Microvascular Free Tissue Transfer

Plastic Surgery

Taipei Veterans General Hospital

History

- 1899 – Dorfler advocated use of all layers of vessels in repair
- 1907 – (Carrel) "The Surgery of Blood Vessels" (*JH Hospital Bull.*)
  - 1st replantation of canine limbs
  - 1st esophageal-intestinal interposition
- 1959 – (Seidenberg) human esophageal-intestinal interposition
- 1960 – (Jacobson/Suarez) operating microscope introduced (1 mm vessels)
- 1966 – (Antia/Buch) fasciocutaneous transfer
- 1972 – (McLean/Buncke) omental flap to scalp

Advantages of free tissue transfer

- 2 team approach
- Improved vascularity and wound healing
- Low rate of resorption
- Defect size of little consequence
- Potential for sensory and motor innervation
- Use of osseointegrated implants

Blood Flow Regulation

- Skin blood flow
  - Varies constantly
  - Maximal flow = 20x constricted flow
- Extrinsic (α receptors)
  - Sympathetics → NE
  - Circulating catecholamines → NE & E
    - shunt sphincters *extremely sensitive* to catechols
- Intrinsic
  - Tissue metabolites
    - CO2, NO, lactate → dilation
    - potassium → constriction
  - Kinins, histamine, serotonin
  - **Prostaglandins**

Free Flap Physiology

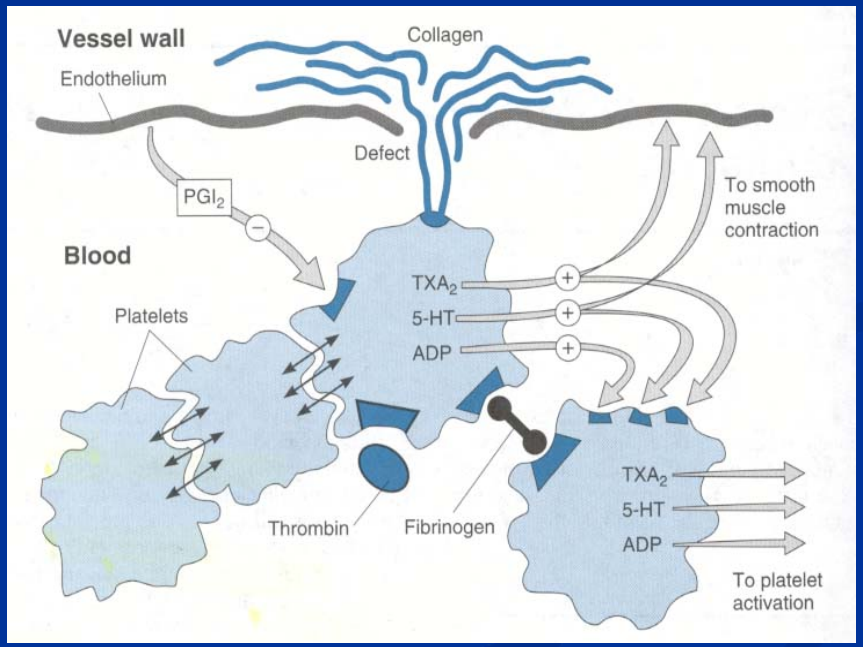
- Responses to Ischemia
  - Skin
    - *Anaerobic* metabolism preferred (glycolysis)
      - temperature regulation?
      - allows prolonged periods of anoxia
  - Muscle
    - *Aerobic* metabolism essential (TCA cycle)
      - 2 hr anoxia – immediate recovery
      - 4 hr anoxia – prolonged recovery (edema)
      - 6 hr anoxia – no recovery (necrosis/infection)
        - little histololgic change until ***reperfusion***
  - Bone/Cartilage
    - Needs dependent on activity of constituent cells
    - Poor studies

Microcirculatory Response to Ischemia

- Endothelial response
  - *Aerobic* metabolism extremely important
    - *irreversible* injury in 2.5 min of anoxia
    - endothelial swelling narrows lumen
    - complete regeneration in 7 – 10 days (monocytes/pleuropotential myoepithelial cells)
- Erythrocyte sludging
  - stiff walls with low pH
  - reduced with hematocrit below 30%
- Leukocyte adherence
- Interstitial swelling
  - increases capillary pressure

