ADVANCES IN COMBAT CASUALTY CARE

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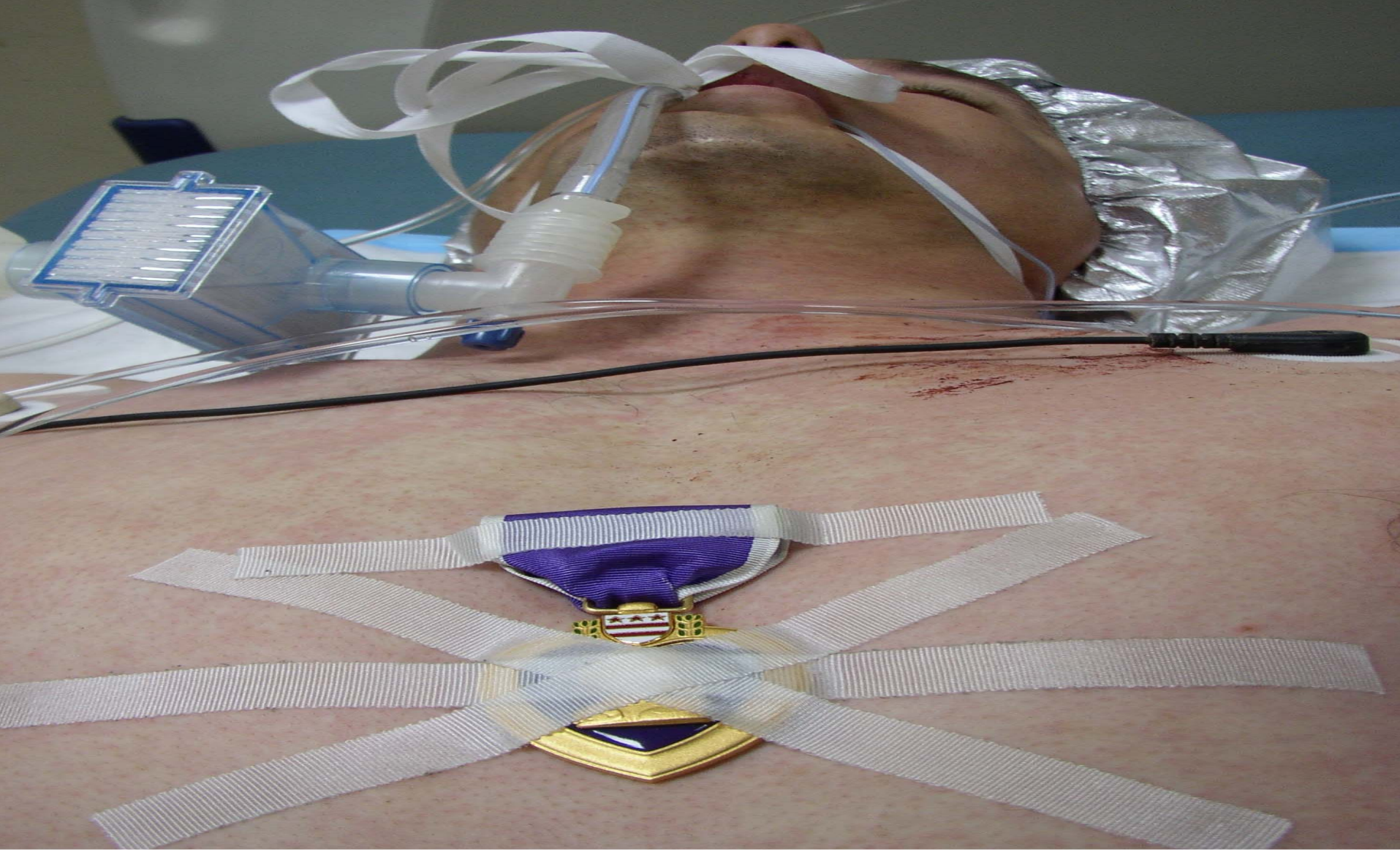
Critical Consultant for the Surgeon General

2004/08/26



War is a terrible thing but as a matter of necessity we are developing significant advances in trauma care

"We are not waiting for the end, but are making changes in the middle of the war" JH

Advances in Trauma Care

- Trauma Systems
  - JTTR
  - JPTA
  - RATS
  - Routine Rapid Evacuation
  - CCATT
  - ICU Organization
- CombatCasualty Care
  - Tourniquets and guidelines
  - Airway Management
  - Hemostatic Dressings
  - Hextend
  - Hypotensive Resuscitation
  - Needle Thoracostomy
  - Burn Prevention
  - Hypothermia Prevention

- Surgical Techniques
  - DCCS
- Resuscitation Techniques
  - Apheresis PLTs
  - Whole Blood
  - FFP
  - Freeze Dried Plasma
  - rFVIIa
  - Anesthetic Techniques
  - Damage Control Resuscitation
  - Hemostatic Resuscitation

The 31st CSH Strategic Development Research Group to Improve Mortality and Morbidity

- Maj Jeremy Perkins
- Maj Alec Beekley
- Maj James Sebesta
- Maj Thomas Repine
- Maj Jennifer Greco
- Maj Baskar Duval
- Maj Phillip Spinella
- LTC Cynthia Clagett
- LTC Gregory Thibault
- LTC Lorne Blackbourne
- LTC Dennis Nichols
- LTC Kurt W Grathwohl
- Col Jack Chiles

86th CSH
10th CSH
AFIP
USAISR
MRMC

Col John Holcomb

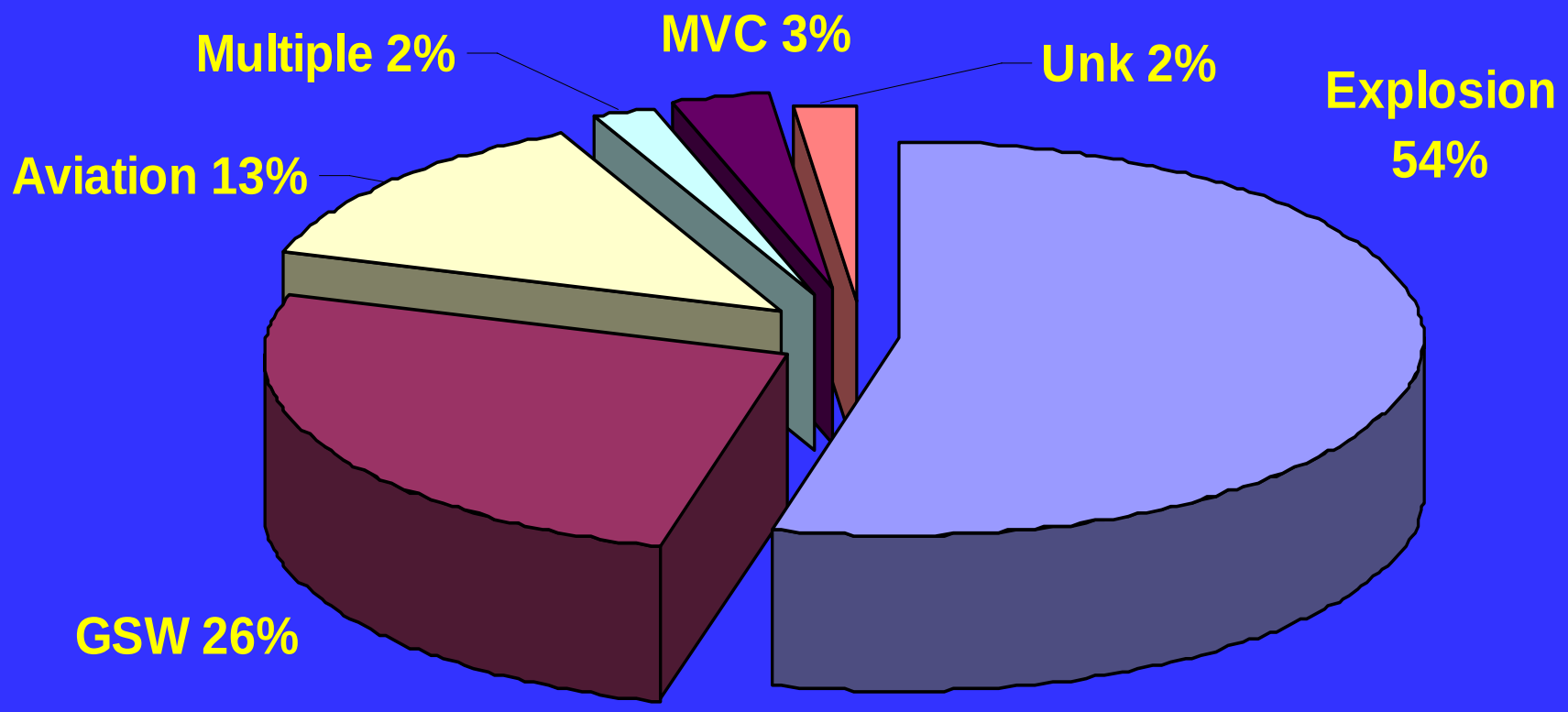
Epidemiology of Combat Injuries

	WW II	Vietnam	Iraq/ Afghanistan
% KIA	25.3	18.6	12.5
% DOW	3.5	3.0	**4.1**
CFR	19.1	16.1	8.8

KIA

- 65%-80% die immediately
  - Penetrating Head Injury/Thorax/Exsanguination
- 20-35% die in minutes/hours
  - Uncontrolled Hemorrhage

