Skin Grafts and Skin Flaps

Harold Friedman, MD, PhD, FACS

HAROLD FRIEDMAN MD, PhD
Division of Plastic and Reconstructive Surgery
USC School of Medicine

PLASTIC AND RECONSTRUCTIVE SURGERY :

THE ROLE OF HYPERBARIC OXYGEN THERAPY

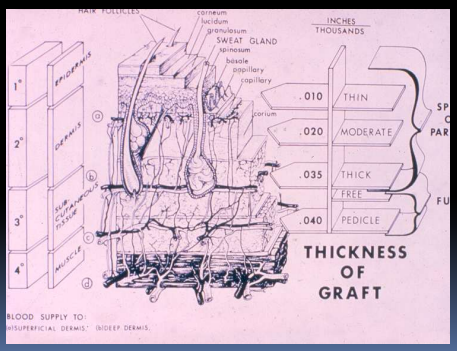
THE RECONSTRUCTIVE LADDER

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

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

SKIN GRAFTS



SPLIT THICKNESS SKIN GRAFT

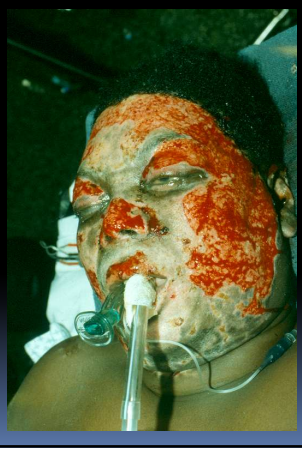
- EPITHELIUM AND PORTION OF DERMIS
- DONOR SITE RE-EPETHIALIZES FROM HAIR FOLLICLES AND OTHER ADENEXAL STRUCTURES
- TAKES APPROXIMATELY THREE WEEKS TO RECOVER THE DONOR SITE

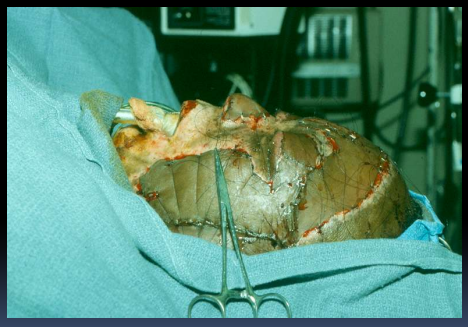
ADVANTAGES OF STSG

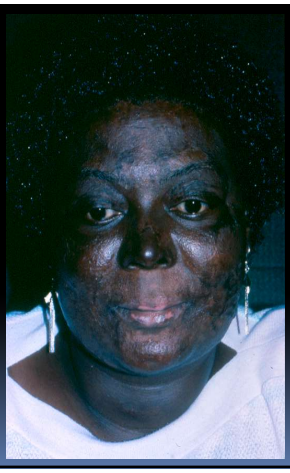
- LARGE AMOUNT OF DONOR SITE
- DONOR SITE CAN BE RE-GRAFTED
- GRAFTS CAN BE MESHED TO INCREASE SURFACE AREA
- EASIER TAKE THAN FTSG

