

# **Skin Grafts and Skin Flaps**

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## PLASTIC AND RECONSTRUCTIVE SURGERY : THE ROLE OF HYPERBARIC OXYGEN THERAPY

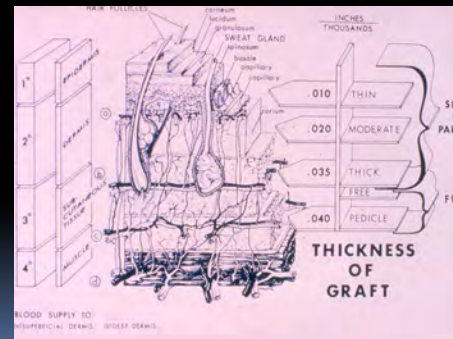
## THE RECONSTRUCTIVE LADDER

- 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

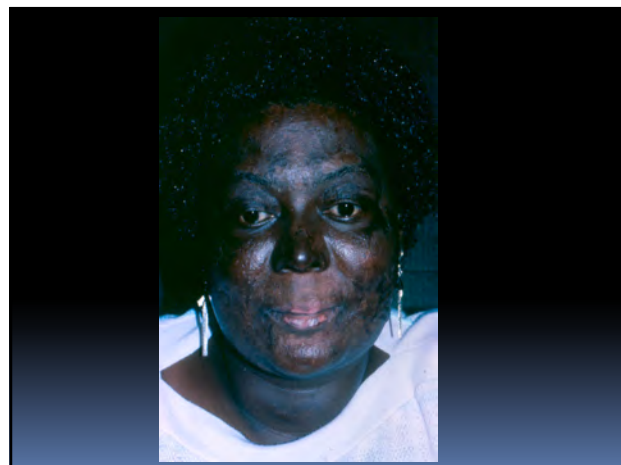
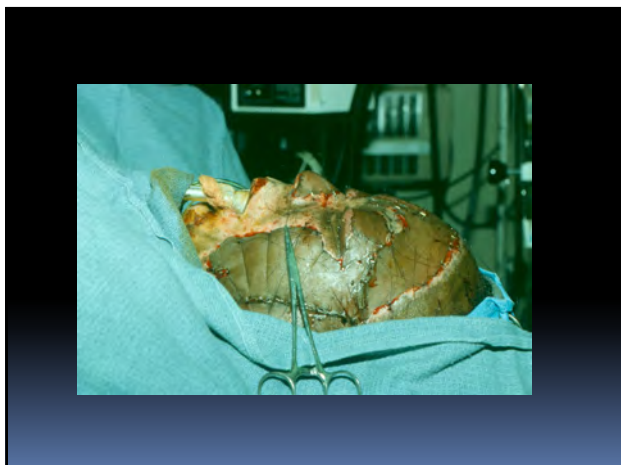
## ADVANTAGES OF STSG

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

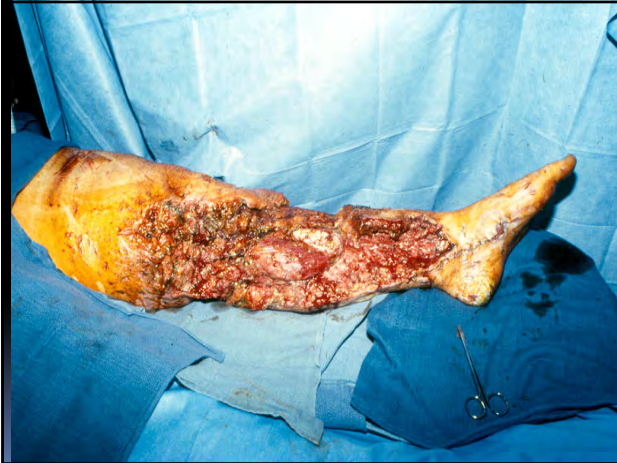
DERMATOME



STSG









### 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

## FLAPS

- VASCULARIZED PIECES OF TISSUE
- CAN INCLUDE : *SKIN, SUBCUTANEOUSTISSUE (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