Causes of Death on the Modern Battlefield: Oct 01-Nov 04, n=495

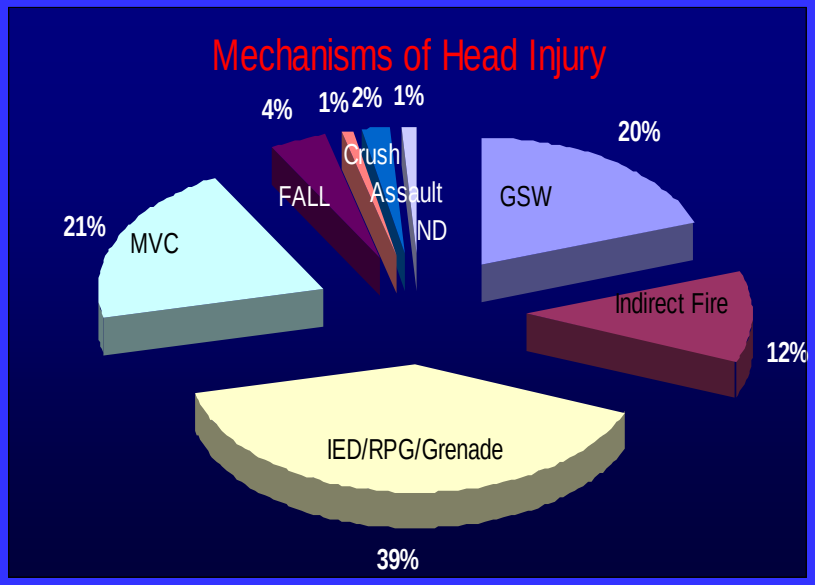


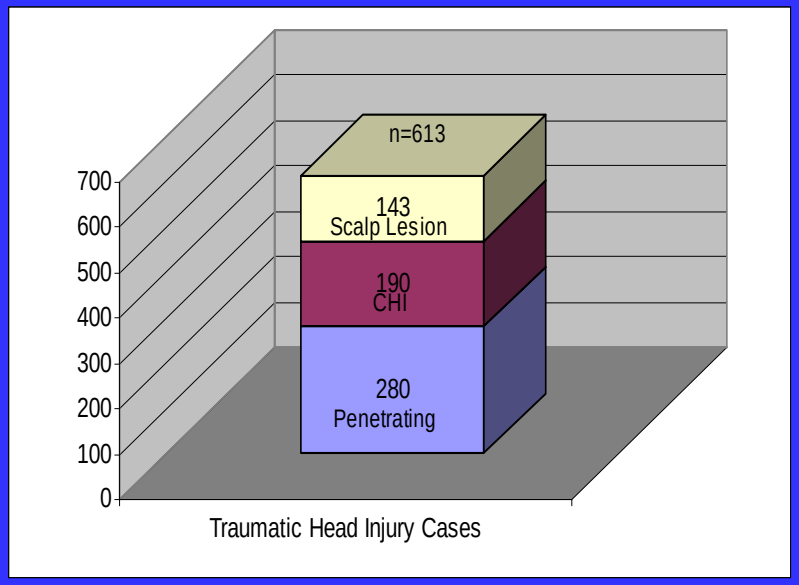
Anatomic Distribution of Penetrating Wounds

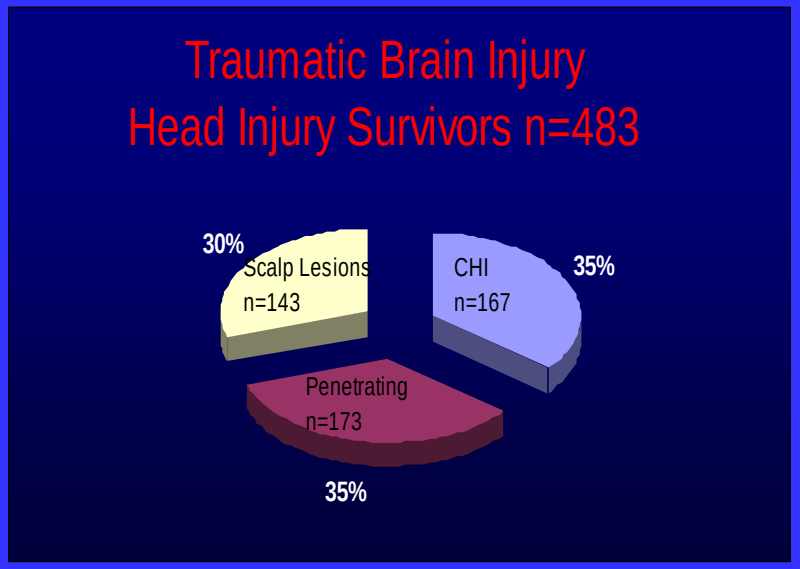
	Head and Neck (%)	Thorax (%)	Abdomen (%)	Limbs (%)	Other (%)
WWI	17	4	2	70	7
WWII	4	8	4	75	9
Korea	17	7	7	67	2
Vietnam	14	7	5	74	
Gulf War	11	8	7	71	18*
OIF2	19#	2	12	63	>50*