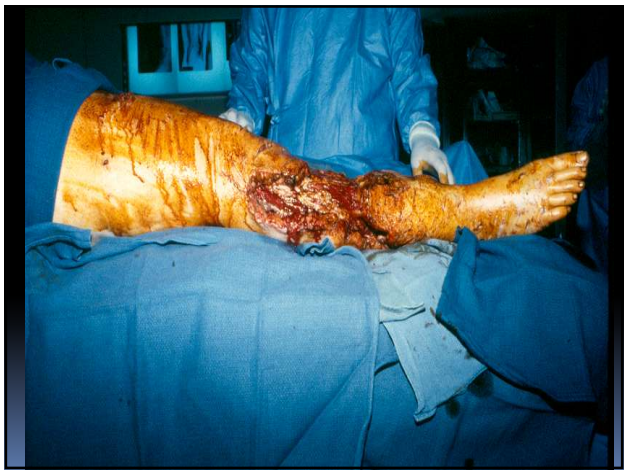
DERMATOME

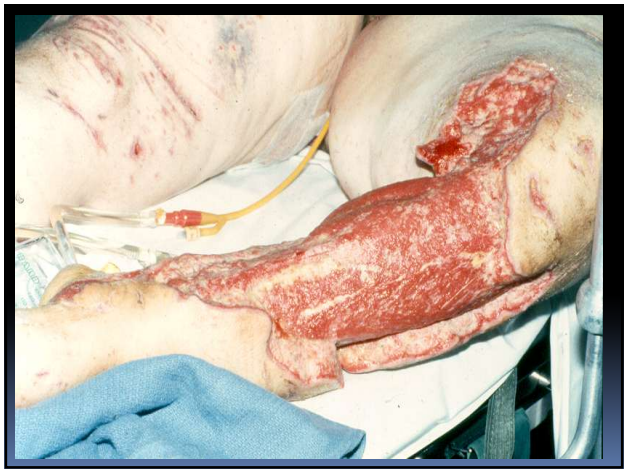
STSG











Hyperbaric oxygen and wound healing. S. Bhutani and G. Vishwanath . Indian J Plastic Surgery 45 (2):316. 2012

FULL THICKNESS SKIN GRAFTS (FTSG)

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

ADVANTAGES OF FTSG

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

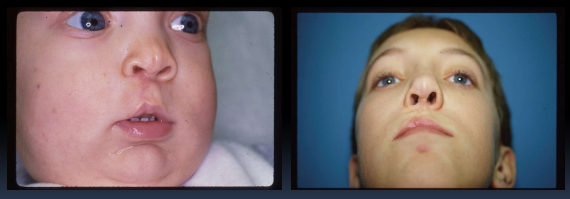
SKIN GRAFT COMPLICATIONS/ FAILURE

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

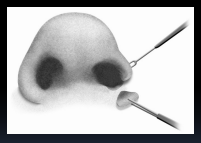
Composite Grafts

- Defects composed of more than just skin (i.e missing fat, cartilage and skin
- Maximum size that one might expect survival is around 1-1.5cm
- Could HBO push this boundary updward?

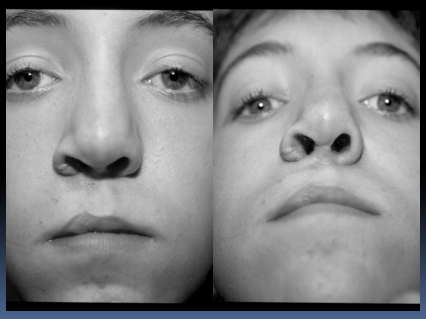
Composite Grafts



Composite grafts



Composite grafts



Composite grafts and HBO

Composite Grafts

- **Friedman, HI**, Stonerock C, Brill, A: Composite earlobe grafts to reconstruct the lateral nasal ala and sill. Ann. Plast. Surg. 50: 275 – 281 2003

Composite Grafts

- Hyperbaric Oxygen Therapy for Large Composite Grafts: An Alternative in Pedicatric Facial Reconstruction. Camison et al. JPRAS 73: 2178-2184.2020

Composite Grafts

Composite Grafts

Composite Grafts

FLAPS

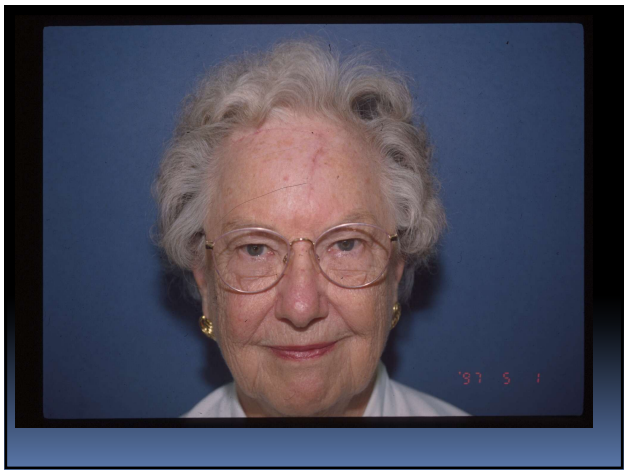
- VASCULARIZED PIECES OF TISSUE
- CAN INCLUDE : *SKIN, SUBCUTANEOUS TISSUE (FAT), MUSCLE OR BONE*
- NO PERIOD OF ISCHEMIA (*UNLIKE GRAFTS)*
- DO NOT REQUIRE WELL VASCULARIZED RECIPIENT SITES
- CAN TOLERATE HIGHER LEVELS OF BACTERIAL CONTAMINATION