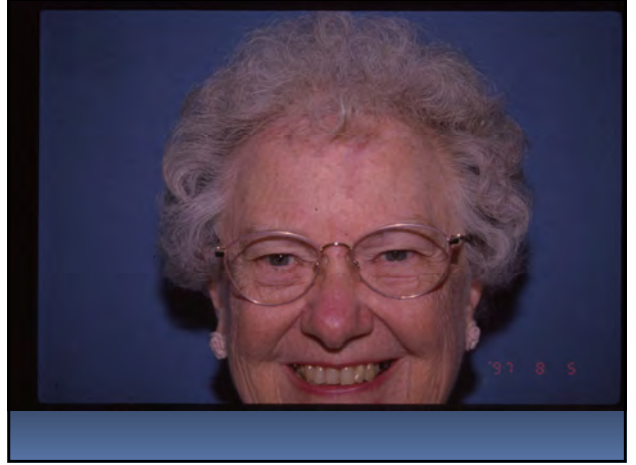
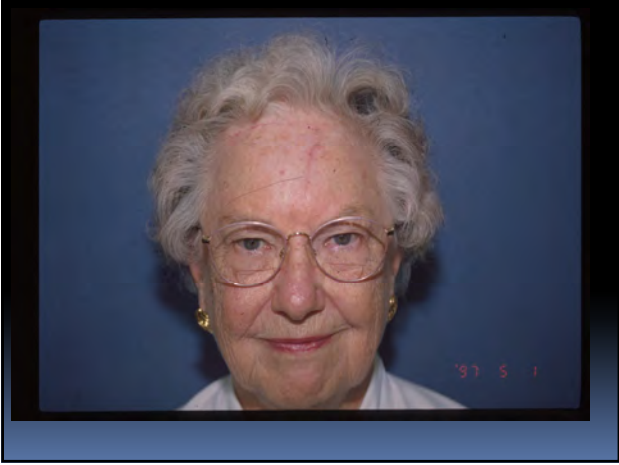
- SKIN AND FASCIA (FASCIOCUTANEOUS)
- SKIN AND MUSCLE (MUSCUOLOLOCUTANEOUS)
- MUSCLE
- OSSEO-MUSCULO-CUTANEOUS
- BONE
- SKIN AND SUBCUTANEOUS TISSUE

## FLAP CLASSIFICATION BY BLOOD SUPPLY

- LOCAL ROTATION
- DISTANT
- FREE









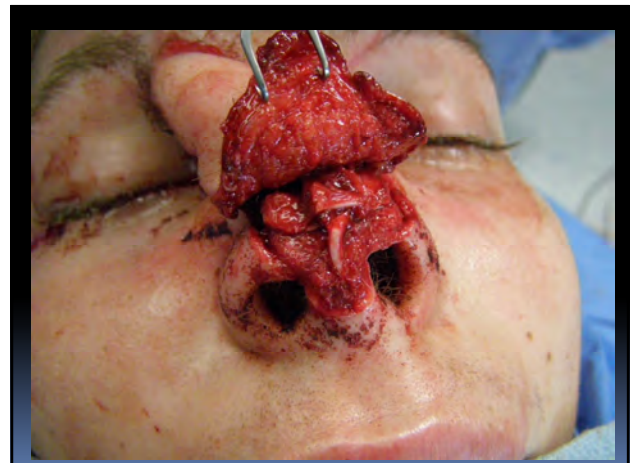
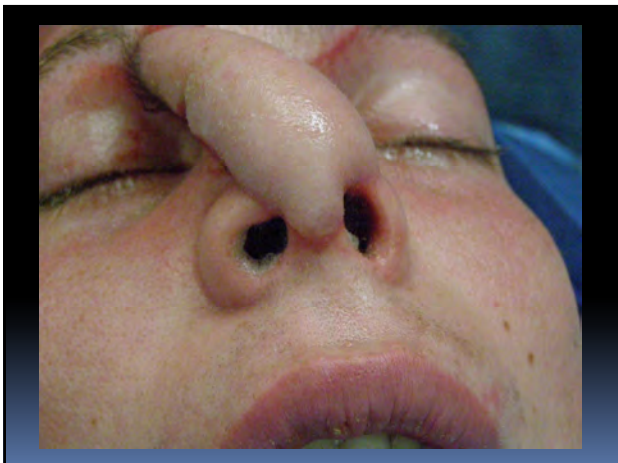