*Multiple Injuries
Includes Ocular

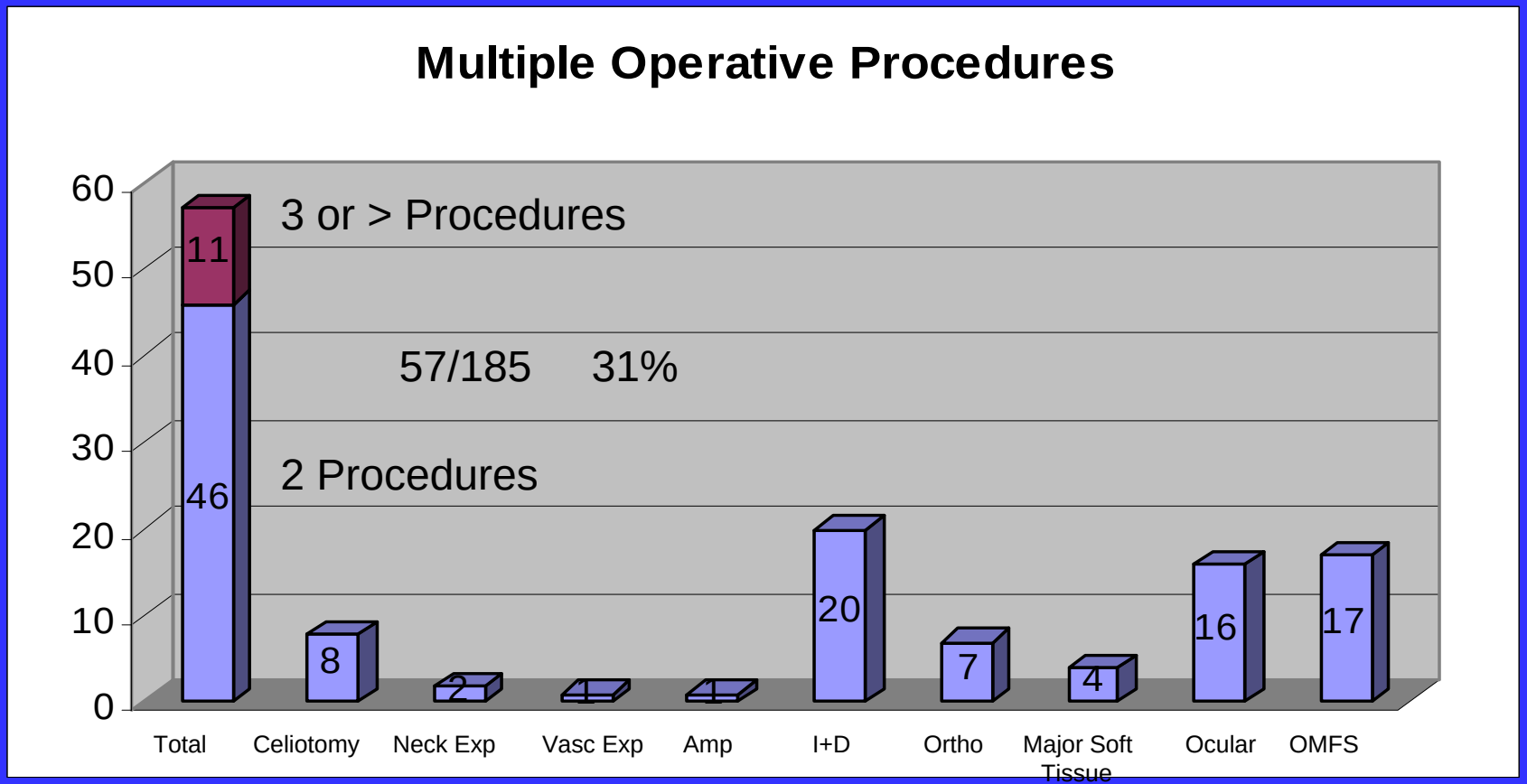
OIF-2 Head Injury



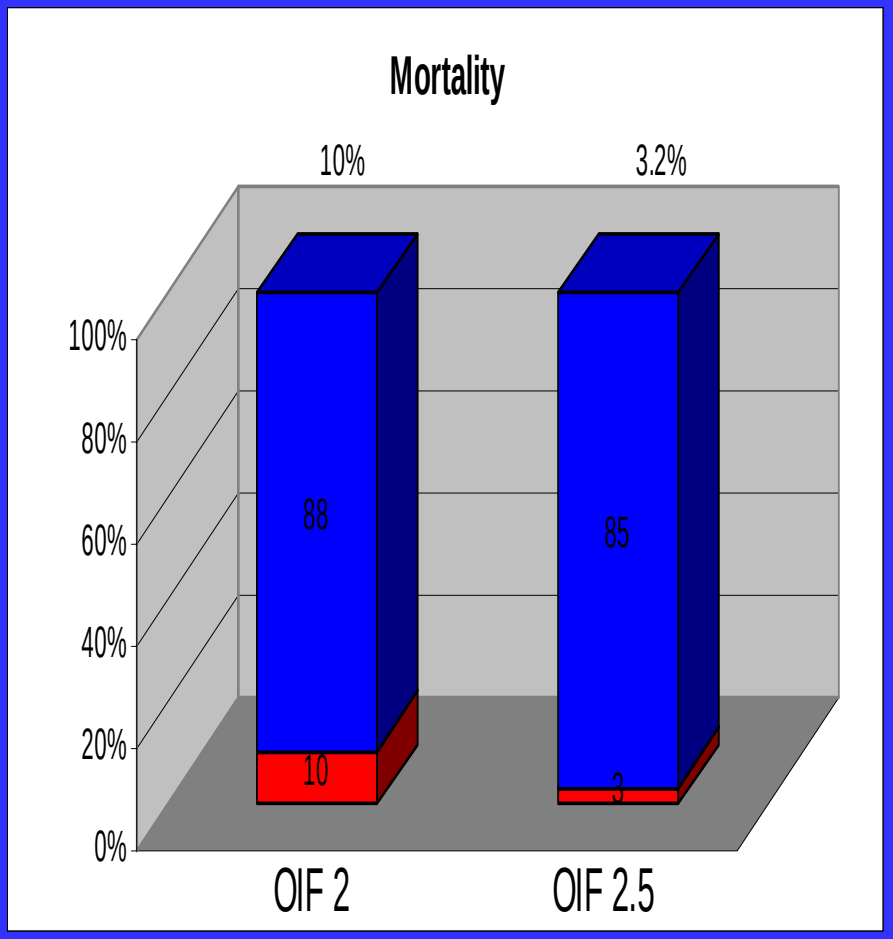




Penetrating Brain Injury with > 1 Injury Requiring Surgery



Mortality For Penetrating Brain Injury



Vietnam Brain Injury

- Mortality

  20/121= 16%

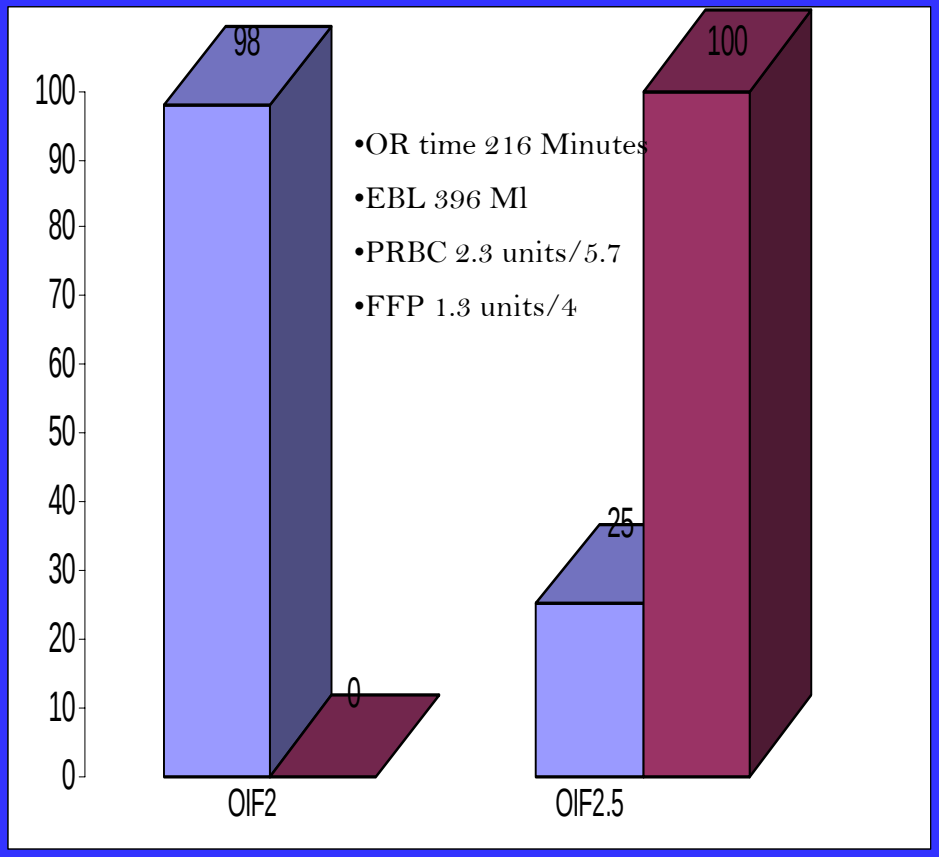
- Lebanon Conflict 1982-85
  - Mortality 19%

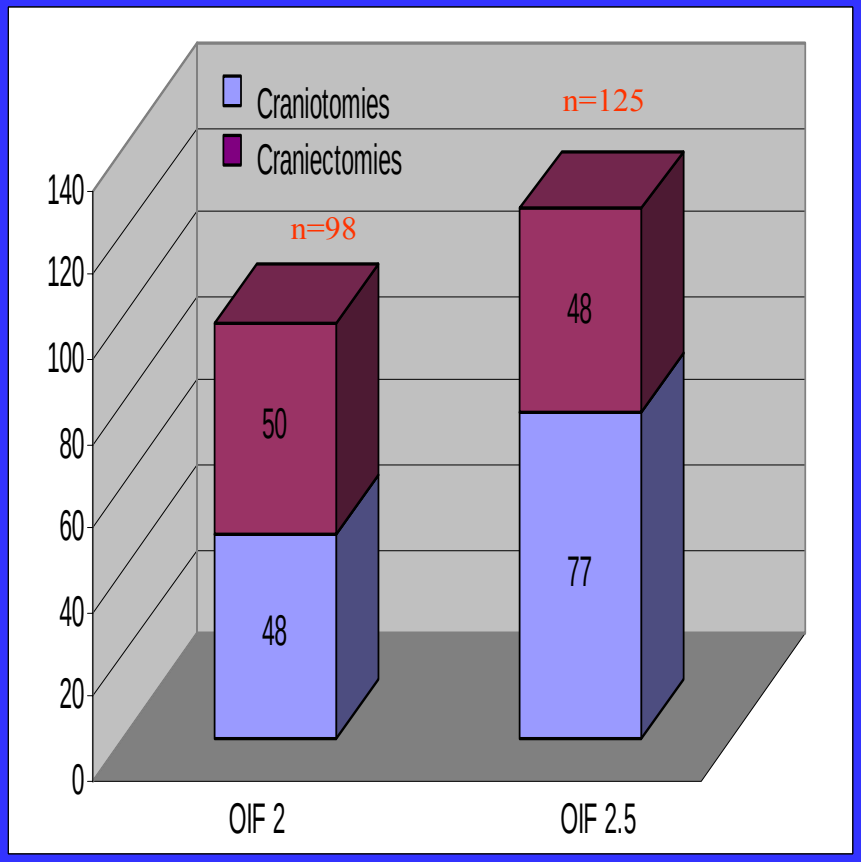
Secondary Brain Insult

- SYSTEMIC
  - Hypotension
  - Hypoxemia
  - Anemia
  - Hyper/Hypoglycemia
  - Hyperthermia
  - Hyper/Hypocapnia
  - Excitatory Amino Acids/Free radical

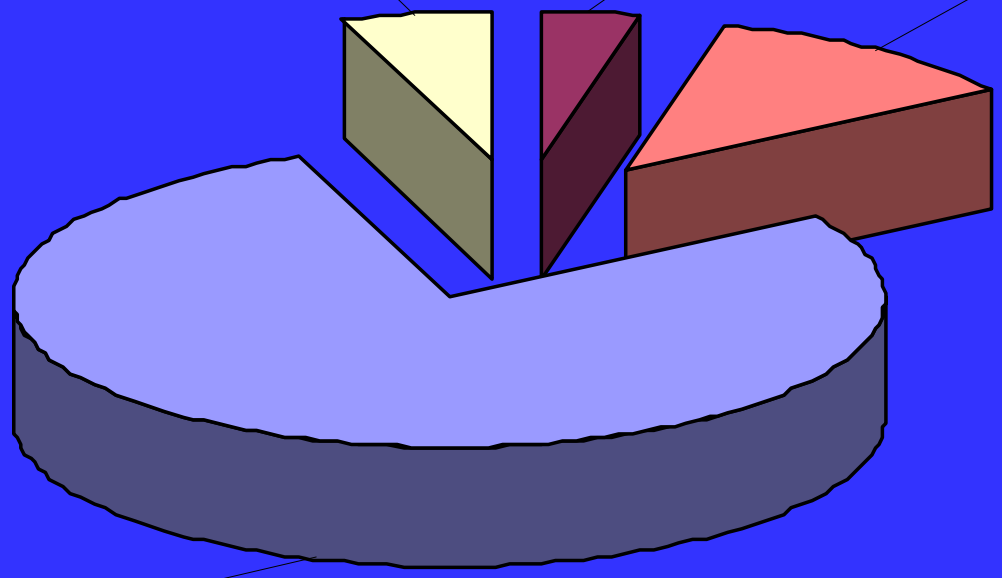
- INTRACRANIAL
  - Hypertension
    - Masses
  - Post-traumatic cerebral injury DAI
  - Vasospasm
  - Hydrocephalus
  - Infections
  - Seizures

Traumatic Head Injury OIF-2
Craniotomy/ectomy Patients





Causes of Potentially Survivable Deaths Oct 01-Nov 04, n=85 (17%)



31% Compressible (prehospital target)
69% Non-Compressible (FST/CSH target)

Data includes 107 causes of death in 85 potentially survivable casualties

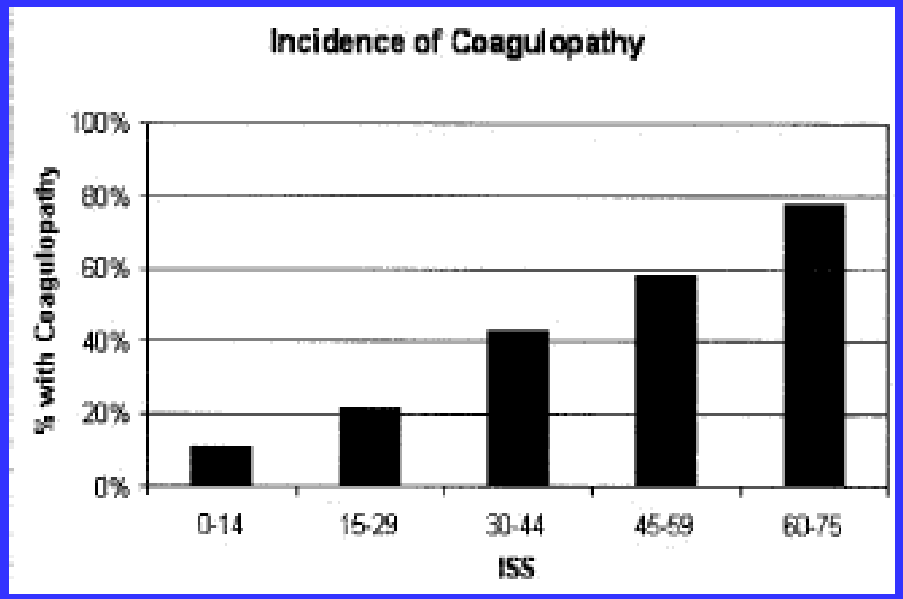
ACIDOSIS

HYPOTHERMIA ⟷ **COAGULOPATHY**

Consumptive
Dilutional

Coagulopathy and Trauma

- Derangements in coagulation occur rapidly after trauma
- By the time of arrival at the ED, 28% (2,994 of 10,790) of trauma patients had a detectable coagulopathy that was associated with poor outcome (MacLeod et al., 2003)