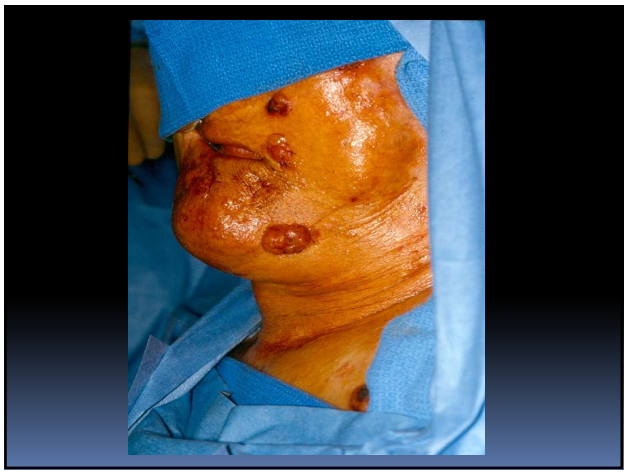
FLAP CLASSIFICATION

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

FLAP CLASSIFICATION BY BLOOD SUPPLY

- LOCAL ROTATION
- DISTANT
- FREE



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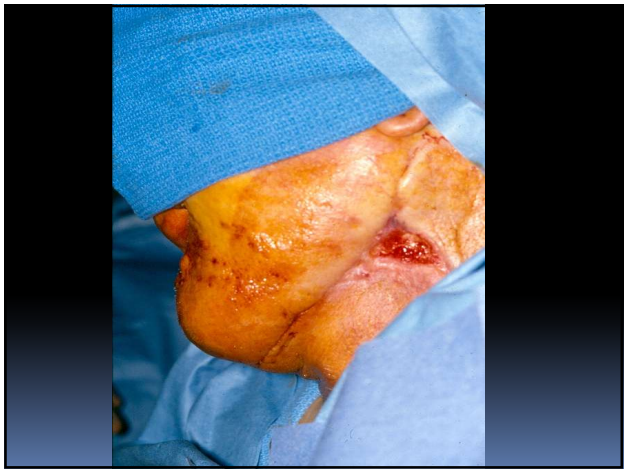
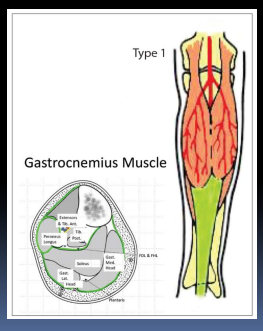
PRE HBO

