



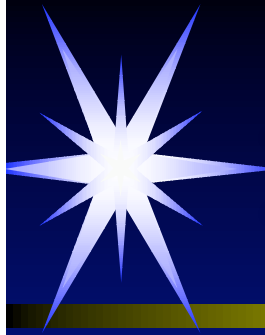
TRAUMA ANESTHESIA

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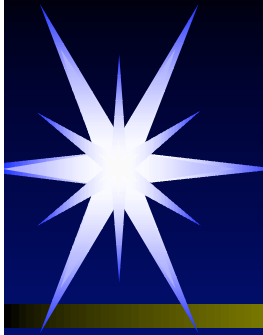
GOALS

- Introduction
- Initial Evaluation
- Preparation
- Treatment
- End Points of Resuscitation



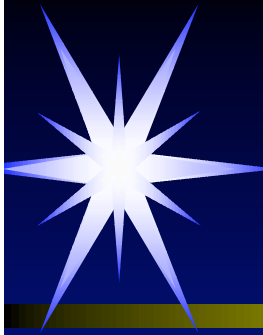
Introduction

- United States-Fourth leading cause of death.
- Until age 44 yrs.-leading cause of death.
- 15-24 yrs.-77% of all deaths.
- 3.5-4.0 million years of potential life lost/year
- Greater than \$100 billion in medical and other expenses.



Introduction

- Trauma: (Greek) an injury to living tissue caused by an extrinsic agent.
 - Blunt (majority)
 - Penetrating
 - Thermal
 - Chemical
 - Ionizing radiation
 - Nuclear radiation
 - etc.



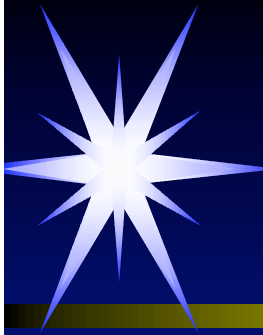
Introduction

- Mortality
 - Trimodal Distribution
 - 1st hour: 50% of all deaths secondary to CNS or great vessel injury-not amendable to treatment.
 - 1-4 hours: 30% of all deaths due to CNS or hemorrhage-early intervention is of benefit.
 - 1-6 weeks: 20% of all deaths due to multi-organ failure and/or sepsis.



Initial Evaluation

- ATLS-Advanced Trauma Life Support
 - American College of Surgeons
 - Early systematic approach to the injured patient.
 - Improves overall survival by reducing incidence of missed injuries and under resuscitation



Initial Evaluation

- ATLS
 - Preparation
 - Triage
 - Primary Survey (ABC's)
 - Resuscitation
 - Secondary Survey ("head to toe")
 - Further resuscitation and evaluation
 - Definitive Care



Preparation

- Care team
 - Attending Anesthesiologist
 - Anesthesia resident and/or CRNA
 - Surgeon
 - Anesthesia Technician
 - Operating room nurses
 - Pathology



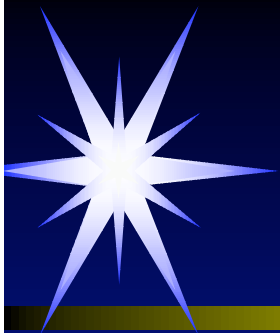
The Care Team In Action





Preparation

- Operating Room Set-Up
 - Optimal readiness
 - Cost effectiveness
 - Final room preparation



Swank Getting Ready For a Torn Thoracic Aorta





Treatment

- GOALS
 - Secure the airway
 - Ventilation and oxygenation
 - Maintenance of hemodynamics
 - Maintain organ perfusion
 - Euthermia
 - Coagulation
 - Achieve end point(s) of resuscitation



Treatment

- Patient Preparation
 - Oxygen
 - Standard monitors
 - Intravenous access
 - Invasive monitoring



Treatment

- Airway
 - If intubated, *confirm* proper endotracheal tube placement.
 - Not intubated, secure the airway.
 - Rapid Sequence Induction (always a full stomach)
 - Modified Rapid Sequence Induction
 - Awake intubation
 - Cricothyroidotomy/tracheostomy
 - Other-Always suspect c-spine injury



Bad Looking Airway





Do the Right Thing





Treatment

- Fluid Administration
 - NS versus LR (plasmalyte, etc.)
 - Colloid versus crystalloid
 - Hespan, Hextend, Albumin
 - Blood Products



Treatment

- Fluid Administration
 - Pressure bags
 - Hotline
 - Level 1 System
 - Rapid Infusion System



Level 1 – The Work Horse



100's of Units of Blood Products and Crystalloid





Resuscitation

- Shock (ATLS): Abnormality of the circulatory system that results in inadequate organ perfusion and oxygenation.
- Resuscitation is complete when:
 - Tissue acidosis is eliminated
 - Aerobic metabolism is restored
 - Oxygen debt has been repaid



Resuscitation

- Adequate resuscitation does NOT equal “normal” vital signs, (i.e. compensated shock).
- Scalea (1994) and Abou-Khalil (1994): 80-85% of trauma patients had evidence of inadequate resuscitation despite normal blood pressure, heart rate, and urine output.
 - Elevated lactate and/or decreased mixed venous oxygen saturation.