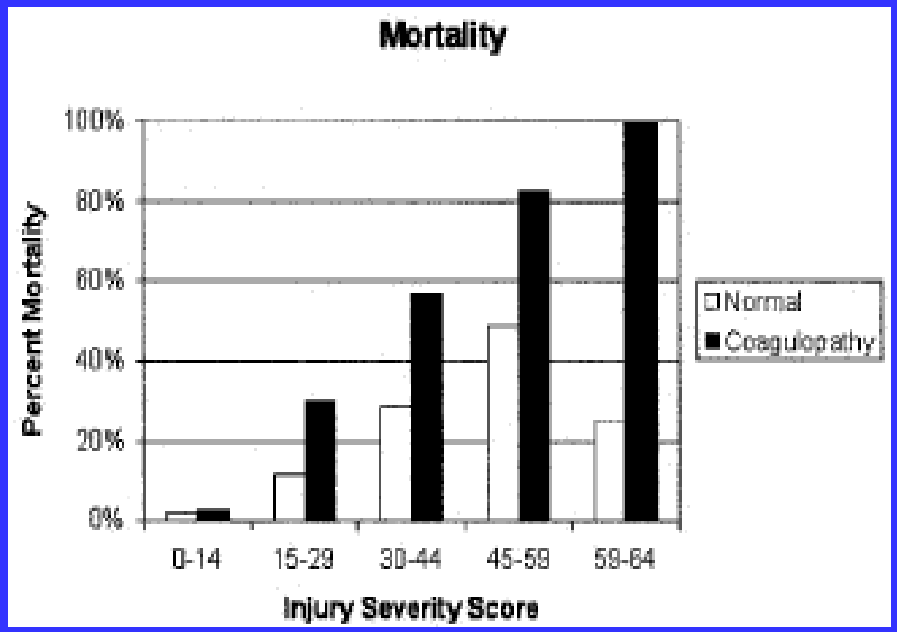
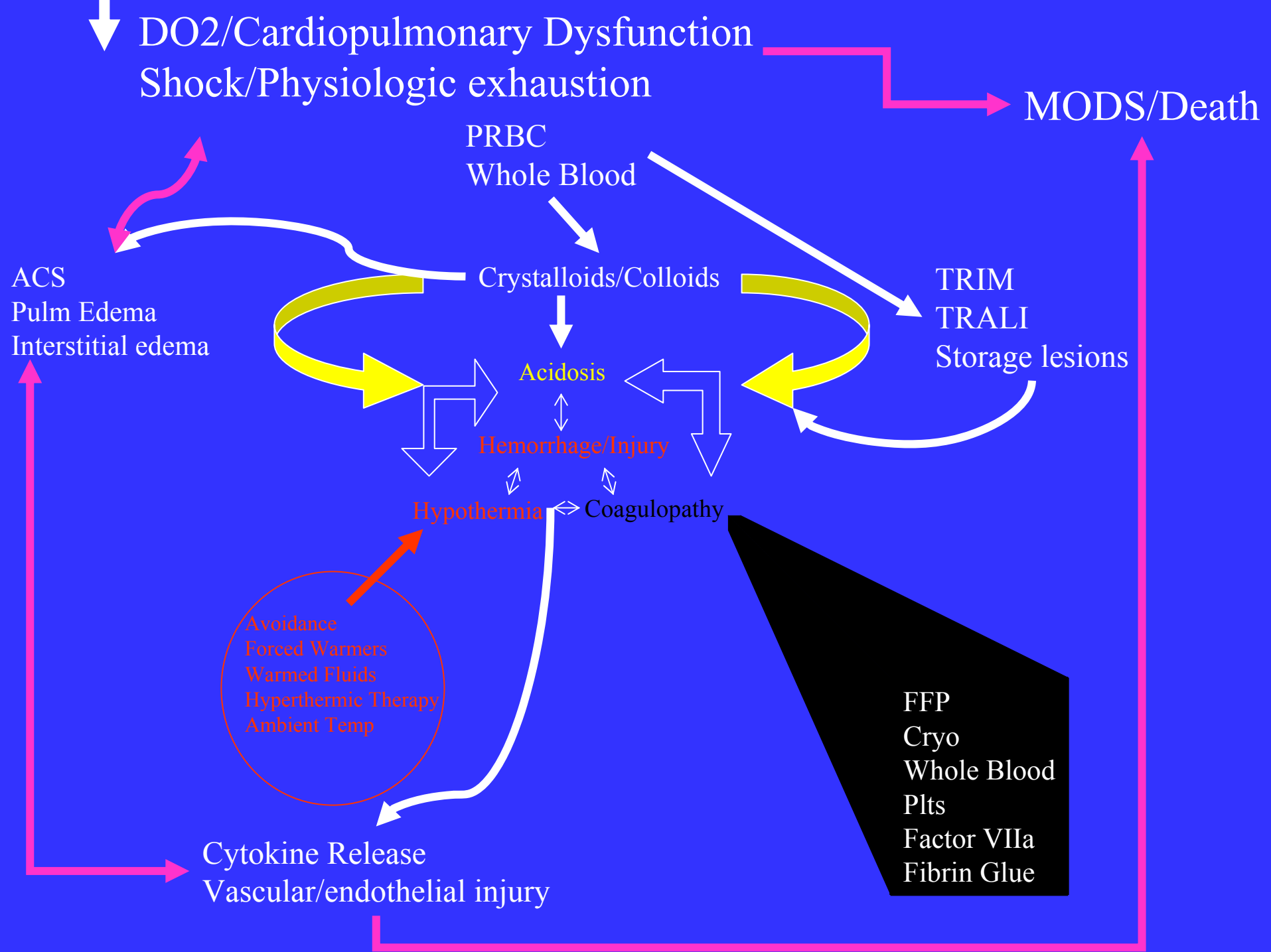


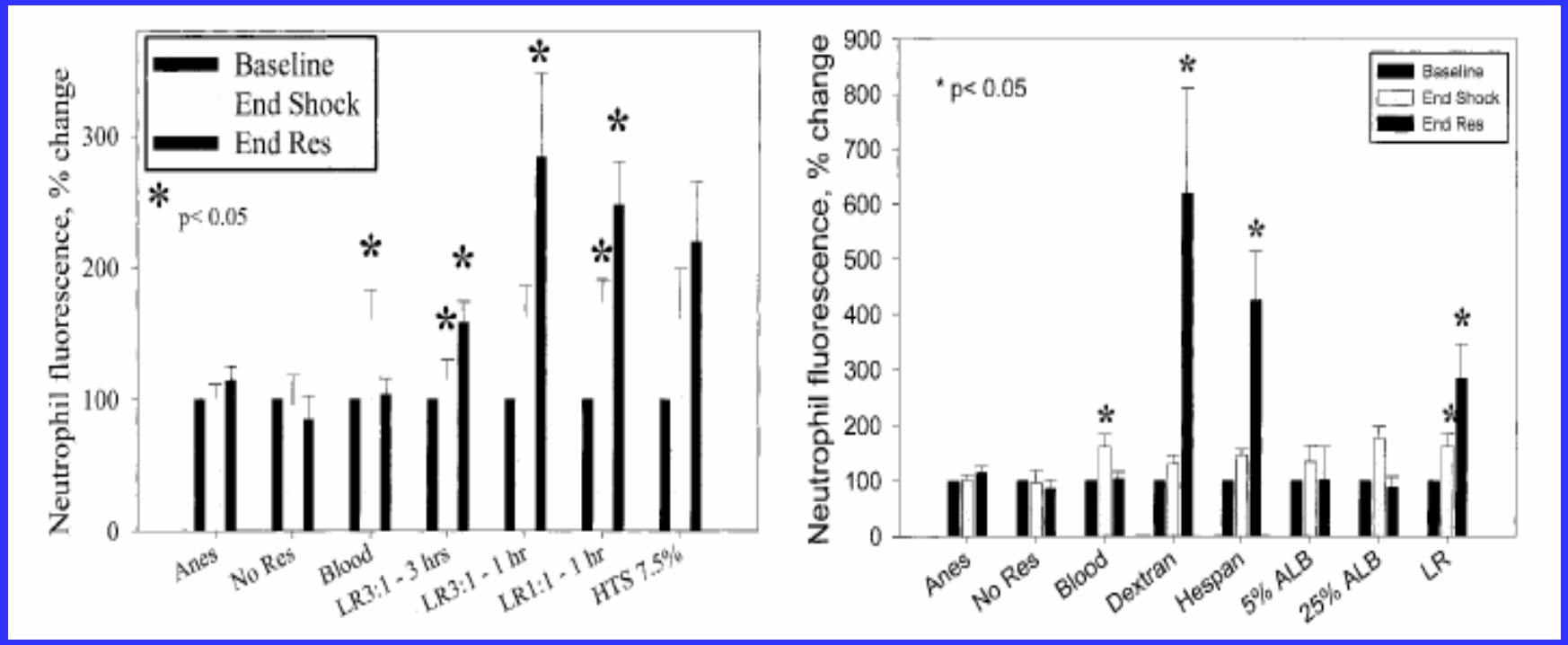
Fig 1. Incidence of coagulopathy increases with increasing injury severity score
Fig 2. Coagulopathy associated with increased mortality even after adjusting for ISS