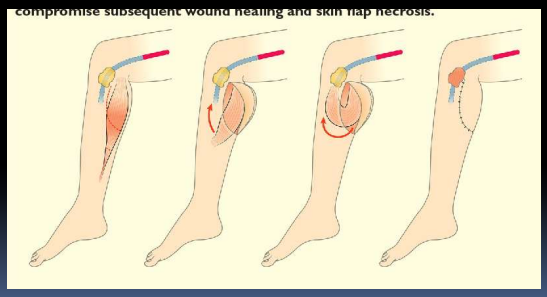


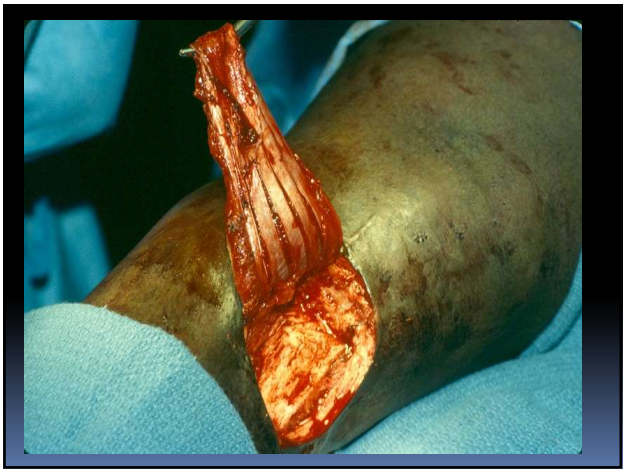
Gastrocnemius muscle

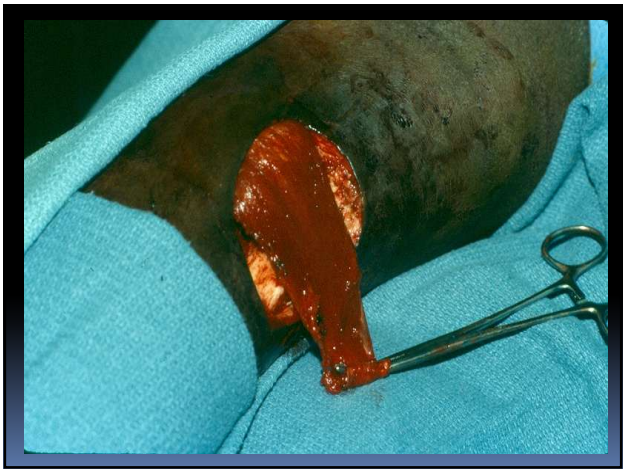


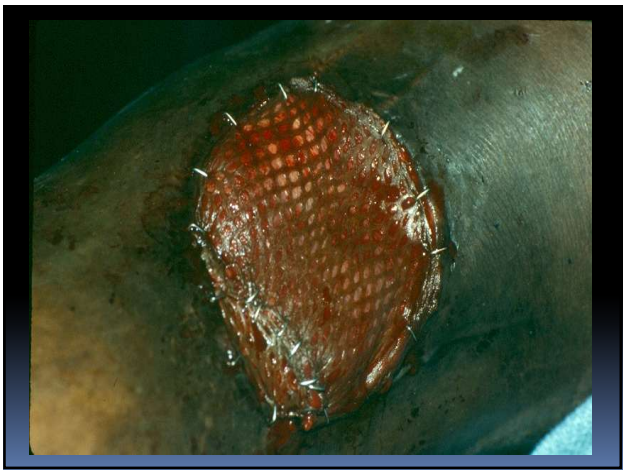
Gastrocnemius muscle flap

compromise subsequent wound healing and skin flap necrosis.