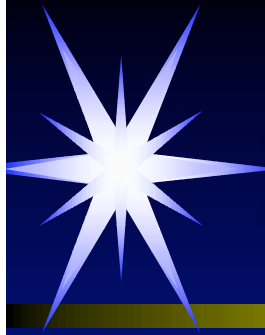
Resuscitation

- Supernormal O₂ transport variables
 - Shoemaker: repay the oxygen debt.
 - $CI > 4.5 \text{ L/min/m}^2$
 - $DIO_2 > 600 \text{ mL/min/m}^2$
 - $VIO_2 > 170 \text{ mL/min/m}^2$
 - Achieved with fluid, colloid, blood products and vasoactive drugs.



Resuscitation

- Supernormal O₂ transport variables
- Shoemaker - many studies
 - 1998: Trauma victims, critically-ill patients, and patients undergoing major operative procedures.
 - Protocol group had statistically reduced mortality, complications, duration of hospitalization, ICU duration, mechanical ventilation, and overall cost.



Resuscitation

- Supernormal O₂ transport variables
- Heyland
 - Reviewed all papers from 1980-1994.
 - Identified 7 relevant studies of 1,106 patients.
 - Performed a meta-analysis of the studies
 - Conclusions: “interventions designed to achieve supraphysiologic goals of CI, DIO₂, and VIO₂ did not *significantly* reduce mortality rates in all critically ill patients.”



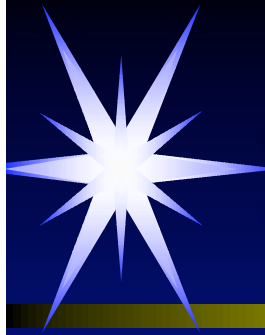
Resuscitation

- Supernormal O₂ transport variables
- Gattinoni (1995)
 - 10,726 ICU patients.
 - Three groups: Resuscitated to normal CI, supernormal CI, and to a normal mixed venous oxygen saturation (>70%)
 - Results: therapy aimed at supernormal CI or normal mixed venous oxygen saturation did not reduce morbidity and mortality.



Resuscitation

- Supernormal O₂ transport variables
- Durham (1996)
 - Randomized 58 critically ill patients.
 - Resuscitated to conventional parameters versus supernormal end points.
 - Results: No difference in incidence of organ failure or mortality.
 - (lactate levels at the end of 24 hours correlated with organ failure.)



Resuscitation

- Supernormal O₂ transport variables
- Hayes (1994)
 - 109 critically ill patients
 - 9 met supernormal O₂ transport variables with volume only.
 - Remaining patients were randomized to a control group or to receive dobutamine until supernormal values were met.
 - Results: Dobutamine group had increased in-hospital mortality.



Resuscitation

- Lactate
 - Produced from pyruvate (reversible reaction).
 - With oxygen: pyruvate-->Acetyl-CoA-->Krebs cycle--38 moles of ATP
 - Without oxygen: pyruvate-->lactate--2 moles of ATP
 - All cells with mitochondria can remove lactate, however the liver and kidneys remove 50% and 30% respectively (Cori cycle).



Resuscitation

- Lactate
 - Broder and Weil (1964): first correlated increasing lactate with increasing mortality.
 - Serum lactate is an indirect measure of the oxygen debt and is an approximation of the magnitude of hypoperfusion and shock.



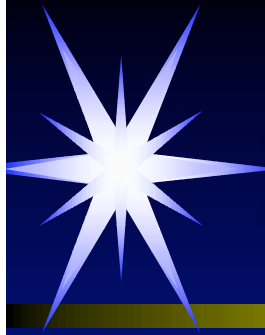
Resuscitation

- Lactate
 - Dunham (1991)
 - Predictive value of lactate levels and mortality in hemorrhaged dogs.
 - Vincent (1983)
 - 27 patients
 - 100% survival if lactate decreased $> 5\%$ in the first hour with volume resuscitation.



Resuscitation

- Lactate
 - Abramson (1993)
 - 76 consecutive patients; normalization of lactate (≤ 2 mmol/L)
 - Normalization within 24 hours: 100% survival
 - 24-48 hours: 78% survival
 - > 48 hours: 14 % survival
 - Of note: 40% of nonsurvivors achieved supernormal O₂ transport values and 29% of survivors did not.



Resuscitation

- Base Deficit
 - It is the amount of base, in millimoles, required to titrate 1 liter of whole arterial blood to a pH of 7.40, with the sample fully saturated with oxygen at 37 degrees and a PCO₂ of 40 mmHg.
 - Although not directly measured, evidence exists showing lactate has a close relationship to base deficit and is a valuable indicator for shock.



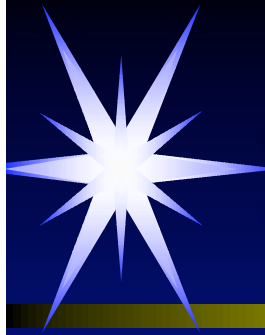
Resuscitation

- Base Deficit
 - Davis (1988)
 - Base deficit correlated with ongoing hemorrhage.
 - First stratified BD:
 - Mild: -2 to -5
 - Moderate: -6 to -14
 - Severe: less than -15



Resuscitation

- Base Deficit
 - Dunham (1991) Dog model
 - BD correlated most closely with developing oxygen debt and mortality. However, the combination of BD with lactate was superior to either alone.
 - Siegel (1990)
 - 185 blunt liver injury patients.
 - Admission BD was the single most important variable predicting mortality.



