Hand Vascular Disorders

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

Hand Vascular Disorders

Precautions After Lymph Node Dissection

- Avoid trauma
- Prevent infection
- Avoid constriction
- Exercise the arm

Hand Vascular Disorders

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

Hand Vascular Disorders

Reading List

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

Hand Vascular Disorders

Late Onset Upper Extremity Lymphedema After Hand Surgery in Breast Cancer Survivors

Baltzer et al, 2015 ASSH Annual Meeting

- Retrospective Level III of breast cancer pts rx lymph node bx/dissection, XRT, \pm chemo
- 4/103 pts (3.8%) had self-limited lymphedema
- Correlated with combined chemo & XRT
- Tourniquet safe in this population

Hand Vascular Disorders

Lymphedema After Elective Hand & Wrist Surgery in Women Post Axillary Node Dissection: Prospective Cohort Study

Gaston et al, 2016 ASSH Annual Meeting

- Prospective, multi-center, Level II study
- 44 pts (24 with tourniquet, 20 without)
- No cases of lymphedema at 3 & 6 month F/U
- Surgery safe after lymph node dissection
- Tourniquet does not increase lymphedema

Hand Vascular Disorders

Frostbite

- Exposure to low temperature (28°F = -2°C)
- 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

Hand Vascular Disorders

Degree of Injury

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

Hand Vascular Disorders

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

Hand Vascular Disorders

Nonsurgical Rx Protocol

- Re-warming if core temp $> 95^{\circ}\text{F} = 35^{\circ}\text{C}$
- Prevent thaw-refreeze cycles
- Rapid re-warming water bath $104\text{-}107.6^{\circ}\text{F}$ ($40\text{-}42^{\circ}\text{C}$)
- Tetanus prophylaxis, antibiotics, analgesics
- Topical aloe, silver sulfadiazine
- Daily hydrotherapy, elevation, splinting

Hand Vascular Disorders

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

Hand Vascular Disorders

Reading List

Surgical Rx Protocol

- Debridement
- Escharotomy
- Fasciotomy
- Amputation

Hand Vascular Disorders

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

Hand Vascular Disorders

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

Hand Vascular Disorders

Symptom Triad

- Cold hypersensitivity
- Paroxysmal pain
- Pinpoint pain

Hand Vascular Disorders

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 pos 4/4

Hand Vascular Disorders

Reading List

Evaluation & Treatment

- Radiographs - Bone deformation
- MRI - High signal on T2-weighted image
- Preferred treatment is elective excision

Hand Vascular Disorders