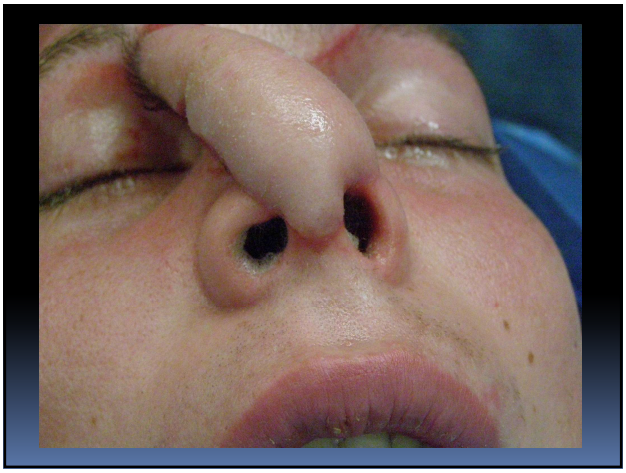


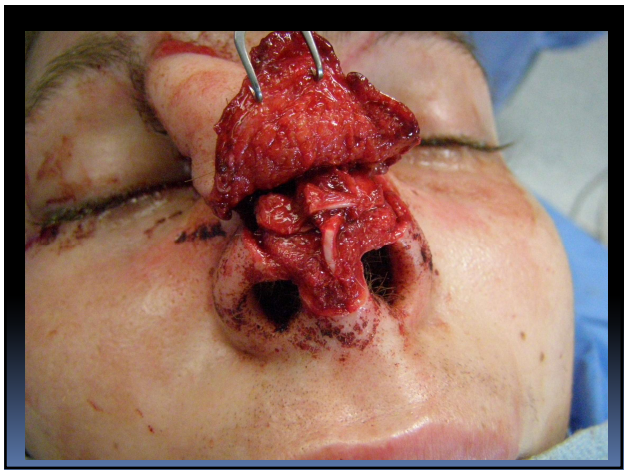
FLAP COMPLICATIONS

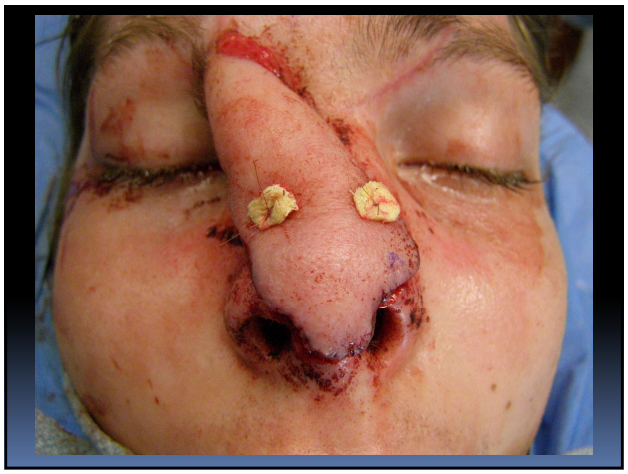
- LOSS OF BLOOD SUPPLY TO PORTION OR ALL OF THE FLAP
  - FLAP IS BIGGER THAN BLOOD SUPPLY TERRITORY
  - COMPRESSION OR TORSION OF PEDICLE
  - IATROGENIC INJURY TO BLOOD SUPPLY (WHOOPS)
  - TOO MUCH TENSION ON FLAP CLOSURE
- VENOUS CONGESTION
- INFECTION

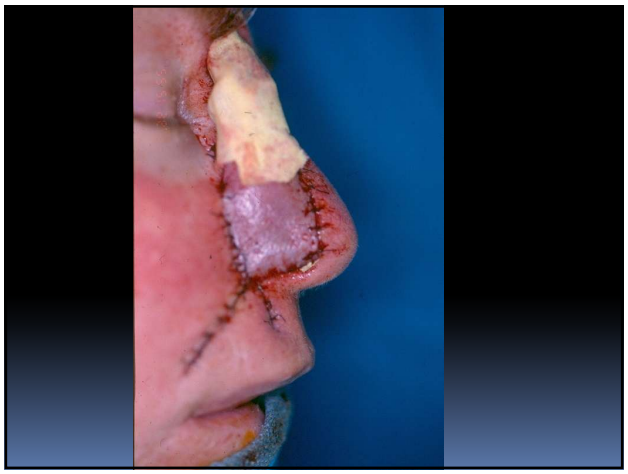
DISTANT FLAP

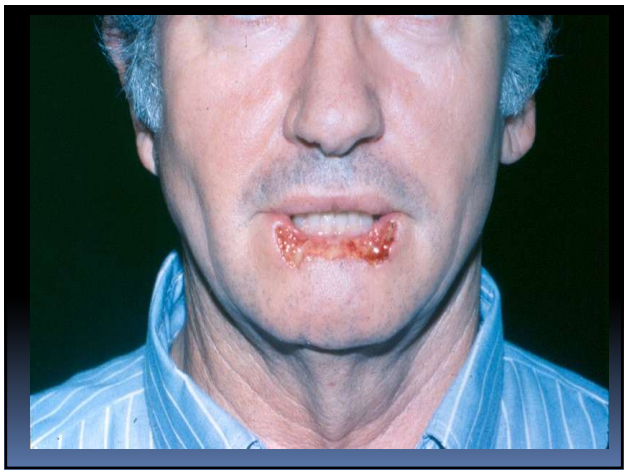
- ATTACHED AT DONOR AND RECIPIENT SITE TO ALLOW INGROWTH OF VESSELS FROM RECIPIENT SITE TO FLAP
- SECOND PROCEDURE DIVIDES THE ORIGIONAL BLOOD SUPPLY AND FLAP IS DEPENDENT ON RECIPIENT SITE
- THREE WEEK PERIOD OF ATTACHMENT AT DONOR AND RECIPIENT SITE