Resuscitation

- Base Deficit
 - Rutherford (1992)
 - 3,791 consecutive trauma patients, retrospective.
 - Admission BD
 - <55 years (no head injury): $BD < -15 = \text{sig. mortality}$
 - >55 years (no head injury): $BD < -8 = \text{sig. mortality}$
 - <55 years (yes head injury): $BD < -8 = \text{sig. mortality}$



Resuscitation

- Lactate and Base Deficit are *global* markers of tissue perfusion
- Regions of inadequate perfusion may still exist.
- Gut mucosa: among the first to be affected during shock and the last to be restored.
 - Therefore *Gastric Intramucosal pH (pHi)* as a regional marker for perfusion.



Resuscitation

- pHi
 - Measurement of the splanchnic bed as a whole.
 - Estimated by gastric tonometry.
 - Gas permeable silicone balloon attached to a nasogastric tube.
 - CO₂ equilibrates between gastric mucosa and saline in the balloon.
 - pH of the saline is calculated using Henderson-Hasselbach.



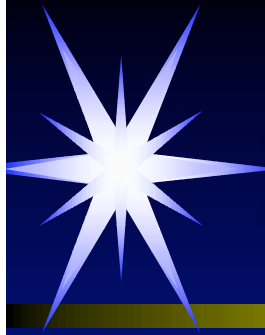
Resuscitation

- pHi
 - Assumption: Mucosal HCO_3^- = arterial HCO_3^- (has been confirmed in canine models)
 - Extraneous CO_2 could falsely lower the pHi.
 - 30-90 minutes required to reach steady state.
 - Therefore, long turn-around time.



Resuscitation

- pHi
 - Roumen (1994)
 - Prospective study of 15 trauma patients.
 - 7 with $\text{pHi} \geq 7.4$: Discharged without complications
 - 8 with $\text{pHi} < 7.32$ once or more within first 48 hours
 - Three developed major complications
 - Two died



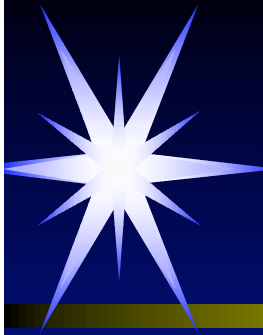
Resuscitation

- pHi
 - Chang (1994)
 - Prospective study of 20 multiple trauma patients.
 - $\text{pHi} = 7.40$ or corrected to 7.40 within first 24 hours: No mortality and 0.62 organ dysfunction/patient
 - $\text{pHi} < 7.32$ and without correction within first 24 hours: 50% mortality and 2.6 organ dysfunctions/patient



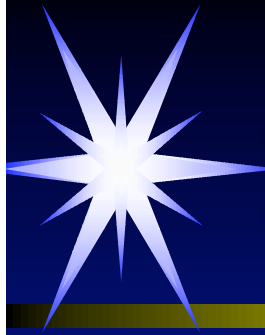
Resuscitation

- pHi
 - Ivatury (1996)
 - Prospectively randomized 57 trauma patients
 - Primary analysis did not reach statistical significance.
 - Subgroup analysis:
 - The time for pHi optimization was significantly longer in nonsurvivors.
 - Only 3/44 patients with pHi > 7.30 within 24 hours died of MOF.
 - In 13 patients, they were unable to optimize pHi within 24 hours: 7/13 died of MOF.



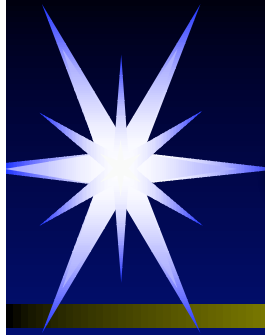
Resuscitation

- Summary
 - Supernormal Oxygen Transport Variables
 - ? Predictor of outcome, not an end point
 - Lactate/Base Deficit
 - Global markers
 - Should be used routinely!
 - Intramucosal pH (pHi)
 - Regional marker
 - Future consideration



Resuscitation

- Future Possibilities
 - Subcutaneous PO₂
 - Skin as a marker of perfusion
 - Fiberoptic tonometry
 - Real-time measurements
 - Near infrared spectroscopy



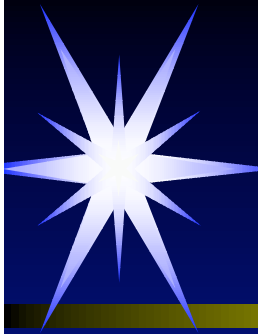
Other

- Think other injuries
 - Mechanism of injury
 - Pneumothorax
 - Cardiac tamponade
 - Intracranial hemorrhage
 - Occult hemorrhage
 - Long bone fractures
 - Retroperitoneal
 - Etc.