Goals of Resuscitation

- Maintain Adequate Perfusion
  - 2 Large Bore IV's/Central Line
  - 2 Liters Crystalloids (NS/LR) 3:1(blood loss)
  - Blood Transfusion if >30-40% blood vol loss
    - PRBC:FFP:PLTS 10:4:6
- End Points
  - SBP >120 mm Hg, MAP > 70 mm Hg
  - UOP > O.5 ml/kg
  - Base Deficit < 2
  - Serum Lactate < 2.5 mmol/L


DO2/Cardiopulmonary Dysfunction
Shock/Physiologic exhaustion
MODS/Death
PRBC
Whole Blood
ACS
Pulm Edema
Interstitial edema
Crystalloids/Colloids
TRIM
TRALI
Storage lesions
Acidosis
Hemorrhage/Injury
Hypothermia
Coagulopathy
Avoidance
Forced Warmers
Warmed Fluids
Hyperthermic Therapy
Ambient Temp
FFP
Cryo
Whole Blood
Plts
Factor VIIa
Fibrin Glue
Cytokine Release
Vascular/endothelial injury

Resuscitation Injury

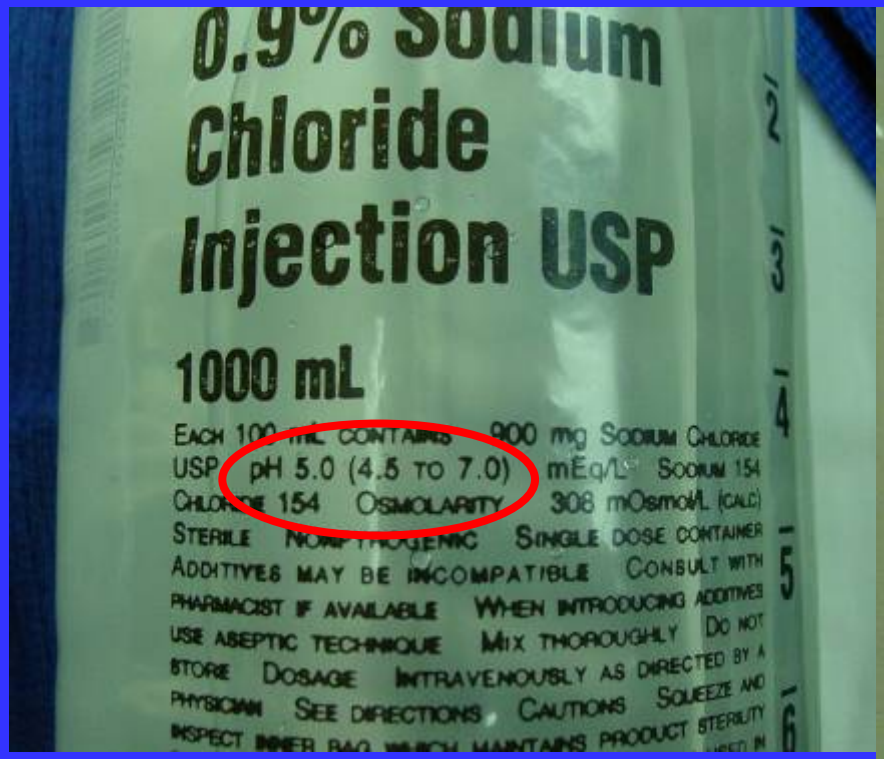


Rhee P, Koustova E, Alam HB: Searching for the optimal resuscitation method: Recommendations for the initial fluid resuscitation of combat casualties. J Trauma 2003;54:S52-S62

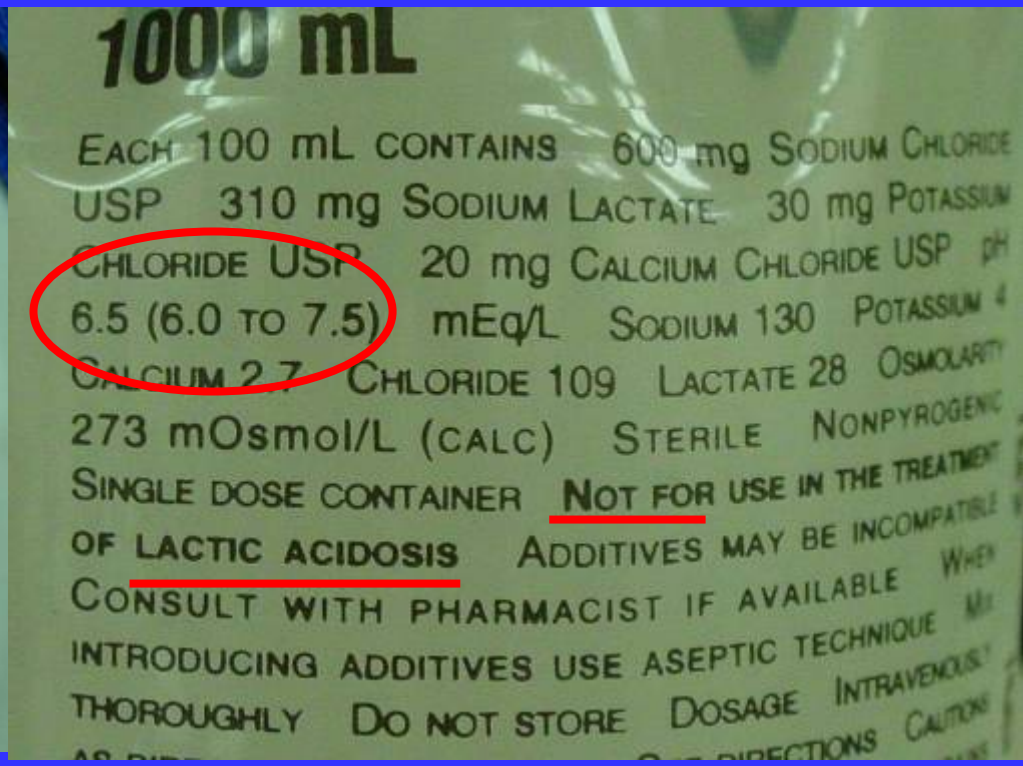
Resuscitation Injury

Iatrogenic Acidosis?

NS



LR



Cotton BA, et. al. The cellular, metabolic, and systemic consequences of aggressive fluid resuscitation strategies. Shock. Aug, 2006.

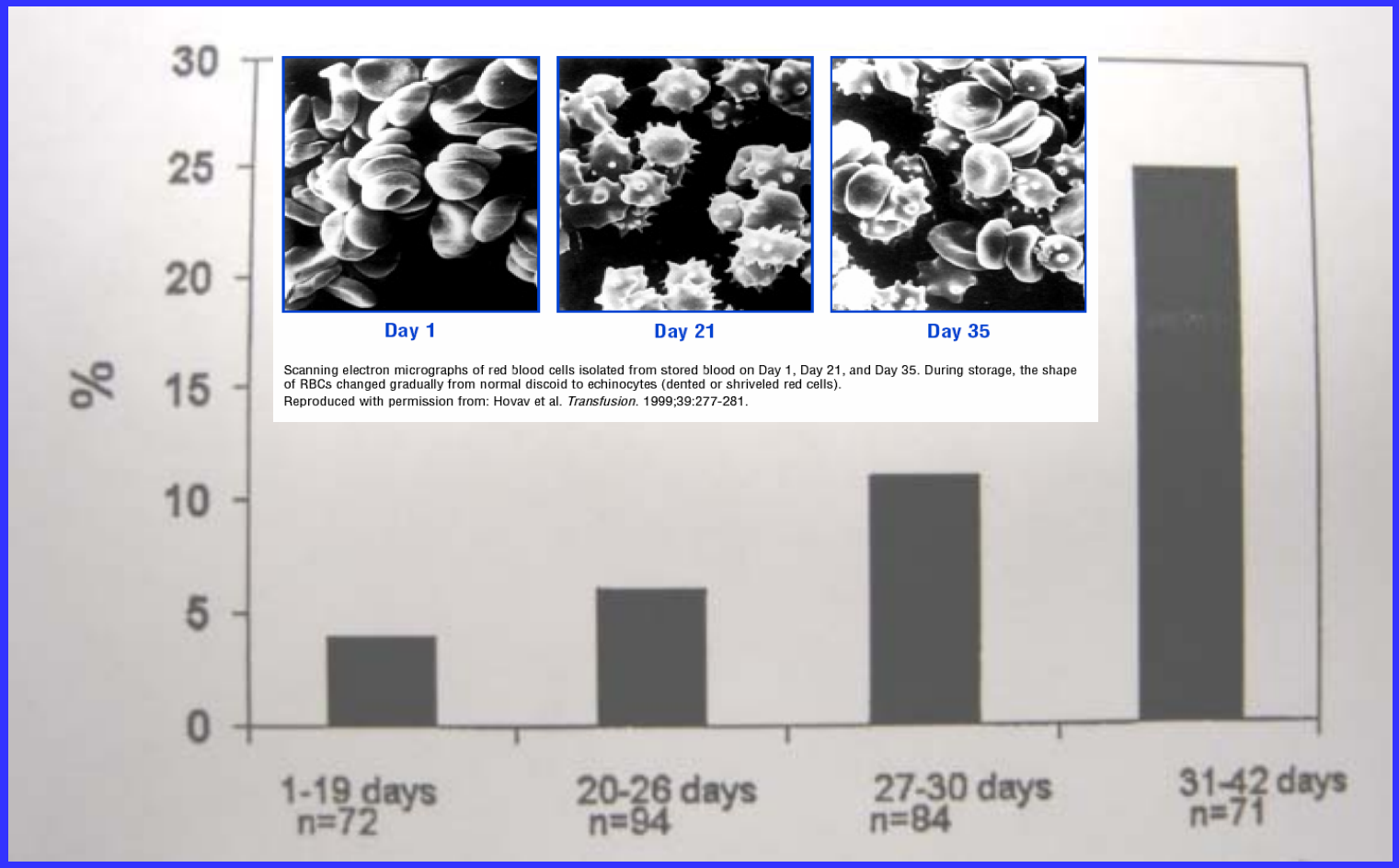
Resuscitation Injury

Table 2. Transfusion of stored red blood cells (RBCs) and associations with morbidity and mortality