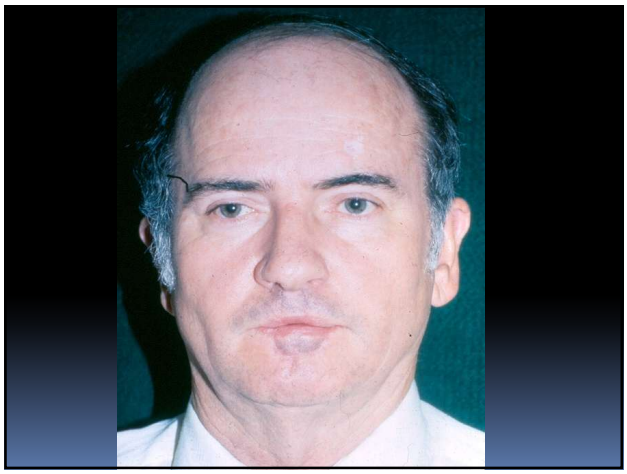






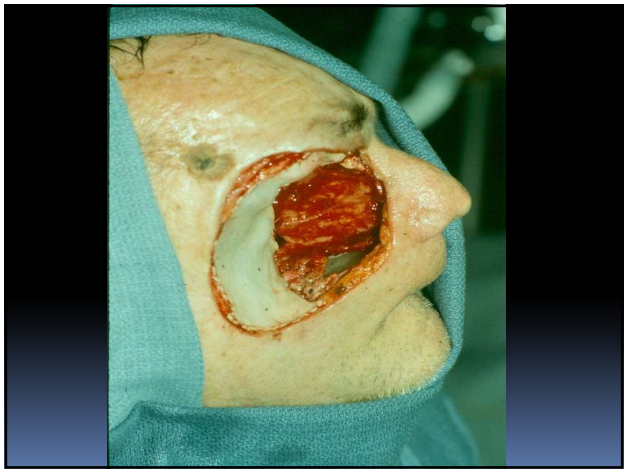


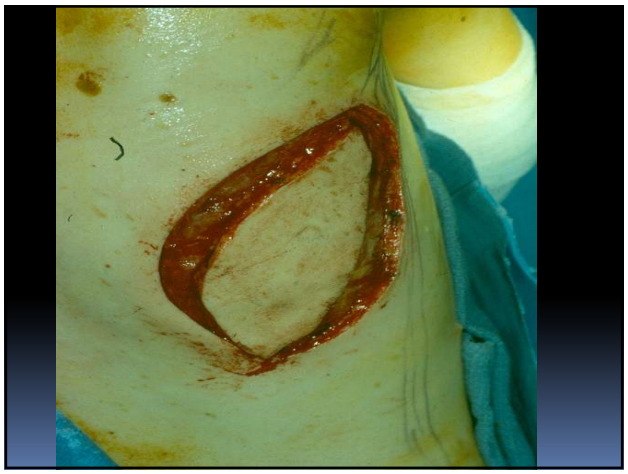


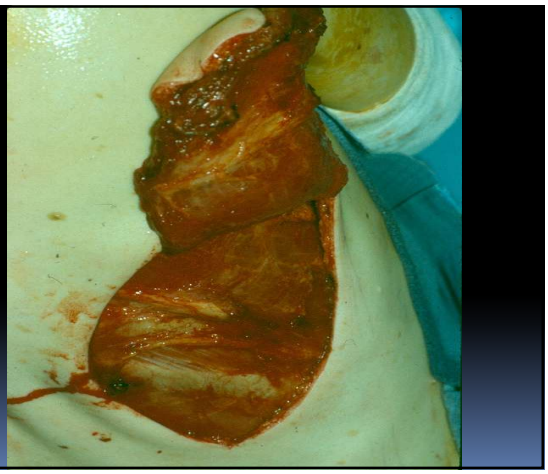


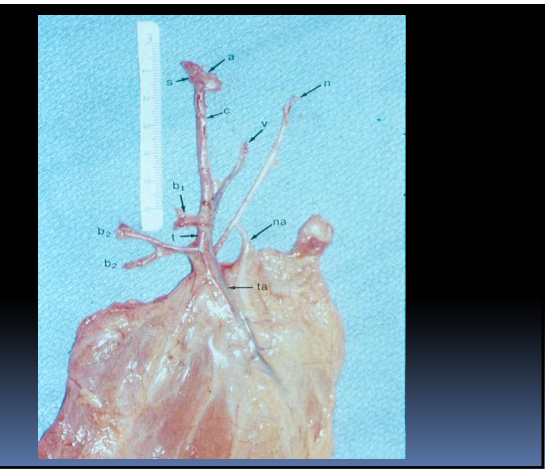
FREE FLAPS

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





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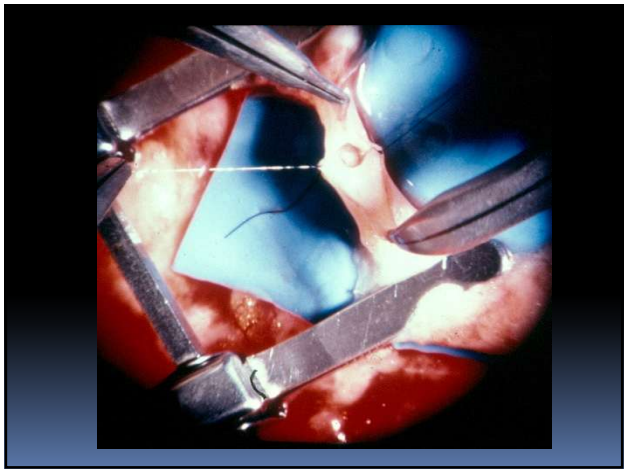
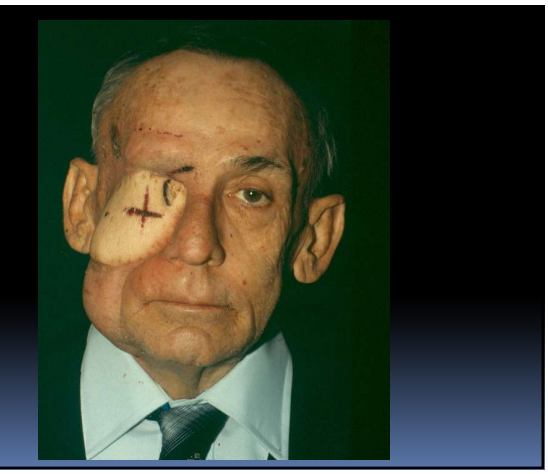
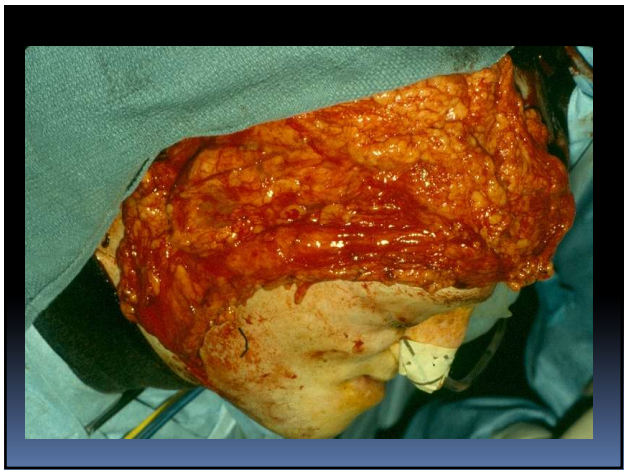






COMPLICATIONS OF FREE FLAPS

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

PLASTIC SURGERY AND HBO

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

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 POSITIVELY EFFECTS BOTH PROCESSES

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)

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

HBO AND LOCAL STEM CELLS

- THIOREDOXIN ➡ TRANSCRIPTION FACTOR

CAUSING STEM CELLS TO PROMOTE AND EXPRESS

HYPOXIA – INDUCIBLE FACTORS (HIF) ➡

STIMULATE GENES INVOLVED IN NEOSCULARIZATION

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