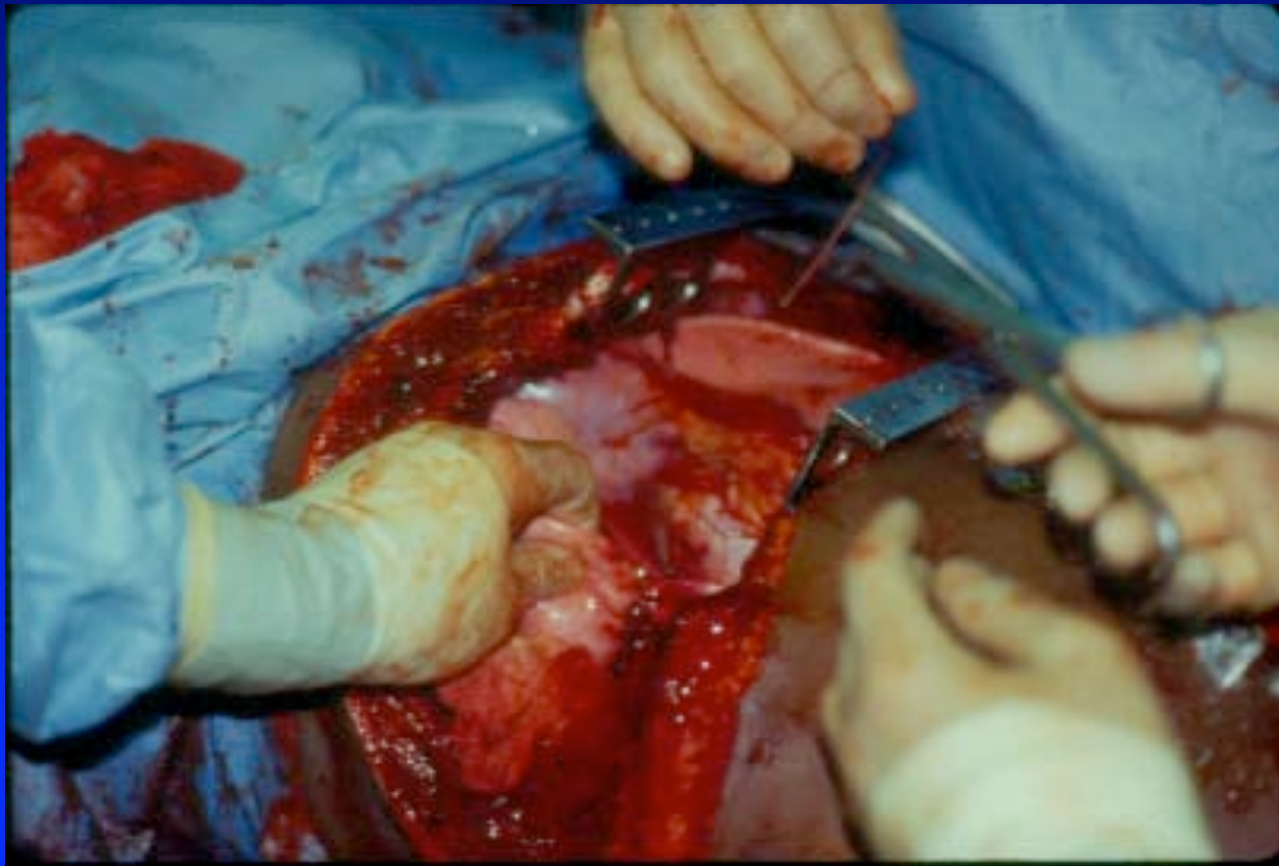
The Red Trauma Light Sounds





Torn Thoracic Aorta







Sharp Objects

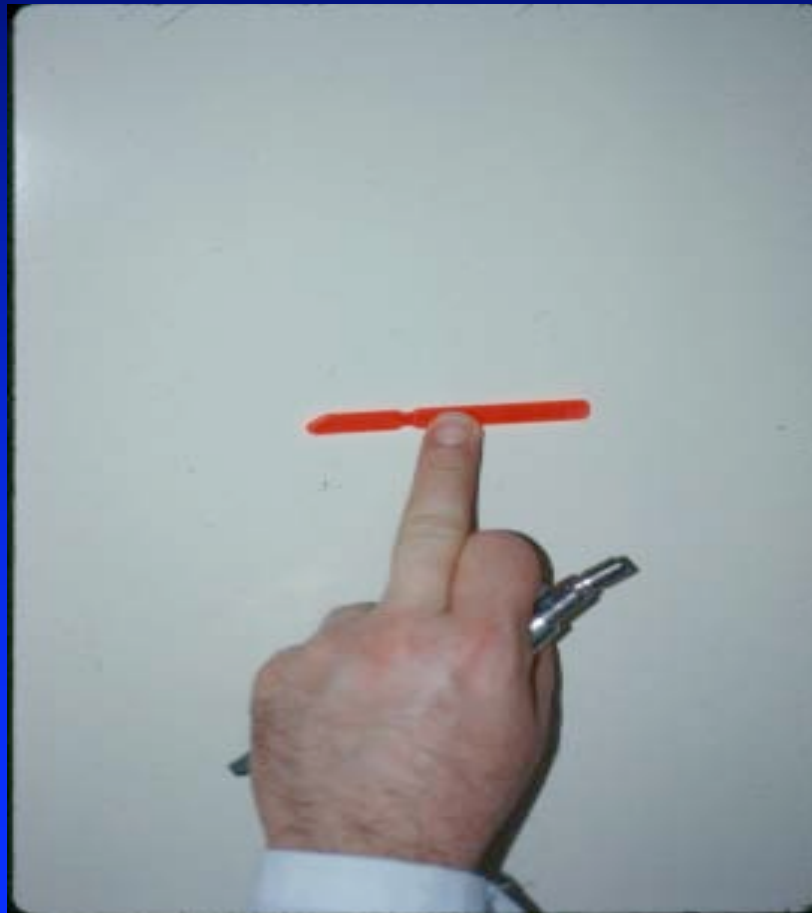