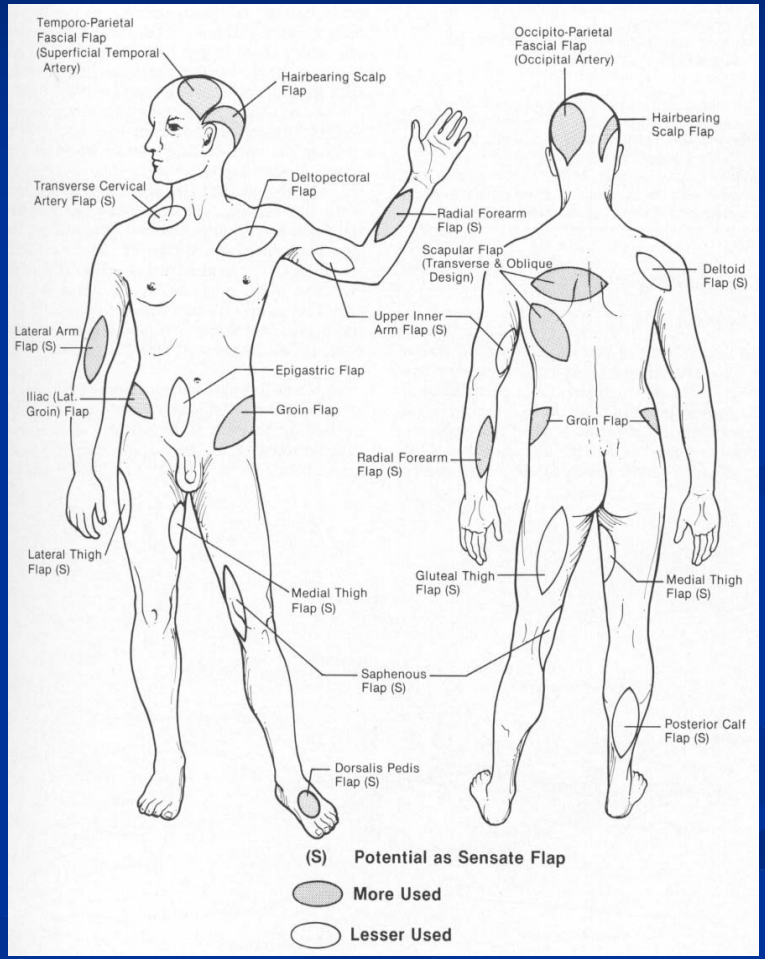
Consequences of Vascular Injury

- Endothelium
  - Actively produces PGI_2
    - vasodilator
    - acts on distal arterioles
- Basement membrane
  - Exposed following endothelial loss
  - Potent activator of platelets
  - Rapid growth of clot (TxA_2)
    - vasoconstriction
    - vascular occlusion
- Muscularis and adventitia
  - Heals with scar deposition
  - Extensive injury leads to ↓ patency and aneurysm



Principles of Microsurgery

- Macrocirculation of Composite Tissue
  - Segmental vasculature (axial flaps)
    - skin/fascia
    - skin/fascia & muscle
    - skin/fascia & bone +/- muscle
  - Vessels 0.8 to 4 mm appropriate for transfer

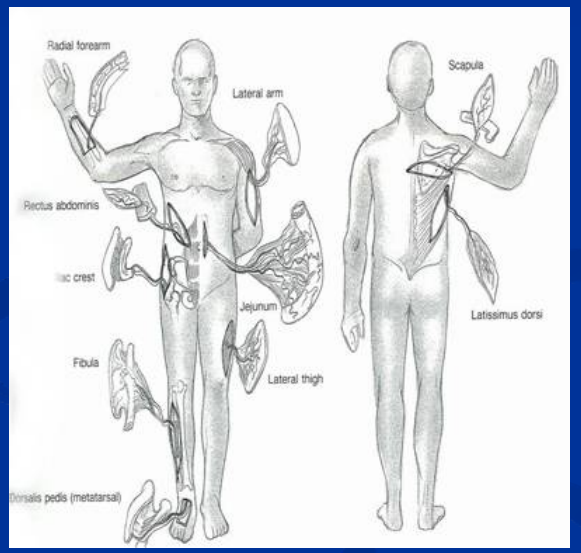


Factors Affecting Anastomosis Patency

- Technical
- Flow factors
  - Turbulence
  - Smaller vessels more sensitive
- Coagulation Factors
  - PGI_2 → vasodilation
  - TxA_2 → vasoconstriction
- Spasm
  - Vessel handling
  - Blood, temperature, desiccation
  - Circulating catecholamines
    - smoking
    - sympathetic activity stress/exogenous α-agonists

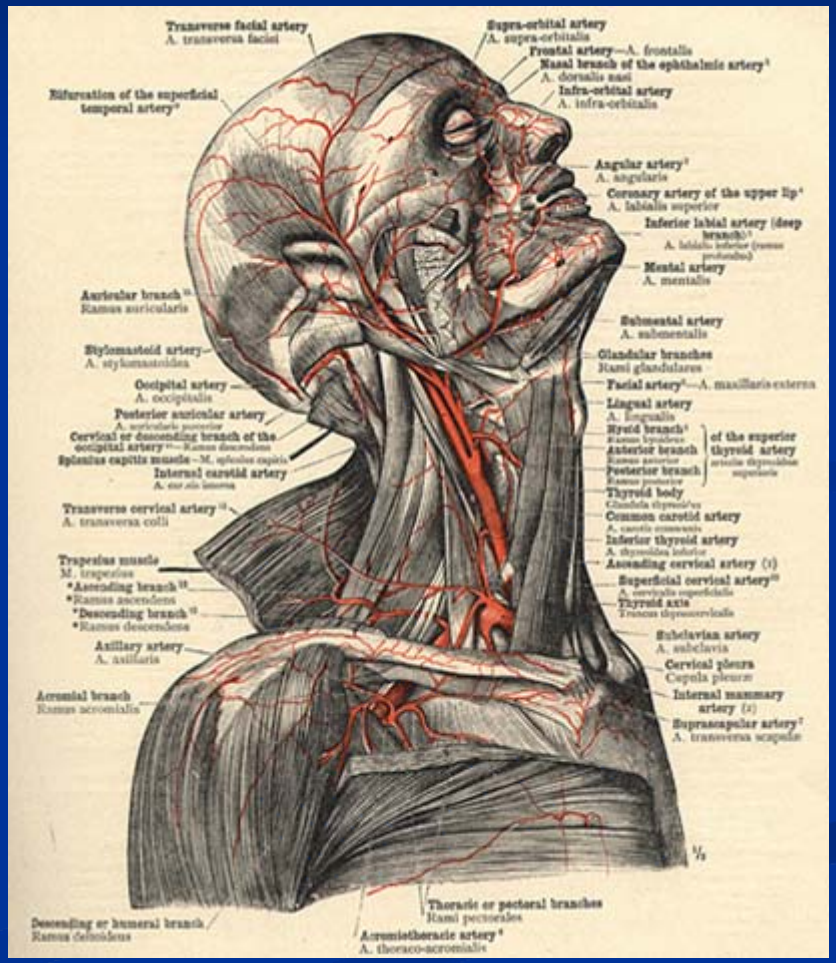
Advantages of free tissue transfer

- Wide variety of available tissue types
- Large amount of composite tissue
- Tailored to match defect
- Wide range of skin characteristics
- More efficient use of harvested tissue
- Immediate reconstruction