Clinical Outcome	Associations Reported in Clinical Studies	Patient Population	Quality of Evidence	Citation
Gastric mucosal pH	Transfusion of RBCs stored >15 days is associated with a decrease in gastric mucosal pH, a marker of splanchnic ischemia	Severe sepsis	Prospective, controlled interventional	7
ICU LOS	Transfusion of RBCs stored >14 days is associated with increased ICU LOS	Medical/surgical ICU	Retrospective cohort	27
Survival to hospital discharge	Transfusion with RBCs stored >16 days increases mortality	Severe sepsis	Retrospective cohort	21
Postinjury MOF	Mean age of blood, number of units stored >14 days and >21 days are independent risk factors for postinjury MOF	Trauma	Prospective cohort	28
Postoperative pneumonia	Risk of pneumonia is increased with mean storage time of RBCs (↑ 1% per day)	Postoperative cardiac surgery	Retrospective cohort	39
LOS, ICU LOS, and mechanical ventilation	No significant associations between length of storage and LOS, stay, ICU stay, or mechanical ventilation time	Postoperative cardiac surgery	Retrospective cohort	24
Tissue oxygenation	No change in P_{CO_2} gap, pH, or any measured oxygenation following transfusion of stored leukodepleted RBCs	ICU	Prospective, double-blind, randomized controlled	49
Major infections	Transfusion of RBCs stored >14 days is associated with increased risk of major infection	Trauma	Prospective cohort	41
Postoperative pneumonia	Duration of storage of the oldest unit is a predictor of pneumonia	Postoperative cardiac surgery	Prospective cohort	29

ICU, intensive care unit; LOS, length of stay; MOF, multiple organ failure.

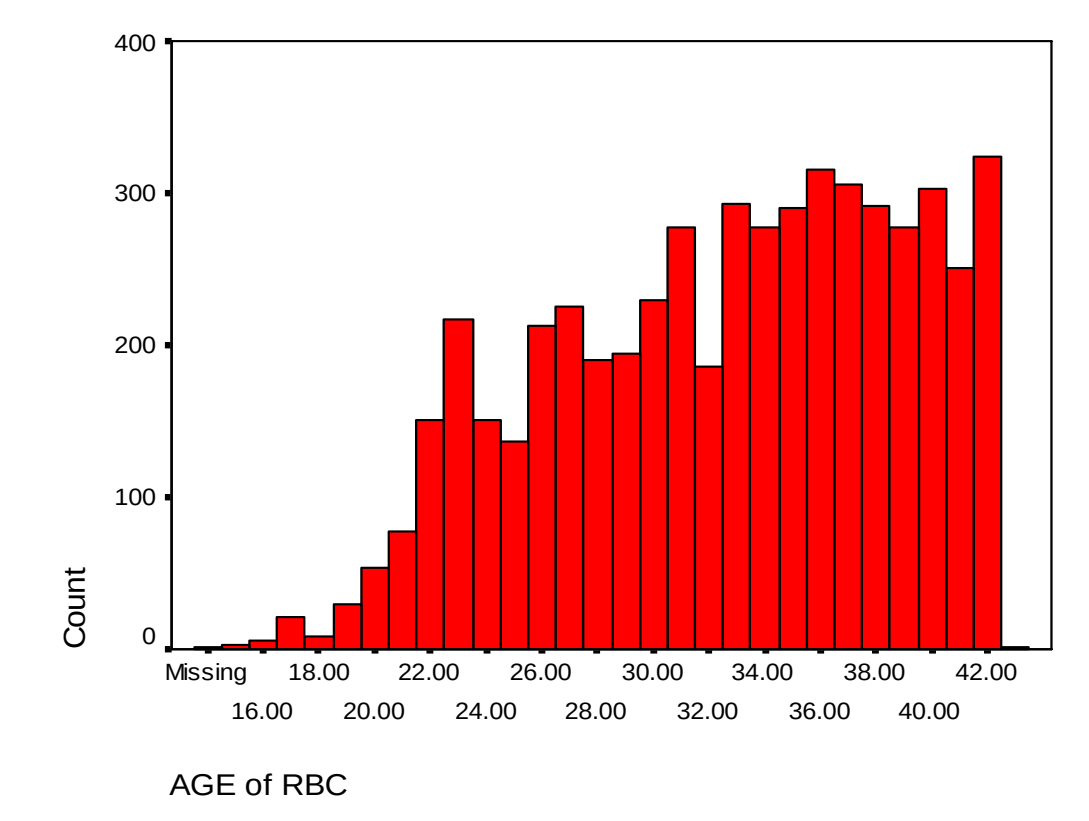
Resuscitation Injury

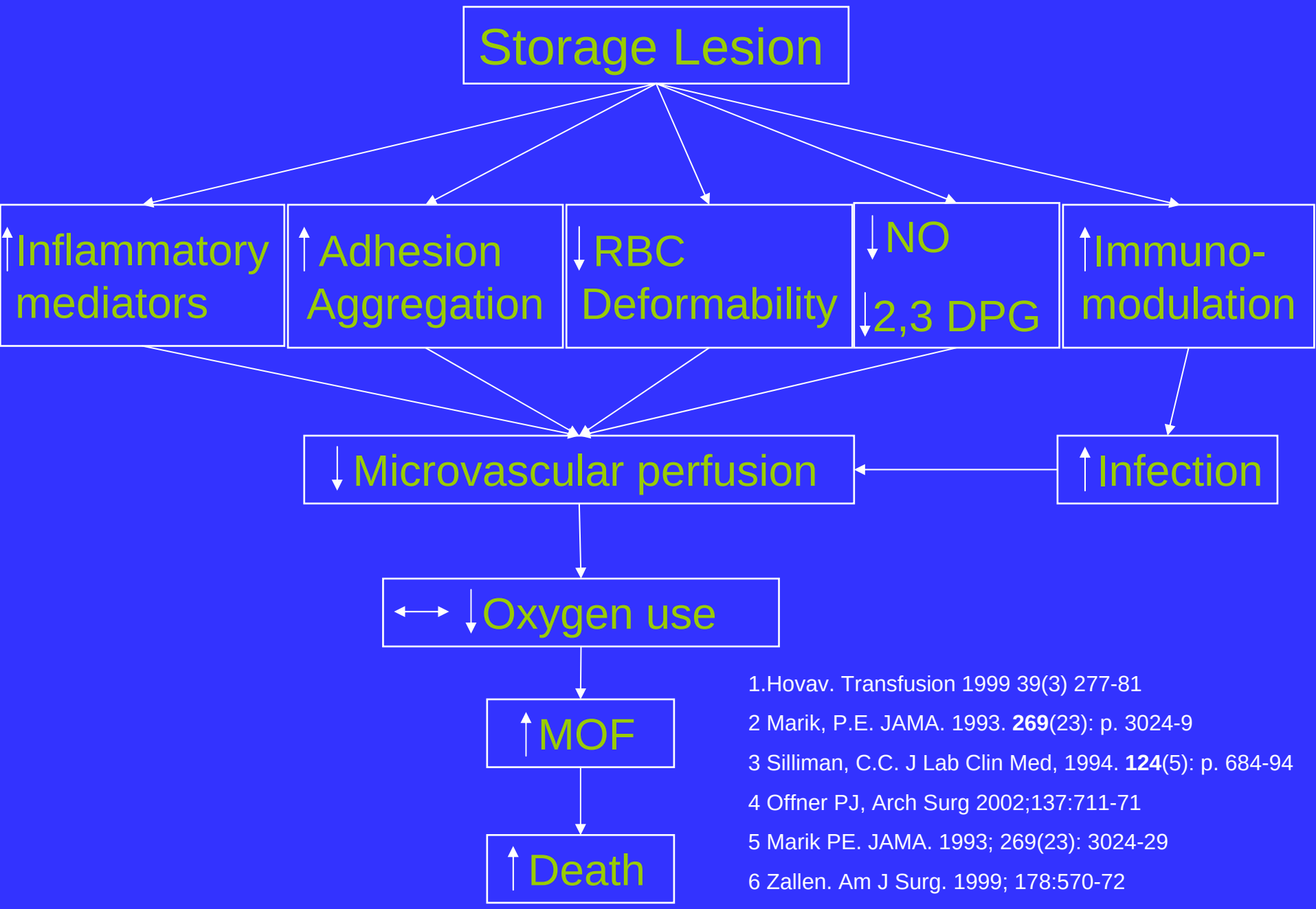


Basran S, et. al. The association between duration of storage of transfused red blood cells and morbidity and mortality after reoperative cardiac surgery. Anesth Analg. 2006 July

Packed RBC Risks

- 5294 Units transfused at 31st CSH
  - Age at delivery 27 days
  - Age at transfusion 33 days +/- 6 days