Careful Playing With The Toy Doctor's Kit

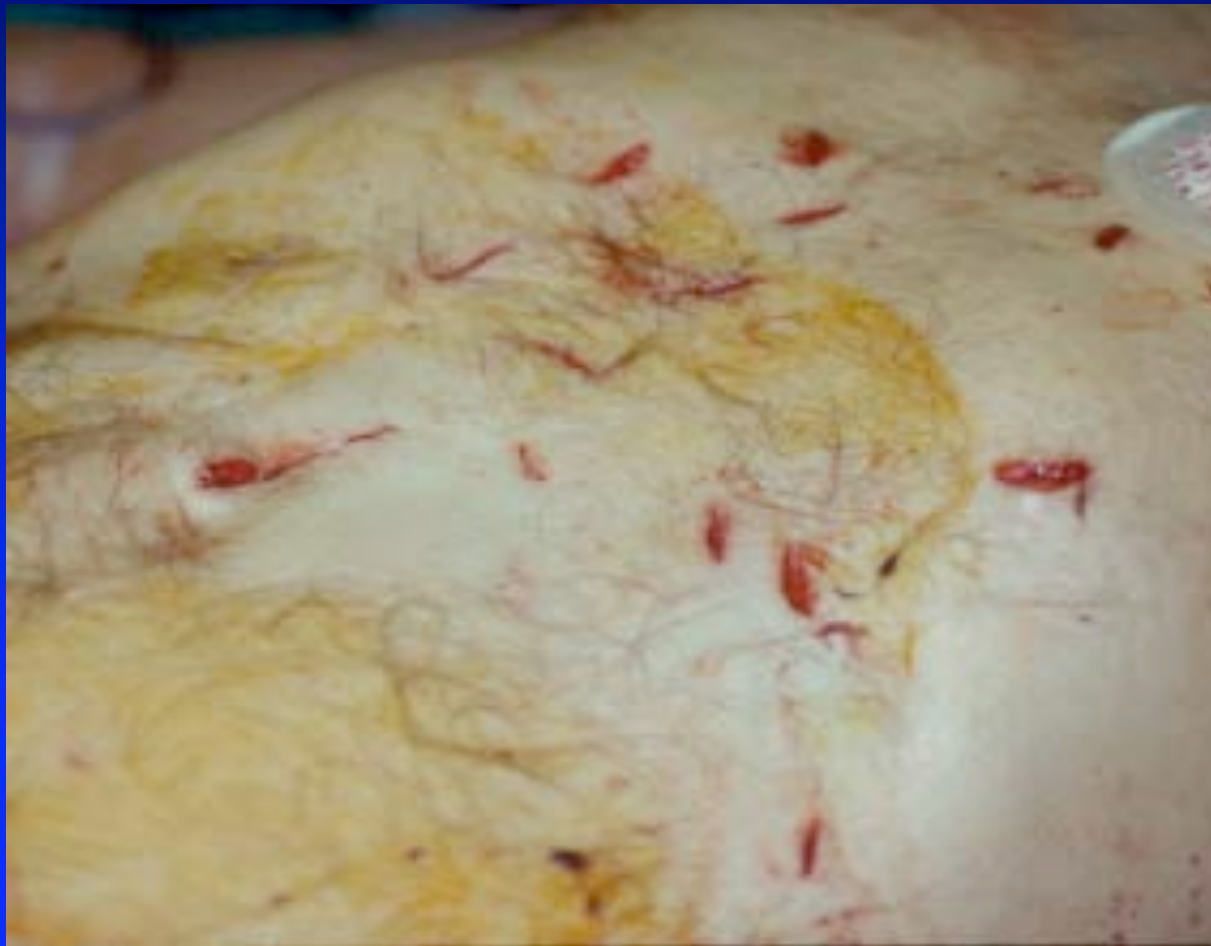






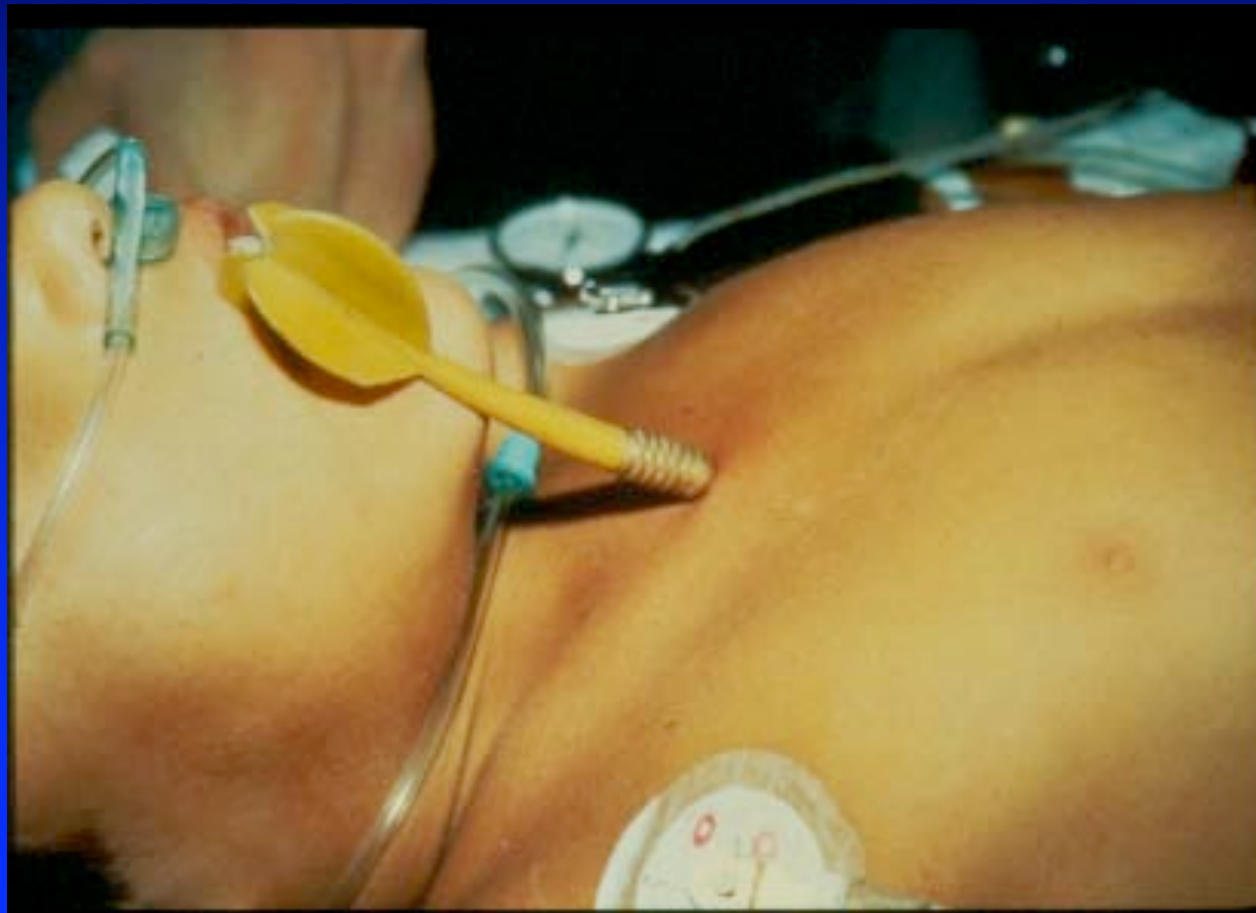