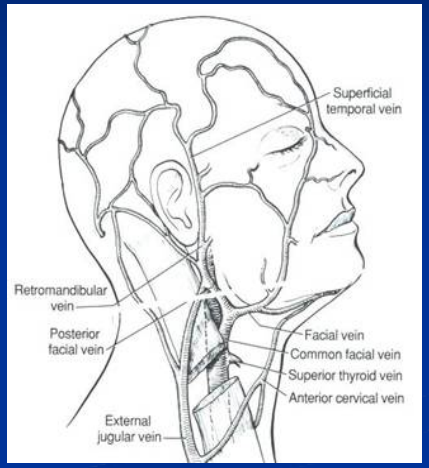
Recipient vessels

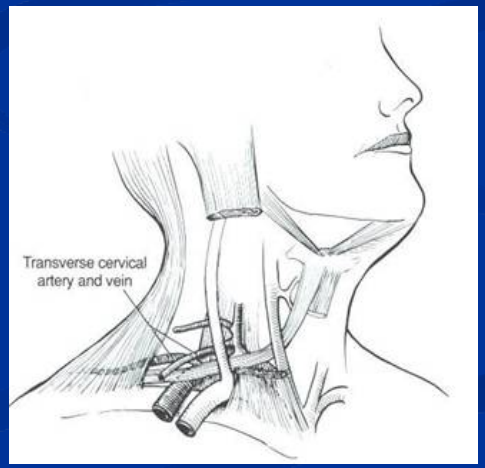
- Arteries
  - Superficial temporal system – scalp and upper face
  - Facial artery—midface and cervical region (atherosclerosis common)
  - Superior thyroid or lingual artery—lower cervical region
  - Other: thyrocervical trunk, external carotid, common carotid



Recipient vessels

- Veins
  - External jugular
  - Branches of internal jugular (common facial)
  - Internal jugular
  - Retrograde (superficial temporal, thyroid)
  - Transverse cervical, occipital (very small)



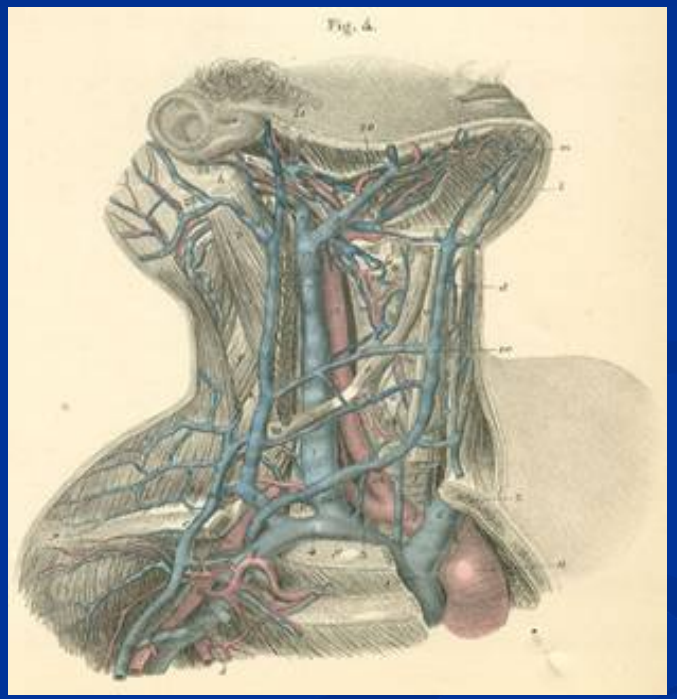


Recipient vessels after previous neck dissection

- Gold standard: Angiogram (short-term injury to endothelium reported)
- Operative reports
- Long-pedicled flaps
- Thyrocervical trunk (transverse cervical), Occipital vessels, retrograde drainage (thyroid veins, superficial temporal), external carotid artery
- Contralateral vessels (recipient or graft)
- End-to-side anastomoses with large vessels
- Vein grafts
- Arteriovenous loop (poorer results)

Vessel selection

- Size
  - Arterial vs. Venous
- Atherosclerosis
- XRT-related changes
- Vessel geometry (location and orientation)
- Vessel length



Vessel preparation

- Arteries need to have strong pulsatile flow—cut until it flows.
- Cut back beyond branches or ligate them if sufficiently distant from the anastomosis site.
- Atherosclerosis
- Intimal inspection
- Dilation
- Removing the adventitia

Irradiated vessels

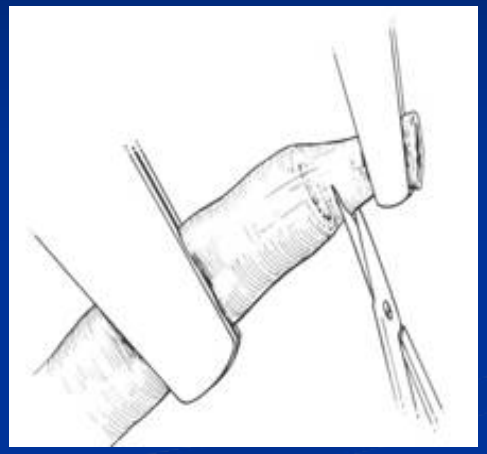
- Technically more difficult—effects appear specific to arteries
- Higher incidence of atherosclerosis
- Vessel wall fibrosis, increased wall thickness, more intimal dehiscence
- No reported difference in outcome of microvascular anastomoses *(Nahabedian MY, et al., 2004, Kroll SS, et al 1998)*
- Microvascular anastomoses tolerate XRT well long-term *(Foote RL., et al., 1994)*
- Require careful handling, cut off clot (teasing thrombi may denude vessel wall—"sticky" walls), smaller suture, needle introduced from lumen to outside wall (to pin intima to wall)