HBO AND SKIN GRAFTS

- USED TO HELP RECIPIENT WOUNDS UNDERGO ANGIOGENESIS FOR GRAFT SUPPORT
- HELPS TO PREPARE A HYPOXIC COMPROMISED RECIPIENT BED FOR GRAFTING – (Used Preoperatively)

WOUNDS THAT MIGHT REQUIRE HBO

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

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)
- Z. Bai et al. Effect of hyperbaric oxygen therapy on the patients with venous leg ulcer: A systemic review and meta-analysis. Asian J. Surgery 46 : 4131-4137. 2023 Conclusion: HBO was helpful in patients having surgery for venous stasis ulcers

DECUBITUS ULCERS (PRESSURE SORES)

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

HBO AND CONNECTIVE TISSUE DISEASES

- FEW REPORTED SUCCESSES PYODERMA GANGRENOSA (RECENT LITERATURE REVIEW)
- 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

VASCULAR INSUFFICIENCY NON-DIABETIC

- ARTERIOGRAM
- REVASCULARIZATION (BY-PASS)
- TRIAL OF HBO IF $TcPO2 \leq 40$ AND BONE OR TENDON NOT EXPOSED
- ZHAO LL ET AL- ISCHEMIC RABBIT EAR MODEL
- GROLMAN ET AL 2001 RETROSPECTIVE REVIEW OF PATIENTS.

