Skin Grafts and Skin Flaps

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PLASTIC AND RECONSTRUCTIVE SURGERY :

THE ROLE OF HYPERBARIC OXYGEN THERAPY

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THE RECONSTRUCTIVE LADDER

- SKIN GRAFTS
- LOCAL FLAPS
- DISTANT FLAPS
- FREE FLAPS

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SKIN GRAFTS

- AVASCULAR PIECES OF TISSUE
- SURVIVE BY SERUM IMBIBITION (48-72 HOURS)
- RED CELLS PRESENT IN GRAFT ON 3-4 TH DAY
- BLOOD FLOW IN THE GRAFT ON 5-6 TH DAY

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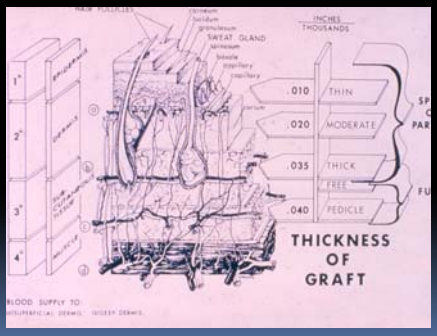
SKIN GRAFTS



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SPLIT THICKNESS SKIN GRAFT

- EPITHELIUM AND PORTION OF DERMIS
- DONOR SITE RE-EPETHIALIZES FROM HAIR FOLLICLES AND OTHER ADENEXAL STRUCTURES
- TAKES APPROXIMATELY THREE WEEKS TO RECOVER THE DONOR SITE

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ADVANTAGES OF STSG

- LARGE AMOUNT OF DONOR SITE
- DONOR SITE CAN BE RE-GRAFTED
- GRAFTS CAN BE MESHED TO INCREASE SURFACE AREA
- EASIER TAKE THAN FTSG

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DERMATOME

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STSG

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FULL THICKNESS SKIN GRAFTS (FTSG)

- CONTAINS ENTIRE EPITHELIUM AND DERMIS
- DONOR SITE MUST BE CLOSED PRIMARILY OR GRAFTED

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ADVANTAGES OF FTSG

- RESISTANCE TO WEAR
- LESS SHRINKAGE OR CONTRACTURE THAN STSG
- BETTER RETURN OF SENSATION AND ADNEXAL FUNCTION
- LESS CONTOUR DEFORMITY

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SKIN GRAFT COMPLICATIONS/ FAILURE

- INFECTION
- HEMATOMA / SEROMA
- INADEQUATE RECIPIENT SITE VASCULARITY
- MOTION OR SHEARING FORCES BETWEEN GRAFT AND RECIPIENT SITE
- DONOR SITE COMPLICATIONS

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FLAPS

- VASCULARIZED PIECES OF TISSUE
- CAN INCLUDE : *SKIN, SUBCUTANEOUS TISSUE (FAT), MUSCLE OR BONE*
- NO PERIOD OF ISCHEMIA (*UNLIKE GRAFTS)*
- DO NOT REQUIRE WELL VASCULARIZED RECIPIENT SITES
- CAN TOLERATE HIGHER LEVELS OF BACTERIAL CONTAMINATION

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FLAP CLASSIFICATION

- SKIN AND FASCIA (FASCIOCUTANEOUS)
- SKIN AND MUSCLE (MUSCUOLOCUTANEOUS)
- MUSCLE
- OSSEO-MUSCULO-CUTANEOUS
- BONE
- SKIN AND SUBCUTANEOUS TISSUE

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FLAP CLASSIFICATION BY BLOOD SUPPLY

- LOCAL ROTATION
- DISTANT
- FREE

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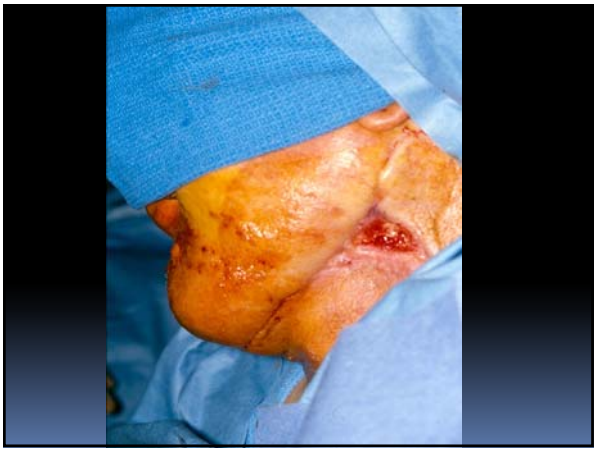