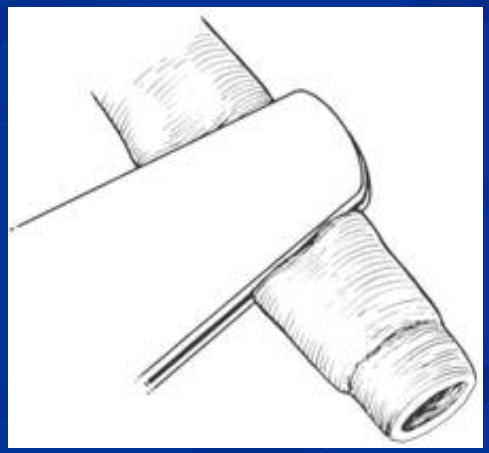
Microvascular Anastomosis

- Prepare vessels
  - Evaluate vessel geometry
  - Trim, irrigate, dilate
- Partial flap insetting (bony cuts and plating done at donor bed, if necessary)
- Arterial vs. venous anastomosis first with early or delayed unclamping of first vessel showed no difference. *(Braun, et al., 2003)*
- Anastomosis of remaining vessel
- Complete flap insetting

Microvascular surgical technique

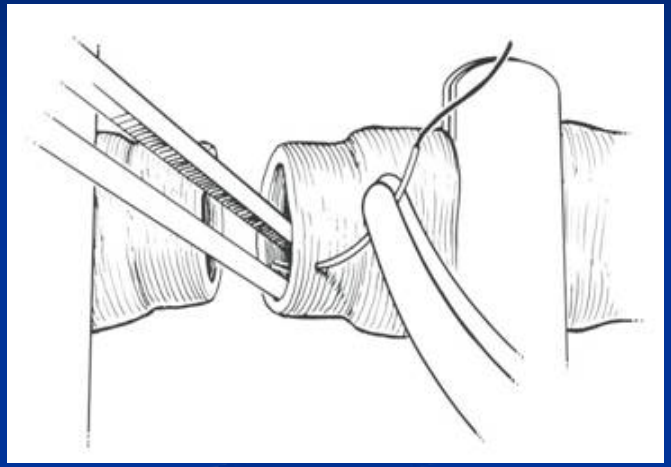
- Trim adventitia
  - 2-3mm
  - Gentle handling (no full-thickness)
  - Trim free edge, if needed
  - Dissect vessels from surrounding tissues
- Irrigate and dilate
  - Heparinized saline
  - Mechanical dilation (1 ½ times normal –paralyses smooth muscle)
  - Chemical dilation, if necessary
- Suturing