Multiple Stab Wounds, Once Just Isn't Enough



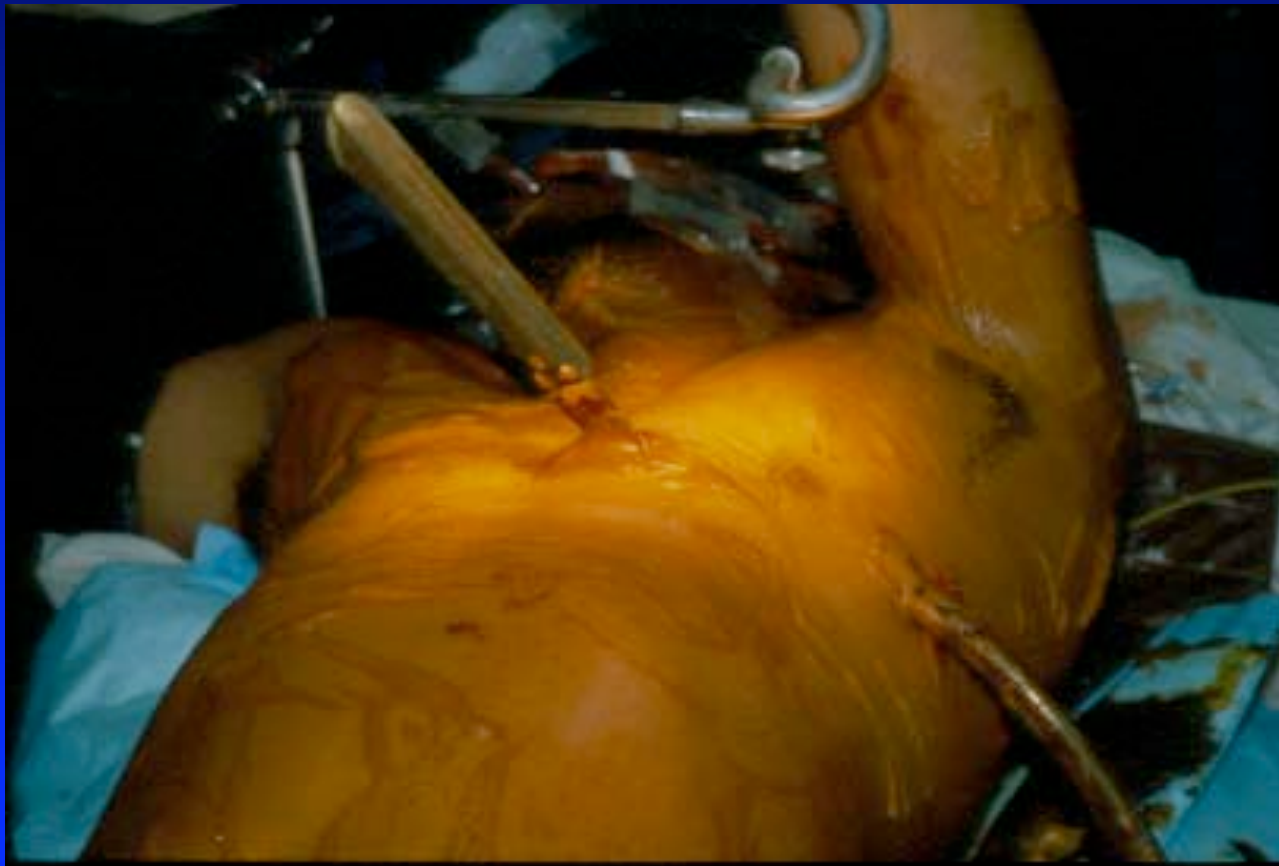


Dart Catching Contest



Always Cut The Bagel Away
From Your Face.