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FLAP COMPLICATIONS

- LOSS OF BLOOD SUPPLY TO PORTION OR ALL OF THE FLAP
  - FLAP IS BIGGER THAN BLOOD SUPPLY TERRITORY
  - COMPRESSION OR TORSION OF PEDICLE
  - IATROGENIC INJURY TO BLOOD SUPPLY (WHOOPS)
  - TOO MUCH TENSION ON FLAP CLOSURE
- VENOUS CONGESTION
- INFECTION

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DISTANT FLAP

- ATTACHED AT DONOR AND RECIPIENT SITE TO ALLOW INGROWTH OF VESSELS FROM RECIPIENT SITE TO FLAP
- SECOND PROCEDURE DIVIDES THE ORIGIONAL BLOOD SUPPLY AND FLAP IS DEPENDENT ON RECIPIENT SITE
- THREE WEEK PERIOD OF ATTACHMENT AT DONOR AND RECIPIENT SITE

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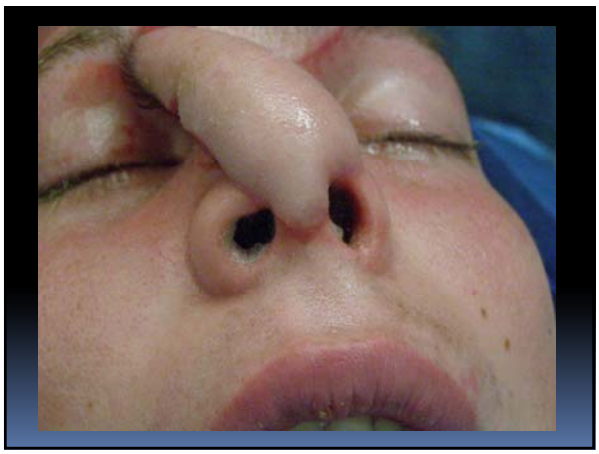

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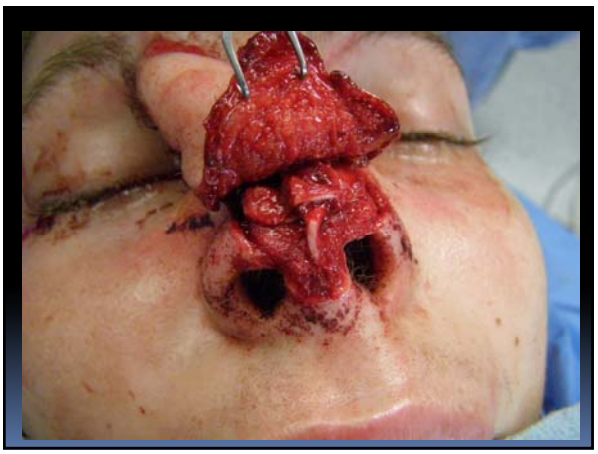

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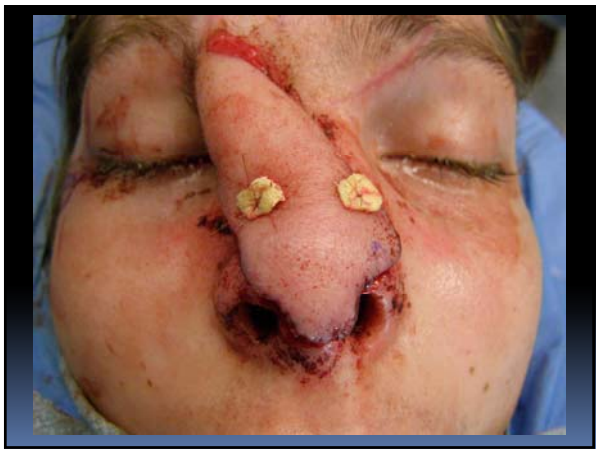