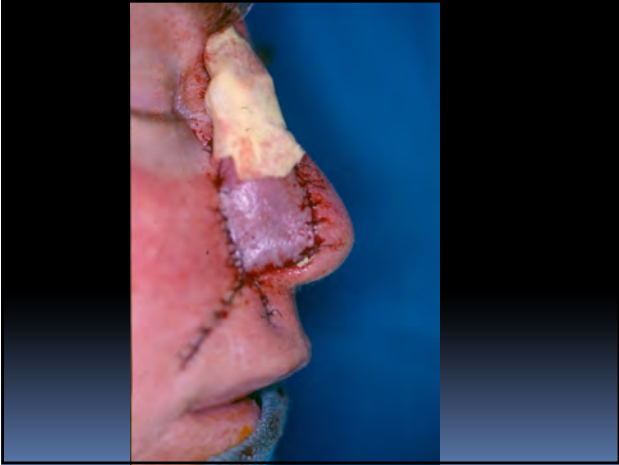
## FLAP COMPLICATIONS

- 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 (WHOOOPS)
  - 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 ORIGINAL BLOOD SUPPLY AND FLAP IS DEPENDENT ON RECIPIENT SITE
- THREE WEEK PERIOD OF ATTACHMENT AT DONOR AND RECIPIENT SITE

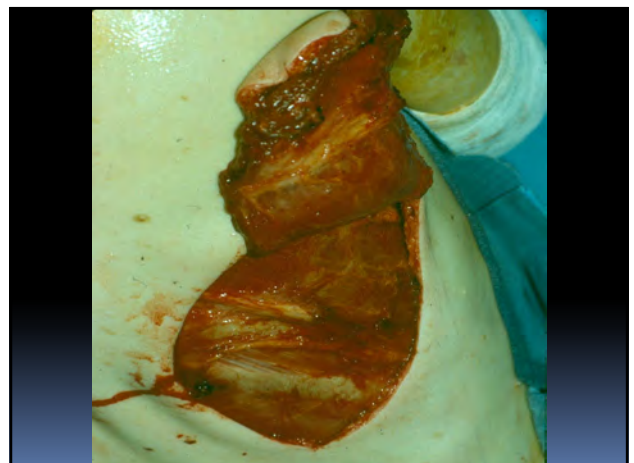


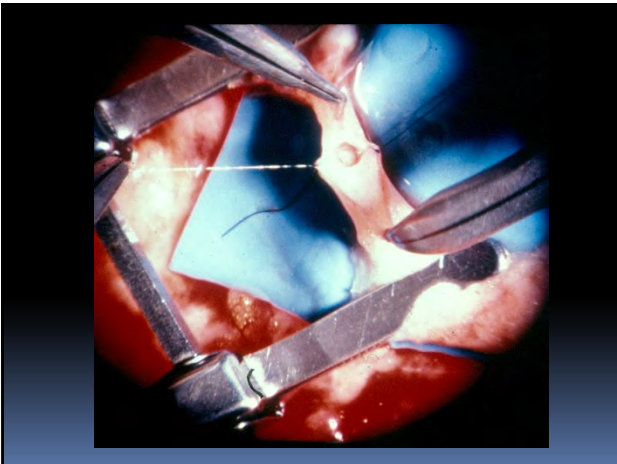
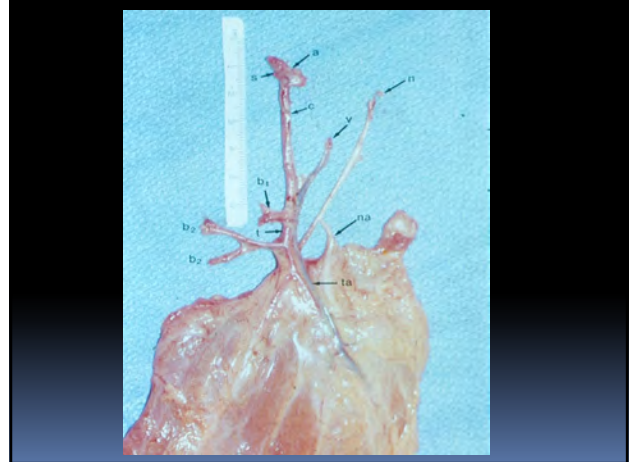
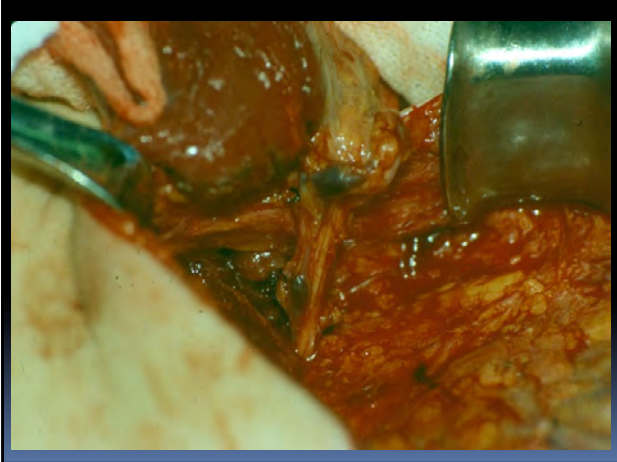