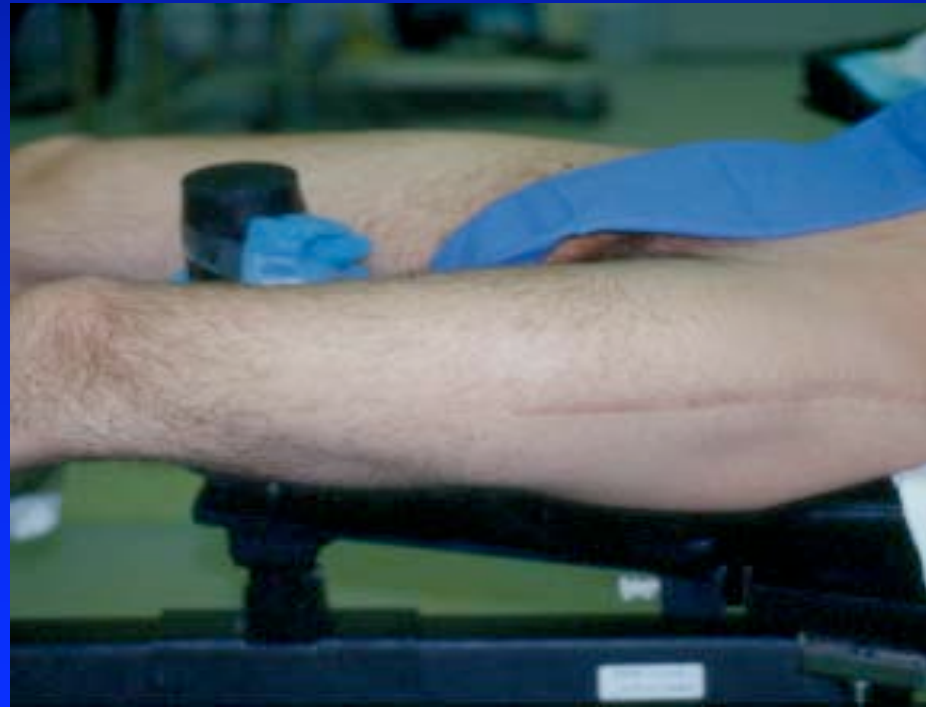






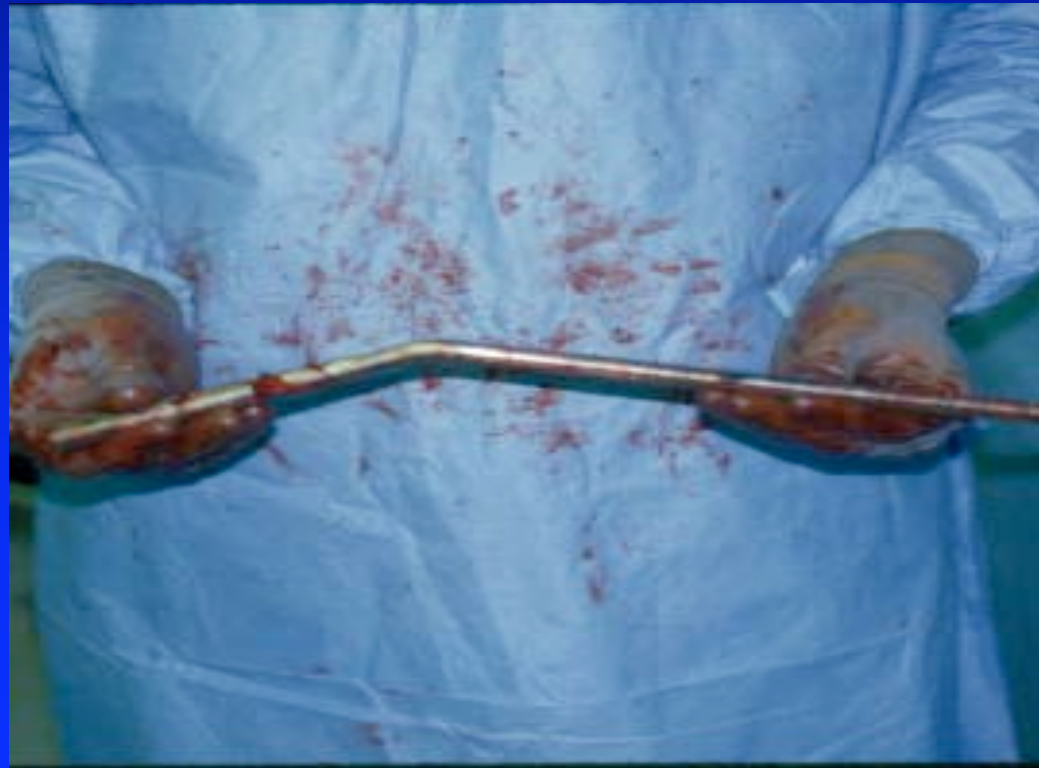
Think Mechanism of Injury

- Well Healed Scar From a Prior Femur Fracture.





- High Mechanism of Injury!!





Don't Stick Your Arm Out Of