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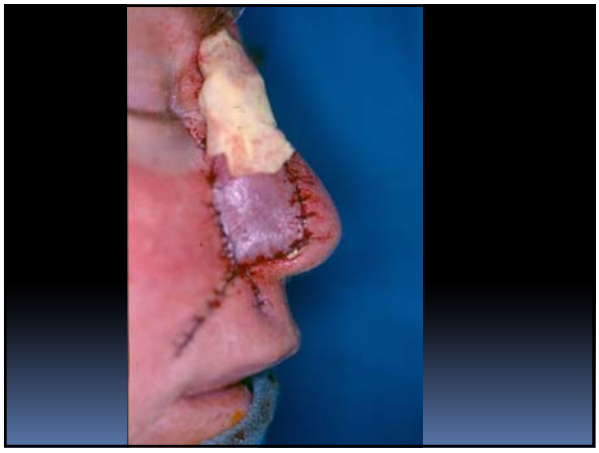

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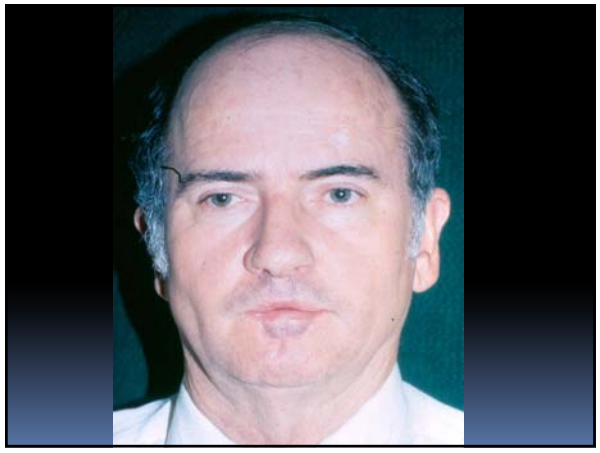

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FREE FLAPS

- CAN MOVE LARGE PORTIONS OF TISSUE FROM DISTANT SITE WITHOUT PERIOD OF ATTACHMENT USING MICROSURGICAL TECHNIQUES

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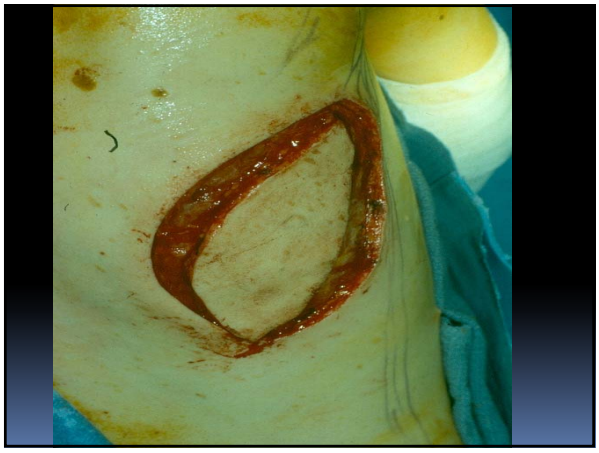

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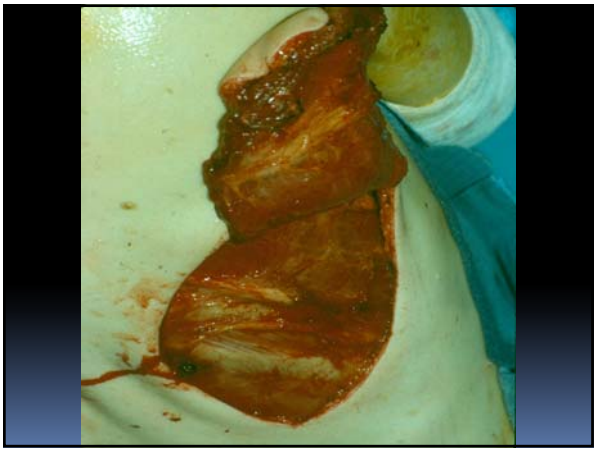