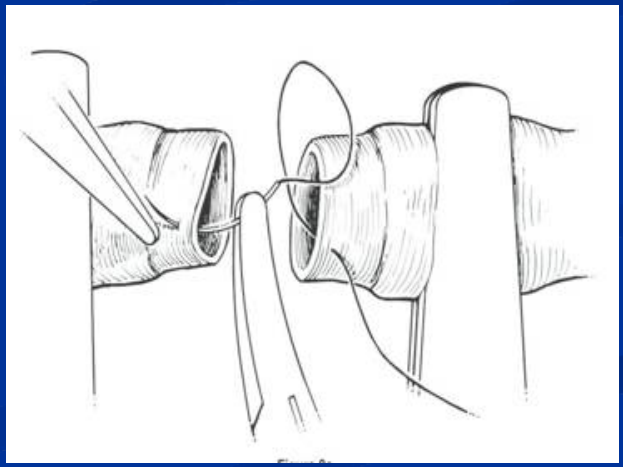




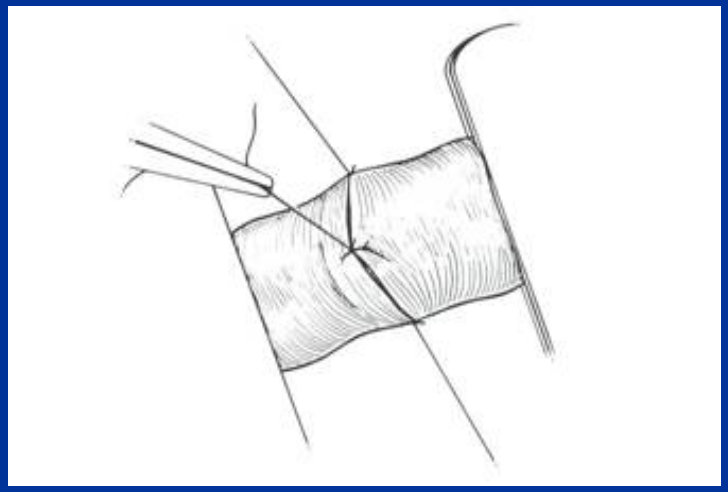
Microvascular suture technique

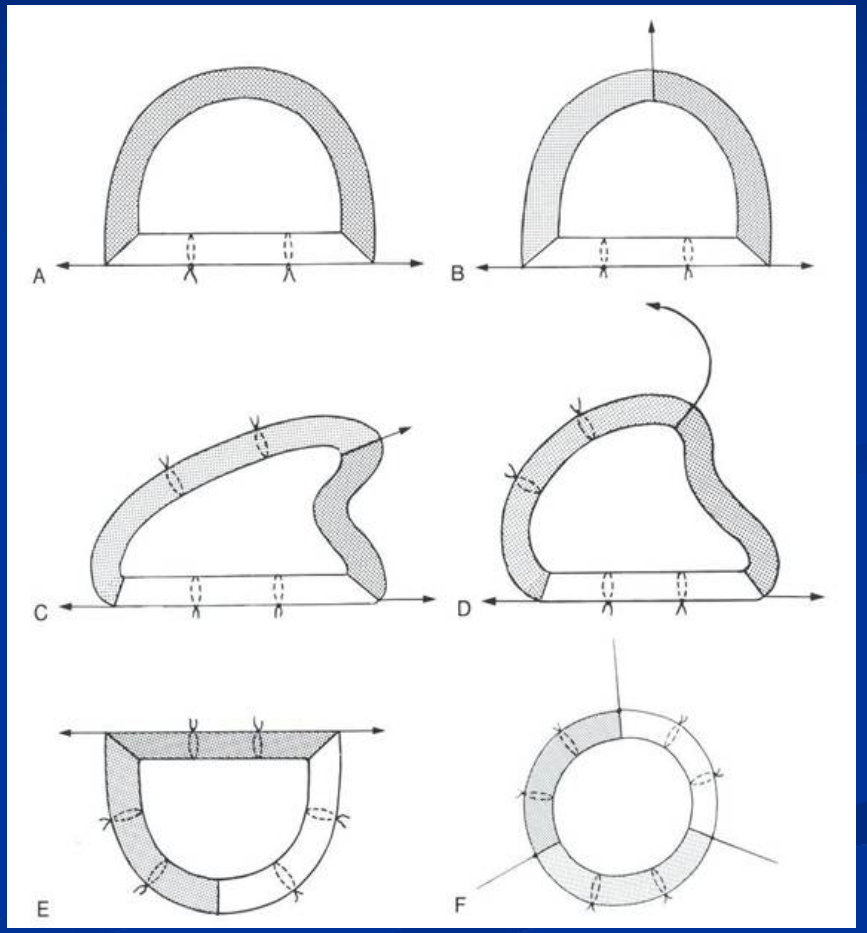
- 3 guide sutures (120 degrees apart)
- Perpendicular piercing
- Entry point 2x thickness of vessel from cut end
- Equal bites on either side
- Microforceps in lumen vs. retracting adventitia
- Pull needle through in circular motion
- Surgeon's knot with guide sutures, simple for others
- Avoid backwalling—2 bites/irrigation