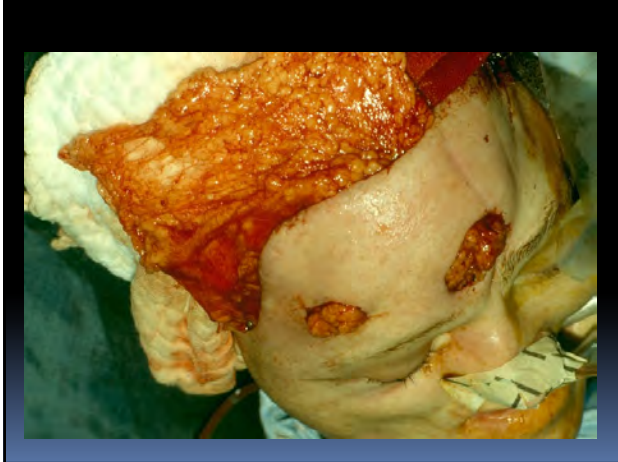
## FREE FLAPS

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









## 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 COLLAGEN 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 EFFECTS BOTH PROCESSES

## HBO AND BONE MARROW

- HBO STIMULATES NITROGEN OXIDE SYNTHASE (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 THIUREDOXIN

## HBO AND LOCAL STEM CELLS

- THIUREDOXIN → TRANSCRIPTION FACTOR  
CAUSING STEM CELLS TO PROMOTE AND EXPRESS  
HYPOXIA – INDUCIBLE FACTORS (HIF) →  
STIMULATE GENES INVOLVED IN  
NEOVASCULARIZATION

## 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 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 )

## HBO AND SKIN GRAFTS

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

## 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)
- HAMMERLAND 1994 (PLAST. RECONS. SURG) DOUBLE BLIND RCT SHOWED REDUCTION IN ULCER SIZE AFTER 6 WEEKS (36% HBO VS 4% CONTROLS)

## 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
- 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  $TcPO_2 \leq 40$  AND BONE OR TENDON NOT EXPOSED
- ZHAO LL ET AL- ISCHEMIC RABBIT EAR MODEL
- GROLMAN ET AL 2001 RETROSPECTIVE REVIEW OF PATIENTS. WHEN  $\Delta Tcom \geq 10$  mmHg (100% O<sub>2</sub> at sea level) 70% wound healing vs 1% when  $\Delta Tcom \leq 10$  mm Hg. All PATIENTS RECEIVED HBO

## 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 ANASTOMOSES

## ANIMAL FLAP STUDIES

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

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. Monoclonal antibodies against CD-18 neutrophil integrin gives same effect as HBO

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

- 2008: Both hyperbaric and hyperoxic environments are needed for HBO effect on neutrophil 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

## 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 IMPROVES ISCHEMIC TOLERANCE IN MANY TISSUES THROUGH MECHANISMS NOT COMPLETELY UNDERSTOOD (alterations in hypoxia inducible factors (HIF) production)

## 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

## COMPROMISED FLAPS SUMMARY

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

## 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

## FREE FLAP

- FLAP DOES WELL IMMEDIATELY POST OP
- THEN SUDDENLY BECOMES UNDERPERFUSED
- RECOMMEND RE-EXPLORATION AND REVISION OF ANASTOMOSES →
- ADDITIONAL ISCHEMIA →
- NEUTROPHIL ADHERENCE →
- HBO (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%