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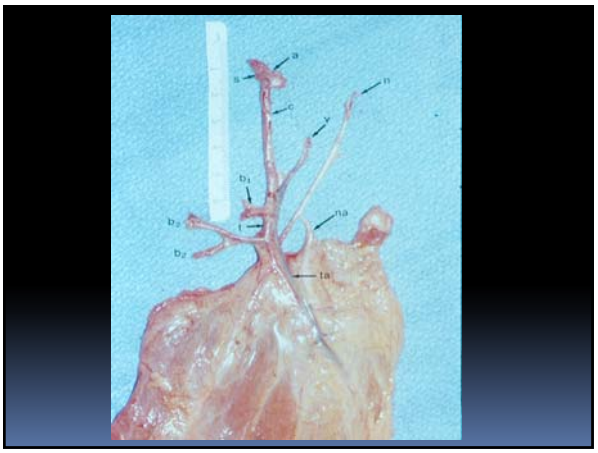

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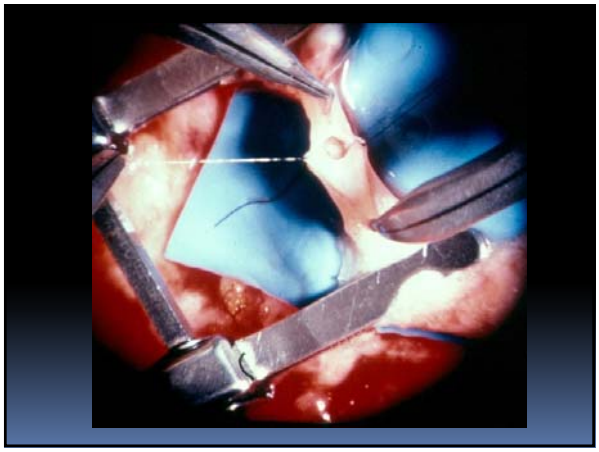

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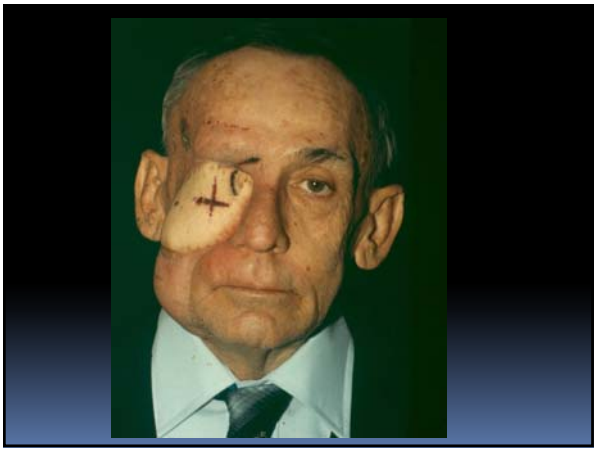

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COMPLICATIONS OF FREE FLAPS

- ARTERIAL INFLOW OCCLUSION
  - THROMBUS
  - KINKING OF THE PEDICLE
  - OTHER TECHNICAL PROBLEMS
- VENOUS OUTFLOW OCCLUSION
- OTHER TECHNICAL PROBLEMS

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PLASTIC SURGERY AND HBO

- STIMULATES FIBROBLASTS AND COLLLAGEN SYNTHESIS
- ENHANCES LEUKOCYTE FUNCTION AND BACTERIAL CLEARENCE
- STIMULATES ANGIOGENESIS

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HBO AT THE CELLULAR LEVEL

- ANGIOGENESIS = NEW BLOOD VESSEL GROWTH BY LOCAL ENDOTHELIAL CELLS
- VASCULOGENESIS = THE RECRUITMENT AND DIFFERENTIATION OF CIRCULATING STEM/ PROGENITOR CELLS TO FORM NEW VESSELS DE NOVO
- HBO EFFECTS BOTH PROCESSES

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HBO AND BONE MARROW

- HBO STIMULATES NITROGEN OXIDE SYNTHETASE (NOS)
- NOS MOBILIZES STEM / PROGENITOR CELLS (human)
- STEM / PROGENITOR CELLS HOME TO WOUNDS AND ACCELERATE HEALING (animal)

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HBO AND LOCAL STEM CELLS

- AS A SEPARATE EFFECT HBO AT THE LOCAL WOUND LEVEL STIMULATES STEM / PROGENITOR CELLS TO PRODUCE VASCULAR GROWTH FACTORS