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

SURGICAL CORRECTION

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

HBO Mechanisms of Action

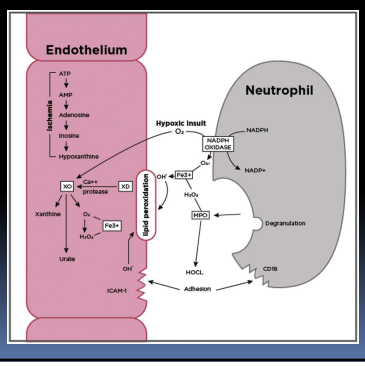
Zamboni et al in a period of time spanning 1989 - 2010 demonstrated the following:

1. HBO reduces flap/muscle ischemia induced necrosis
2. Reduces neutrophil adherence to endothelial walls and arteriolar vasoconstriction by blocking the action of integrins (CD-18) on the surface of neutrophils.
3. Both hyperbaric and hyperoxic are required for the effect on integrins and flap survival

HBO Mechanisms of Action

- 4. Nitric oxide is important to this process. Blocking NO synthetase or using a NO scavenger inhibits the positive effect of HBO on flap survival

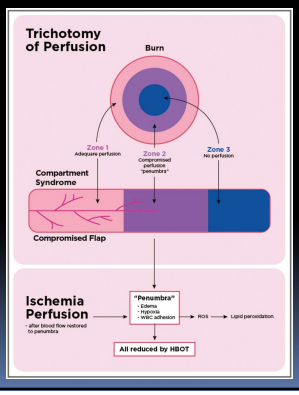
Defining the Role of Hyperbaric Oxygen Therapy as an Adjunct to Reconstructive Surgery. MJ Harl. Surgical Clinics of North America 100: 777-785. 2020



SUMMARY

- HBO ANTAGONIZES THE EFFECT OF ISCHEMIA REPURFUSION INJURY (HELPS SCAVANGE OXYGEN FREE RADICALS)
- INCREASES MICROVASCULAR OXYGENATION
- REDUCES NEUTROPHILE ENDOTHELIAL ADHERENCE HENCE BLOCKING PROGRESSIVE ARTERIOLAR VASOCONSTRICTION

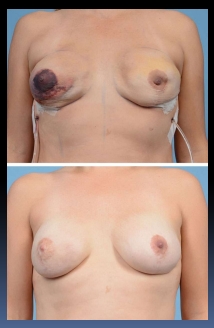
Defining the Role of Hyperbaric Oxygen Therapy as an Adjunct to Reconstructive Surgery. MJ Harl. Surgical Clinics of North America 100: 777-785. 2020



ANIMAL FLAP STUDIES

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

P. Lofti et al. Hyperbaric oxygen therapy and mastectomy flap oschemia following nipple-sparing mastectomy and immediate breast reconstruction. PRS 145 (6) 1114-1115e. 2020



FREE FLAPS

- ALL FREE FLAPS HAVE A PERIOD OF WARM 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

FREE FLAP

- Flap does well immediately postop
- Then suddenly it becomes underperfused
- It is too big a piece of tissue for HBO to help
- Recommend re-exploration and re-establish blood supply to the flap
- Additional ischemia during the re-exploration
- Neutral fill adherence–Oxygen free radicals build up.
- Recommend HBO after blood flow re-established (there must be blood flow in the flap)

VENOUS CONGESTION

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

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%

Summary HBO Plastic Surgery

- Significant amount of basic science research supporting the use of HBO to : stimulate angiogenesis for improved graft take and improve flap survival.
- Multiple case series support the use of HBO in plastic surgery
- However, there is a paucity of prospective randomized, controlled trials in the plastic surgery literature (matching HBO with other modalities like wound vacs, Integra, nitropaste etc).

Additional Bibliography

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3. R. Simman, K. Bach. Role of hyperbaric oxygen therapy in cosmetic and reconstructive surgery in ischemic soft tissue wounds: A case series. ePplasty 22.2022e61. 1-4.
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