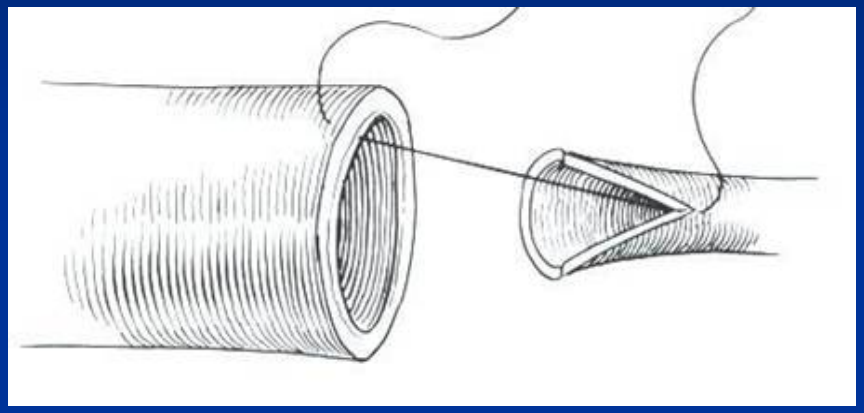


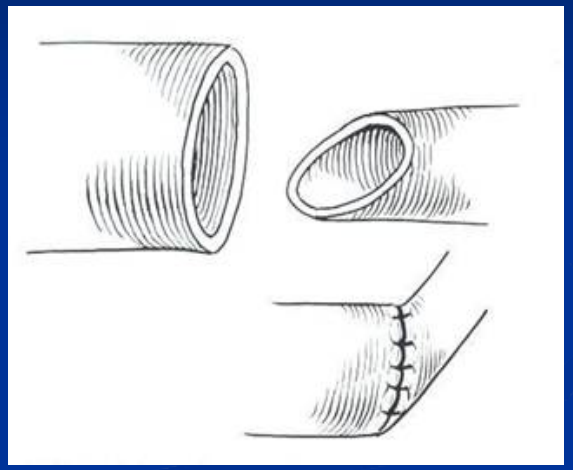
3 suture technique





Vessel size mismatch



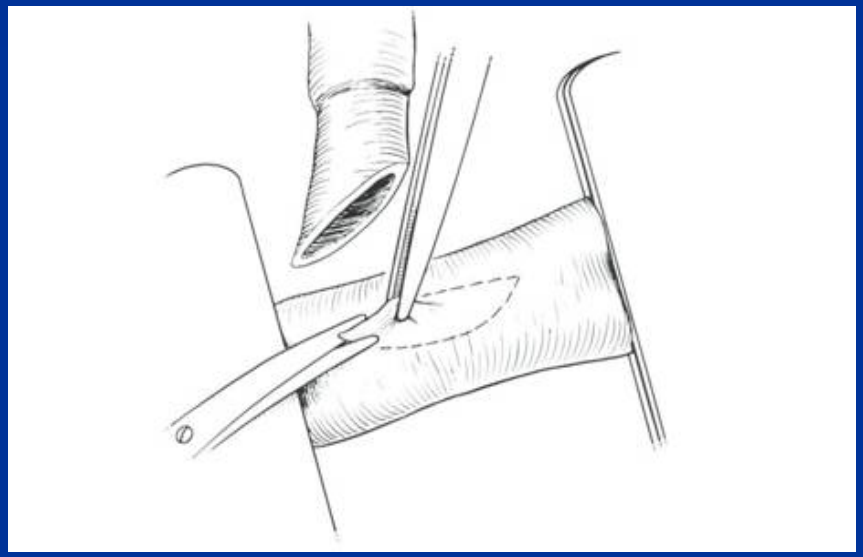


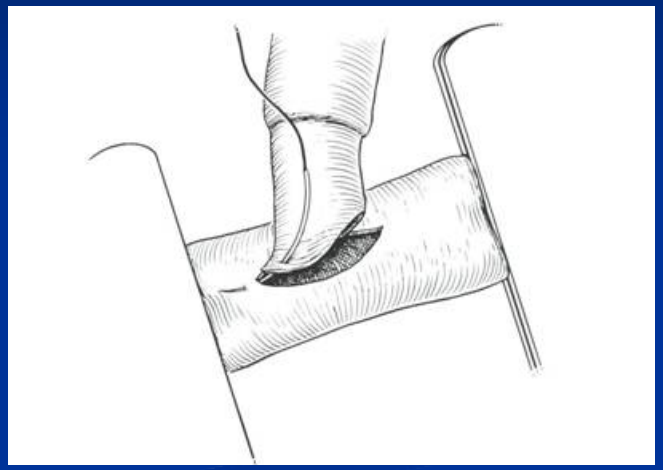
- Laminar flow vs. turbulent flow
- <2:1 – dilation, suture technique
- >2:1, <3:1 – beveling or spatulation (no more than 30 degrees to avoid turbulence)
- >3:1 – end-to-side

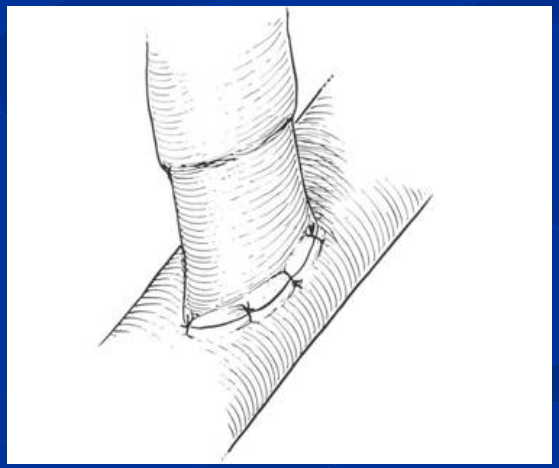
End-to-end vs. End-to-side

- Recent reports indicate end-to-side without increase in flap loss or blood flow rate.
- End-to-side overcomes size discrepancy, avoids vessel retraction, and IJ may act as venous siphon.
- End-to-side felt best when angle is less than 60 degrees (minimize turbulence)
- Vessel incision should be elliptical, not slit
- Can use continuous suture technique

End-to-side Anastomosis





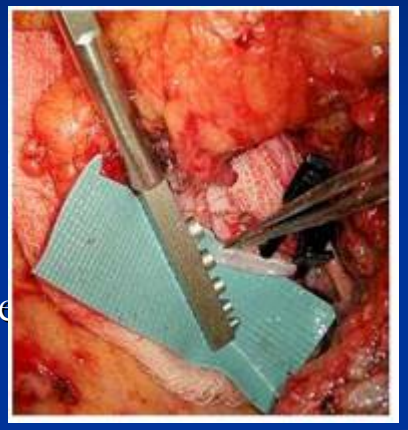


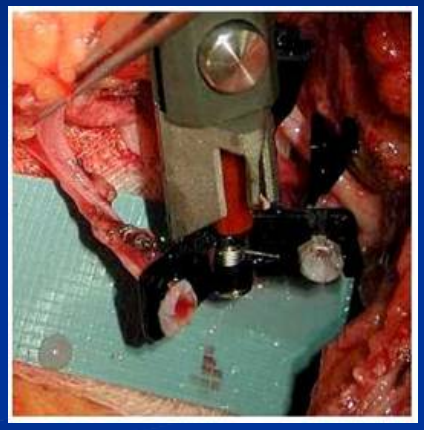
Continuous suture technique

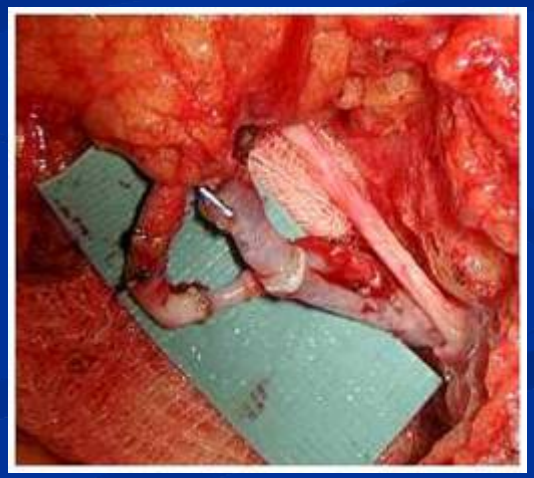
- May significantly narrow anastomosis
- May be used on vessels >2.5 mm
- Decreases anastomosis time by up to 50%
- Decreases anastomosis leakage
- Most commonly used for end-to-side anastomoses with large vessels