COMPLICATED PROCESS: HBO → OXIDATIVE STRESS AT SITES OF NEOVASCULARIZATION → PRODUCTION OF ANTIOXIDANT THIOREDOXIN

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HBO AND LOCAL STEM CELLS

- THIOREDOXIN → TRANSCRIPTION FACTOR

CAUSING STEM CELLS TO PROMOTE AND EXPRESS

HYPOXIA – INDUCIBLE FACTORS (HIF) →

STIMULATE GENES INVOLVED IN NEOSCULARIZATION

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HBO AND OTHER FACTORS

- VASCULAR ENDOTHELIAL GROWTH FACTOR (VEGF) INFLUENCES STEM CELLS HOMING TO WOUNDS AND DIFFERENTIATION INTO ENDOTHELIAL CELLS
- VEGF IS THE MOST SPECIFIC FACTOR FOR NEOVASCULARIZATION
- HBO INCREASES SYNTHESIS OF VEGF

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HBO AND WOUND FACTORS

- HBO STIMULATES SYNTHESIS OF :

VEGF
FGF (FIBROBLAST GROWTH FACTOR)
TGF B (TRANSFORMING GROWH FACTOR)
ANGIOPOIETIN (WORKS LIKE VEGF)
HEPATOCYTE GROWTH FACTOR
PDGF (PLATELET DERIVED GROWTH FACTOR)

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HBO AND SKIN GRAFTS

- USED TO HELP RECIPIENT WOUNDS UNDERGO ANGIOGENESIS FOR GRAFT SUPPORT
- HELPS TO PREPARE A HYPOXIC COMPROMISED RECIPIENT BED FOR GRAFTING

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WOUNDS THAT MIGHT REQUIRE HBO

- DIABETIC ULCERS
- VENOUS STASIS ULCERS
- ARTERIAL INSUFFICIENCY WOUNDS
- DECUBITUS ULCERS
- VASCULITIC WOUNDS

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VENOUS STASIS ULCERS

- HALLMARK OF THERAPY : EDEMA REDUCTION (UNA BOOTS, COMPRESSION STOCKINGS, LEG PUMPS)
- HBO MAY BE USED AS AN ADJUNCT TO PREPARE VENOUS LEG ULCERS FOR GRAFTING IN REFRACTORY CASES (IF GRAFTS ARE NEEDED)
- HAMMERLAND 1994 (PLAST. RECONS. SURG) DOUBLE BLIND RCT SHOWED REDUCTION IN ULCER SIZE AFTER 6 WEEKS (36% HBO VS 4% CONTROLS

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DECUBITUS ULCERS (PRESSURE SORES)

- CAUSED BY PRESSURE NECROSIS
- TREATMENT IS : RELIEF OF PRESSURE, DEBRIDEMENT, FLAP CLOSURE
- HBO NOT INDICATED

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HBO AND CONNECTIVE TISSUE DISEASES

- FEW REPORTED SUCCESSES PYODERMA GANGRENOSA
- RESULT WITH OTHER CONNECTIVE TISSUE DISORDERS (LUPUS, SCLERODERMA ETC) IS NOT CLEAR
- Efrati et al. 2007 Clin. Exp. Derm. Leg ulcers with proven vasculitis (despite steroids). HBO improved chance of healing by factor of 2 with decreased doses of prednisone

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VASCULAR INSUFFICIENCY NON-DIABETIC

- ARTERIOGRAM
- REVASCULARIZATION (BY-PASS)
- TRIAL OF HBO IF $TcPO_2 \leq 40$ AND BONE OR TENDON NOT EXPOSED
- ZHAO LL ET AL- ISCHEMIC RABBIT EAR MODEL
- GROLMAN ET AL 2001 RETROSPECTIVE REVIEW OF PATIENTS. WHEN Δ Tcom ≥ 10 mmHg (100% 02 at sea level) 70% wound healing vs 1% when Δ Tcom ≤ 10 mm Hg. All PATIENTS RECEIVED HBO

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FLAPS

- PROBLEMS WITH ARTERIAL INFLOW OR VENOUS OUTFLOW
- TOTAL OR PARTIAL
- DX MADE BY CLINICAL EXAMINATION AFTER THE FLAP IS CREATED
- HBO TREATMENT IS ADMINISTERED POST-OPERATIVELY
- WHEN SURGICAL CORRECTION IS NOT POSSIBLE