The Window!



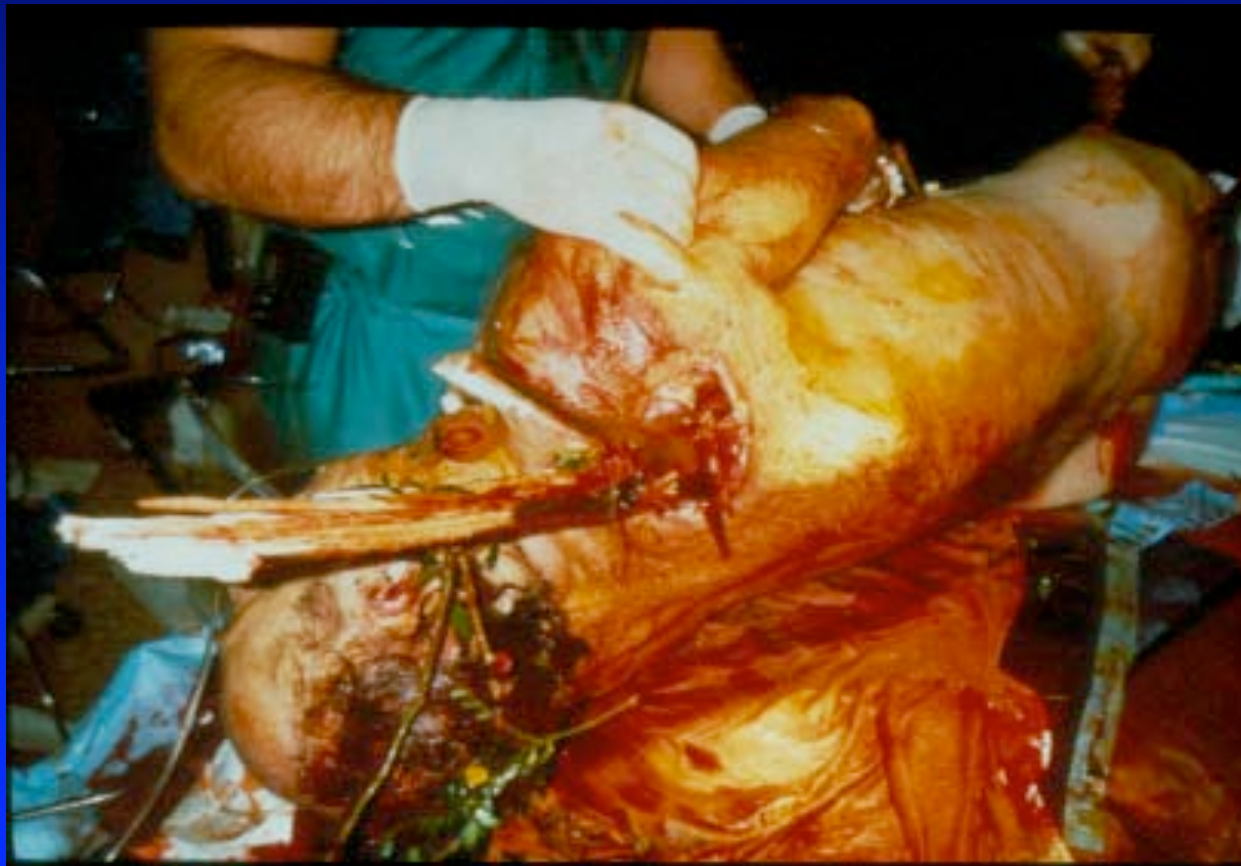


Be Careful Climbing Trees





More Wood



Those Telephone Polls Tend To Jump Out In Front Of You





Only Grind The Sausage





Sunny Day, All's Well