Mechanical anastomosis

- Devices
  - Clips
  - Coupler
  - Laser
- Results
  - Increased efficiency and speed, use in difficult areas
  - Patency rates at least equal to hand-sewn *(Shindo, et al 1996, De Lorenzi, et al 2002)*
  - Can be used for end-to-end or end-to-side *(DeLacure, et al 1999)*
  - Poorer outcome with arterial anastomosis—20-25% failure *(Shindo, et al 1996, Ahn, et al 1994)*







Vein grafts

- Used in situation where pedicle is not long enough for tension-free anastomosis
- Usually harvested from lower extremity (saphenous system)
- Valve orientation is necessary
- Avoid anastomosis at level of vein valve
- Keep clamps in place until both anastomoses sewn
- Prognosis for success controversial *(Jones NF, et al., 1996, German, et al. 1996)*
- Recent literature

Microvascular Hints & Helps

- Use background to help visualize suture
- Demagnetize instruments, if needed
- May reclamp vessels for repair after 15 minutes of flow
- Reclamp both arterial and venous vessels when revising venous anastomosis
- Support your hands and hold instruments like a pencil

Ischemia

- Primary and secondary
  - Primary: 2.25-6 hours
  - Secondary: 1-12 hours
  - Interrelation
  - No flow phenomenon
- Cold vs. normothermic
  - In vitro studies show benefit to cooling of flaps
  - In vivo studies show surface cooling (<4hr ischemia time) does not adversely effect flap success *(Shaw W. et al 1996)*
- Tissue specific critical ischemia times
  - Metobolic rate dependent
- Perfusates (UW, tissusol, Viaspan, Heparin)
  - Literature unclear

Anastomotic failure

- 93-95% success rate expected
- Venous thrombosis:Arterial thrombosis 4:1, ateriovenous loop, tobacco use significant factors *(Nahabedian M., et al, 2004)* Other literature indicates 9/10 thromboses secondary to venous thrombus
- Tobacco use as contribution controversial (4/5 failures in Nahabedian study - venous thrombosis)
- Venous occlusion, Delayed reconstruction, Hematoma significant factors in breast free tissue recon. *(Nahabedian M., et al, 2004)*
- Salvage 50% in breast reconstruction
- Age, prior irradiation, DM (well-controlled), method of anastomosis, timing, vein graft, and specific arteries/veins not felt to contribute to failure rate

Anastomotic Failure--timeline

- 15-20 minutes
- <72 hours
- 5-7 days
- >8 days
  - Thin vs. thick flaps

Thrombus formation

- Injury to endothelium and media of vessel
  - Mechanical vs. thermal
- Error in suture placement
  - Backwall or loose sutures
  - Edges not well-aligned (most common in veins—most common site of thrombus)
  - Intimal discontinuity with exposure of media
    - Oblique sutures, large needles, tight knots
- Infection
- Hypovolemia and low flow states
  - Nitroprusside at dose to decrease arterial pressure by 30% causes severe reduction in flap blood flow (40%) *(Banic, et al. 2003)*
  - Vessel geometry (kinking, tension)

Vessel spasm

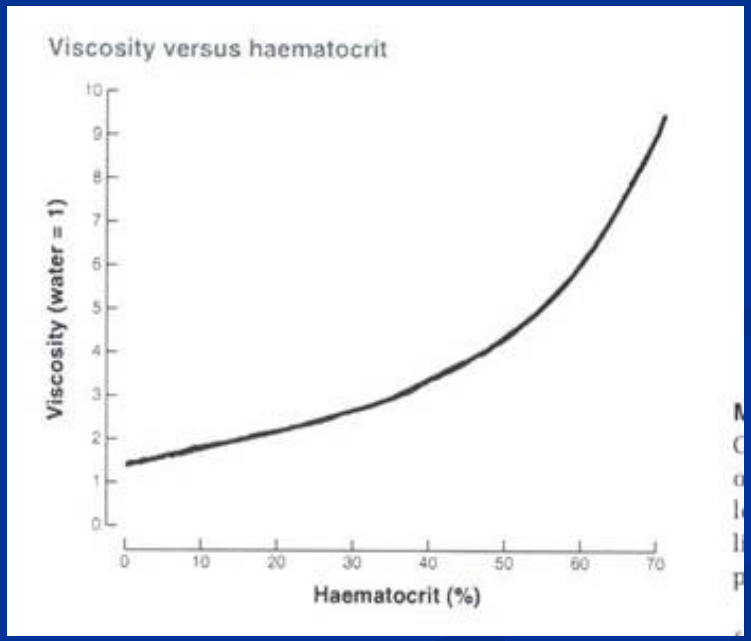
- Causes
  - Trauma
  - Contact with blood
  - Vasoconstrictive drugs
    - Phenylephrine--dose causing 30% increase in arterial pressure shows no effect on flap circulation *(Banic A, et al., 1999)*
    - Nicotine
  - Temperature, drying
- Treatment
  - Warmth
  - Xylocaine
  - Papavarine, thorazine
  - Volume repletion

Treatement for anastomotic failure

- Revision of anastomoses
- Exploration of wound
- Streptokinase, urokinase, rt-PA *(Atiyeh BS, et al 1999)*
- Leech therapy
- Wound care
- Statistics
  - Revisions successful in 50%
  - Revisions less successful after first 24-48hr
  - >6 hrs of ischemia leads to poor survival
  - 12 hrs of ischemia leads to "no-flow" phenomenon
  - After 5 days almost all flaps in rabbit model survived with loss of artery or vein (but not both)—this is rational for other modalities after 48 hours

Post-operative care

- Anticoagulation
- Attention to wound care
- Flap monitoring
- Nothing around neck that might compress pedicle
- Antibiotics
- Hemoglobin/intravascular volume—literature unclear *(Velanovich V., et al 1988, Quinlan 2003)*
- No pressors/nicotine/cooling of flap (literature unclear)