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SURGICAL CORRECTION

- RELIEVE TENSION ON PEDICLE (TAKE OUT SUTURES - RELEASE DRESSINGS)
- EVACUATE HEMATOMA
- FREE FLAPS- EXPLORE AND CORRECT PROBLEMS WITH ANASTAMOSES

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ANIMAL FLAP STUDIES

- RANDOM FLAPS
- MOST RODENT STUDIES SHOW A 15 TO 30% IMPROVEMENT IN FLAP SURVIVAL

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Zamboni et al (Mechanisms for HBO effect on ischemia reperfusion)

- 1989: HBO given during or after 8 hrs of ischemia reduced flap/muscle necrosis
- 1992: Laser doppler flow study confirms
- 1993: 4 hr skeletal muscle ischemia. HBO reduces neutrophil adherence to endothelial walls and arteriolar vasoconstriction
- 1997: 4hr skeletal muscle ischemia. Monocloncal antibodies against CD-18 neutrophile integrin gives same effect as HBO

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Zamboni et al (Mechanisms for HBO effect on ischemia reperfusion)

- 2008: Both hyperbaric and hyperoxic environments are needed for HBO effect on neutrophile CD-18 and flap survival
- 2010 : Demonstrated that NO is important to this process. Blocking nitric oxide synthetase or using NO scavenger inhibits the positive effect of HBO on ischemic flap survival

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COMPROMISED FLAPS

- Beson et al 2003:
- THERE IS A SEPARATE PATHWAY FOR HBO TO IMPAIR PRO-INFLAMMATORY CYTOKINE PRODUCTION BY MONOCYTE/ MACROPHAGES
- THIS FUNCTION MAY ALSO IMPROVE FLAP SURVIVAL
- HBO IMPROVE S ISCHEMIC TOLERANCE IN MANY TISSUES THROUGH MECHANISMS NOT COMPLETELY UNDERSTOOD (alterations in hypoxia inducible factors (HIF) production)

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Distant Flaps

- Bayati et al (1998 Plastic Reconstr. Surg.)

Compared pre-fabricated musculocutaneous flaps and cutaneous flaps treated with either HBO or FGF (fibroblast growth factor).

Either treatment improved amount of flap survival. Both treatments were synergistic

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COMPROMISED FLAPS SUMMARY

- HBO ANTAGONIZES THE EFFECT OF ISCHEMIA REPURFUSION INJURY
- INCREASES MICROVASCULAR OXYGENATION
- REDUCES NEUTROPHILE ENDOTHELIAL ADHERENCE (altering B2 neutrophil integrins –via modification of actin cross-linking in neutrophils)
- HENCE BLOCKING PROGRESSIVE ARTERIOLAR VASOCONSTRICTION

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FREE FLAPS

- ALL FREE FLAPS HAVE A PERIOD OF ISCHEMIA WHILE THE FLAPS ARTERIAL SUPPLY IS DIVIDED BEFORE IT IS RE-ESTABLISHED AT THE DONOR SITE
- PERIOD OF ISCHEMIA MAY BE SEVERAL HOURS .
- MUSCLE WARM ISCHEMIA MAXIMUM TIME IS ABOUT 3 HOURS

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FREE FLAP

- FLAP DOES WELL IMMEDIATELY POST OP
- THEN SUDDENLY BECOMES UNDERPERFUSED
- RECOMMEND RE-EXPLORATION AND REVISION OF ANASTAMOSES →
- ADDITIONAL ISCHEMIA →
- NEUTROPHIL ADHERENCE →
- HBO (there must be blood flow in the flap)

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VENOUS CONGESTION

- PARTIAL CONGESTION → LEECHES
- HBO MAY BE AN ADJUNCT
- COMPLETE VENOUS OCCLUSION HBO ALONE IS INEFFECTIVE

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VENOUS CONGESTION

- Lorenzo et al (1999- Plast. Reconstr. Surg.)
- Rats with axial pattern flaps divided into 5 groups: 1) sham operated, 2) total venous occlusion (TVO) , 3) TVO + HBO, 4) TVO + leeches, 5) TVO + HBO + leeches
- 1) 100% flap survival, 2) 0%, 3) 1%, 4) 25%, 5) 67%

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