Anticoagulation

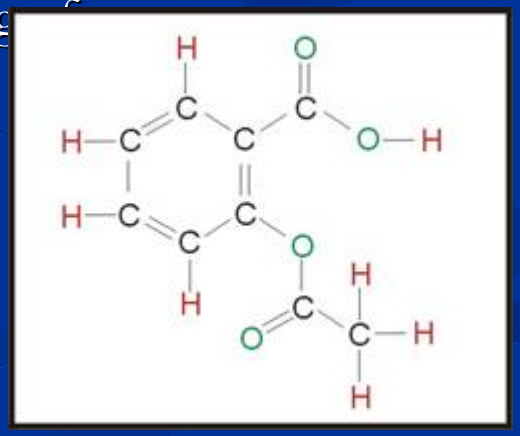
- Rheology
  - RBC concentration
  - Plasma viscosity
  - RBC aggregation
  - RBC deformability
  - Other (platelets, thrombogenic mediators)
- Agents
  - Aspirin
  - Heparin
  - Dextran
  - Other
- Indications
  - Hypercoagulable state *(Friedman G, et al, 2001)*
  - Excessive vessel trauma
- Complications

Dextran

- Macromolecule which is a compound of glucose subunit
- Thought to improve RBC flexibility, increase electronegativity of vessel wall (which decreases platelet adhesion), act as intravascular volume expander, decrease RBC aggregation
- Shown to decrease clotting secondary to exposed collagen in rabbit arteries. Little effect on platelet, rather inhibits fibrin stabilization of thrombi *(Weislander, JB, et al., 1986)*
- No effect on overall flap survival when compared with aspirin. Systemic complications 3.9-7.2 times more common with dextran infusion *(Disa J., et al, 2001)*
- Complications can include renal damage, anaphylactic shock, congestive heart failure, MI, pulmonary edema, pleural effusion, pneumonia

Aspirin

- Prevent platelet thrombosis
- Inhibits arachidonic acid to prostaglandin synthesis on the platelet—prevents release of platelet granuoles that cause platelet aggregation. Mechanism is biphasic and dose-dependant
- High doses of aspirin can have negative effect on endothelial production of prostacyclin which prevents platelet accumulation on exposed collagen and dilates vessels.
- ASA PR qd x several weeks (often given at beginning of case)—5 grains (325 mg)
- No good studies to confirm benefit of use
- Hematoma formation



Heparin

- Naturally occuring glycosoaminoglycan which interrupts clotting cascade
  - Prevents transformation of prothrombin to thrombin, fibrinogen to fibrin
  - Does not lyse existing thrombi
- Strongly adheres to endothelium
  - Concentration on endothelium 100x serum
- ½ life = 90 minutes
- Given at time of first quarter of arterial anastomoses vs. at time of unclamping (bolus only vs. bolus with drip x 3 days)
- Literature unconvincing, although it may increase microvascular perfusion after ischemia
- Hematoma formation
- Used as irrigation solution
- Local infusion may possibly be beneficial

Low molecular weight heparin

- Appears to decrease vessel thrombosis in renal transplants

- *Broyer M, et al.,1991, Alkhunaizi AM, et al, 1998*

Flap monitoring

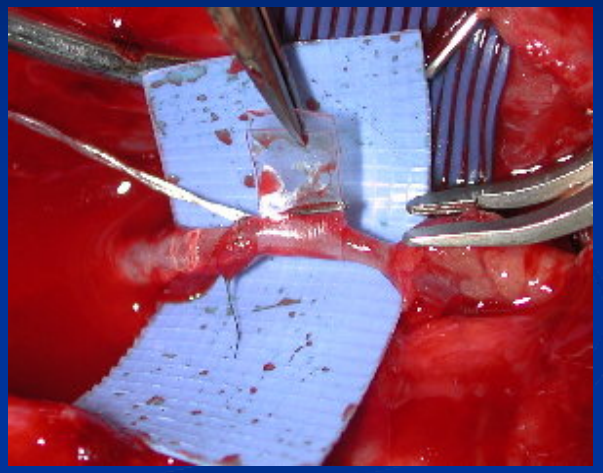
- Clinical –"flap checks"
  - Most commonly used
  - Warmth
  - Color
  - Pin prick
  - Wound monitoring (hematoma, fistula)
  - Frequency
- Mechanical
  - Doppler
    - Implanted vs. external vs. color flow
  - Other

Clinical flap monitoring

- Normal exam:
  - Warm, good color, CRT 2-3 seconds, pinprick slightly delayed with bright red blood
- Venous occlusion (delayed):
  - Edema, mottled/purple/petechiae, tense
  - CRT decreased
  - Pinprick – immediate dark blood, won't stop
- Arterial occlusion (usually <72hr):
  - Prolonged CRT, temperature, turgor
  - Pale
  - Pinprick—little bleeding, very delayed

Mechanical flap monitoring

- Doppler
  - External
  - Implanted
    - Buried flaps
    - 80-100% salvage
      (Disa J, et al 1999)
  - Color flow
- Other



Antibiotics

- 8-20% of patients undergoing free tissue transfer will develop an infection despite intravenous antibiotic coverage.*(Cloke DJ., et al, 2004)*
- 1 day vs. 5 day course of Clindamycin showed no significant difference in free flap survival *(Carroll WR., et al., 2003)*
- Topical antibiotics in combination with intervenous antibiotics did not show a significant difference in post-operative complications after free tissue transfer *(Simons JP, et al., 2001)*

Free flap reconstruction

- Longer ICU stay,
- More expensive,
- Longer OR time