1.Hovav. Transfusion 1999 39(3) 277-81

2 Marik, P.E. JAMA. 1993. **269**(23): p. 3024-9

3 Silliman, C.C. J Lab Clin Med, 1994. **124**(5): p. 684-94

4 Offner PJ, Arch Surg 2002;137:711-71

5 Marik PE. JAMA. 1993; 269(23): 3024-29

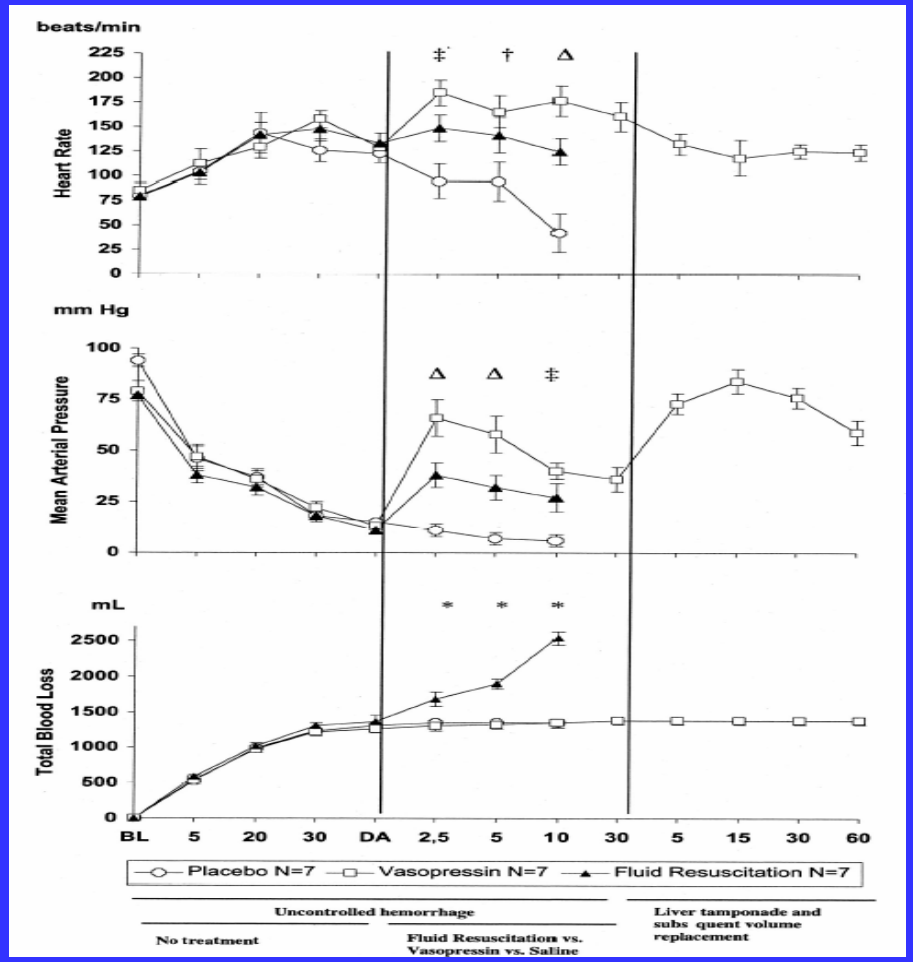
6 Zallen. Am J Surg. 1999; 178:570-72

7 Purdy FR. Can J Anaesth. 1997; 44:1256-61

Figure: Effects of storage lesion associated with increased storage time and amount of red cell transfusions.

Minimizing Resuscitation Injury
Balanced Resuscitation
Vasopressin

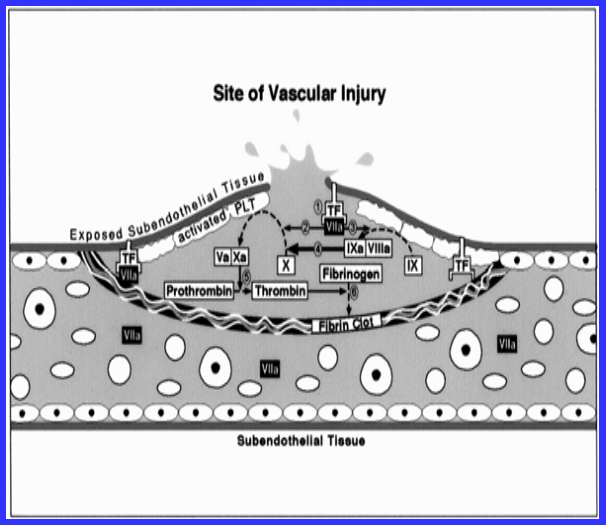
- Vasopressin (n=7) vs saline placebo(n=7) vs fluid resuscitation (n=7LR/Hetastarch)
- 30 minutes after intervention, fluid resuscitated while bleeding was surgically controlled
- No increased bleeding
  - 1343+/-60 vs 1350+/-22 vs 2536+/- 93 (p<0.01)
  - 7/7 vasopressin survived 60 minutes



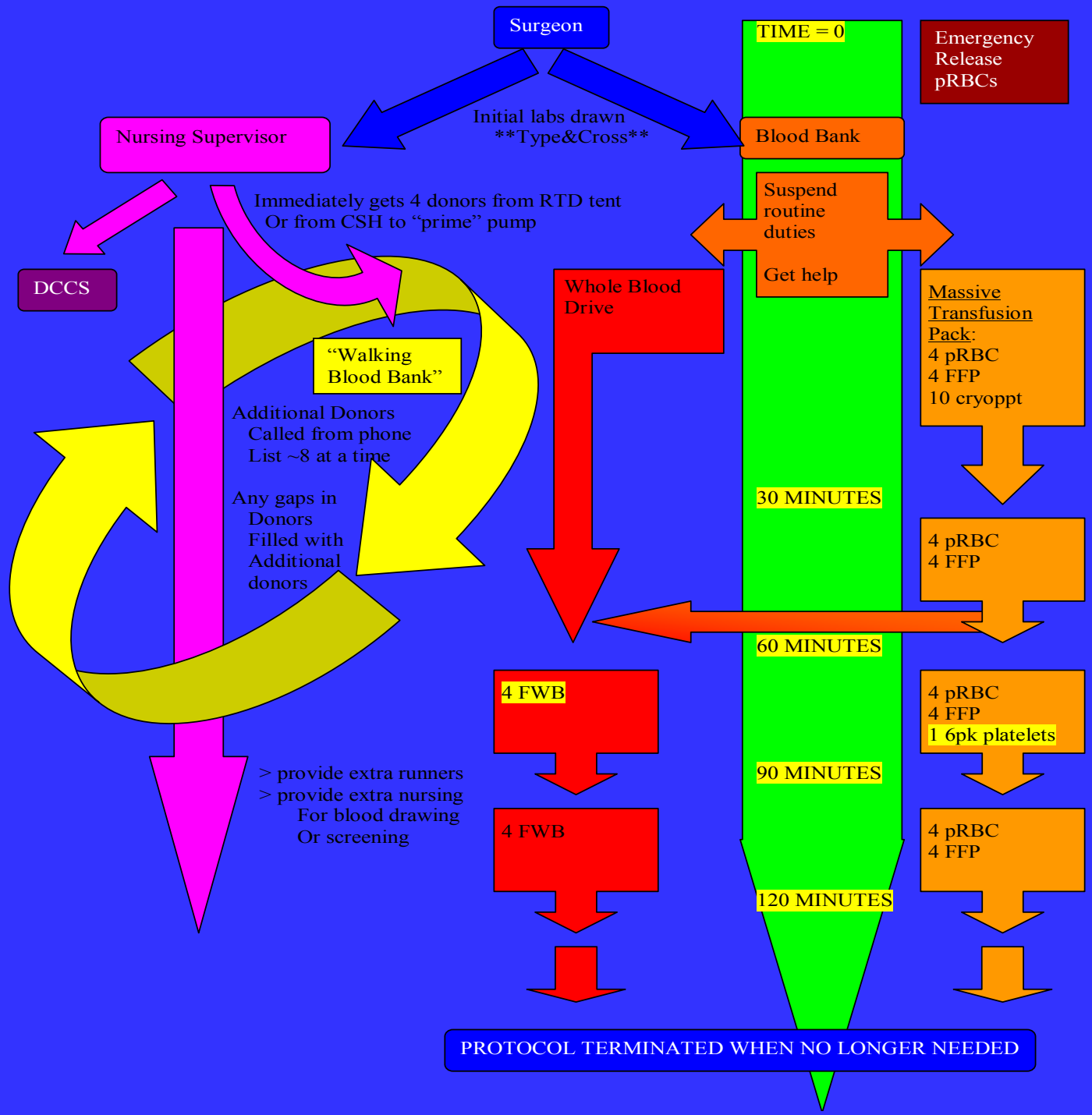
Raedler C, Voelckel WG, Wenzel V, et al. Treatment of uncontrolled hemorrhagic shock after liver trauma: Fatal Effects of fluid resuscitation versus improved outcome after vasopressin. Anesth Analg 2004;98:1759-66

Factor VIIa Correction Traumatic Coagulopathy-Decrease the Need For Resuscitation

- Pig Gr IV Liver Injury Model (180 ug/kg)
  - Blood loss 27.6 +/- 2.1 ml/kg vs 33.3 +/-3.4 ml/kg
  - p=0.2
  - Mortality 0/6 vs 3/7 p=0.08
- Pig Gr IV Liver Injury Model
  - (180 ug/kg vs 720 ug/kg)
  - Improved survival
  - Decreased blood loss p<0.05



Lynn M, Jeroukhimov I, Jewelewicz D et al. Early use of recombinant factor VIIa improves MAP…. J Trauma 2002;52:703-7
Jeroukhimov I, Jewelewicz D, Zaias J et al. Early injection of high-dose recombinant factor VIIa decreases blood loss..53:1053-57
Schreiber MA, Holcomb JB, Hedner U et al. The effect of factor VIIa on non-coagulopathic pigs with…. J Am Coll Surg 2003;196:691-7


Surgeon
TIME = 0
Emergency Release pRBCs
Initial labs drawn
Type&Cross
Nursing Supervisor
Blood Bank
Suspend routine duties
Get help
Immediately gets 4 donors from RTD tent
Or from CSH to "prime" pump
DCCS
Whole Blood Drive
Massive Transfusion Pack:
4 pRBC
4 FFP
10 cryoppt
"Walking Blood Bank"
Additional Donors
Called from phone
List ~8 at a time
Any gaps in
Donors
Filled with
Additional
donors
30 MINUTES
4 pRBC
4 FFP
60 MINUTES
4 FWB
4 pRBC
4 FFP
1 6pk platelets
> provide extra runners
> provide extra nursing
For blood drawing
Or screening
90 MINUTES
4 FWB
4 pRBC
4 FFP
120 MINUTES
PROTOCOL TERMINATED WHEN NO LONGER NEEDED

MT protocol

- Transfuse RBC:FFP:PLT in 1:1:1 ratio
  - In the ED 4 units each of
    - Emergency release O- RBC's
    - Thawed plasma in ED
    - Early use of rFVIIa (90mcg/kg)
      - ? Efficacy affected by acidosis
      - Correct acidosis rapidly
        - » Bicarbonate or THAM
    - Continue with 4 units of RBC and FFP each with either
      - 10 units of cryo or 1 unit of platelets
    - Initiate FWB drive
    - Utilize FWB as soon as possible 4 units at a time
    - Avoid crystalloid
    - Stop when bleeding stops

Component Therapy vs Fresh Whole Blood

Component Therapy:

1U PRBC + 1U PLT + 1U FFP + 10U Cryo

660 COLD mL

- ***Hct 29%***
- ***Plt 87K***
- ***Coag activity 65%***
- ***750 mg fibrinogen***

FWB:

500 mL Warm

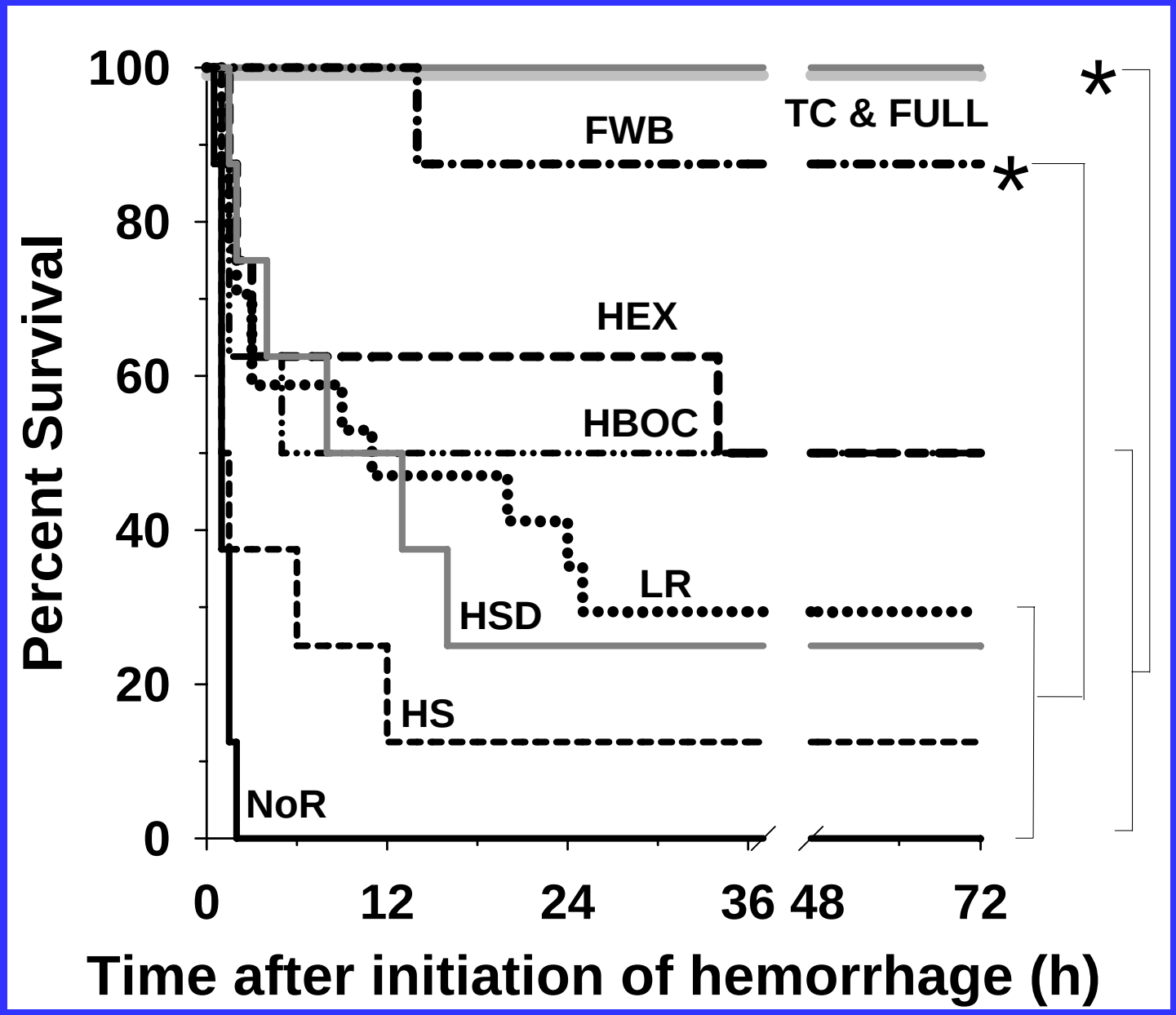
Hct: 38-50%

Plt: 150-400K

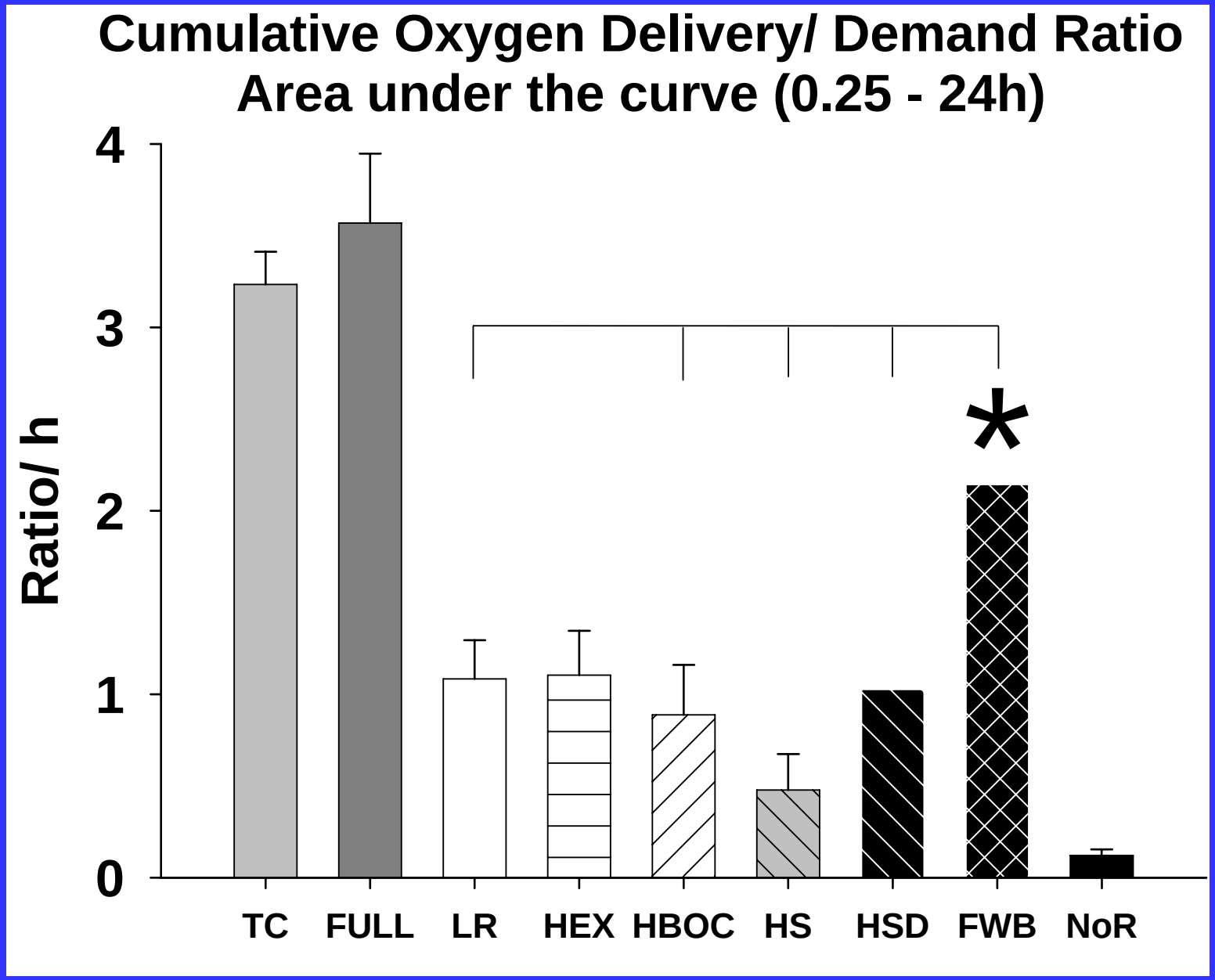
Coags: 100%

1500 mg Fibrinogen

•Armand & Hess, Transfusion Med. Rev., 2003



Sondeen, JL, Wade, CE, Dubick, MA, Prince, MD, JB Holcomb. Fresh Whole Blood is the Best 24-h Hypotensive Resuscitative Fluid in Severe Hemorrhage in Swine. *Shock*. 2006.



Sondeen, JL, Wade, CE, Dubick, MA, Prince, MD, JB Holcomb. Fresh Whole Blood is the Best 24-h Hypotensive Resuscitative Fluid in Severe Hemorrhage in Swine. *Shock*. 2006.

FWB vs Component Therapy

- Why FWB is superior to components
  - Fresh products that
    - Deliver oxygen efficiently
    - Provide hemostasis better than stored components
  - 1 unit of FWB = 1 unit of RBC,FFP, PLT
    - 1 unit of FWB
      - Less volume
      - More concentrated product
    - Does not exacerbate dilutional coagulopathy as CT does
  - Improved microcirculatory hemodynamics
  - Improved cardiac output

Arslan, E., et al., *Microcirculatory hemodynamics after acute blood loss followed by fresh and banked blood transfusion.* Am J Surg, 2005. 190(3): p. 456-62.

Barbee, R.W., J.A. Kline, and J.A. Watts, *A comparison of resuscitation with packed red blood cells and whole blood following hemorrhagic shock in canines.* Shock, 1999. 12(6): p. 449-53.

FWB hemostatic benefits

- Improved hemostasis
  - Reduced blood loss and transfusion requirement when whole blood compared to component therapy [1]
  - 1 unit of stored fresh whole blood had the equivalent hemostatic effect of 8-10 platelet units [2]

1 Manno CS, *Blood* 1991; 77:(5) 930-936
2 Lavee J, *Journal of Thoracic & Cardiovascular Surgery* 1989; 97(2):204-12

Fresh Whole Blood

- Jan 04-Jan 05
- 545 Units of FWB transfused to 87 pts
- Of 87 pts
  - 49 (57%) US Sol
  - 2 (2.3%) Coalition
  - 3 (3.5%) Contractors
  - 23 (25.6%) Iraqi Civ
  - 10 (11.6 %) Combatants

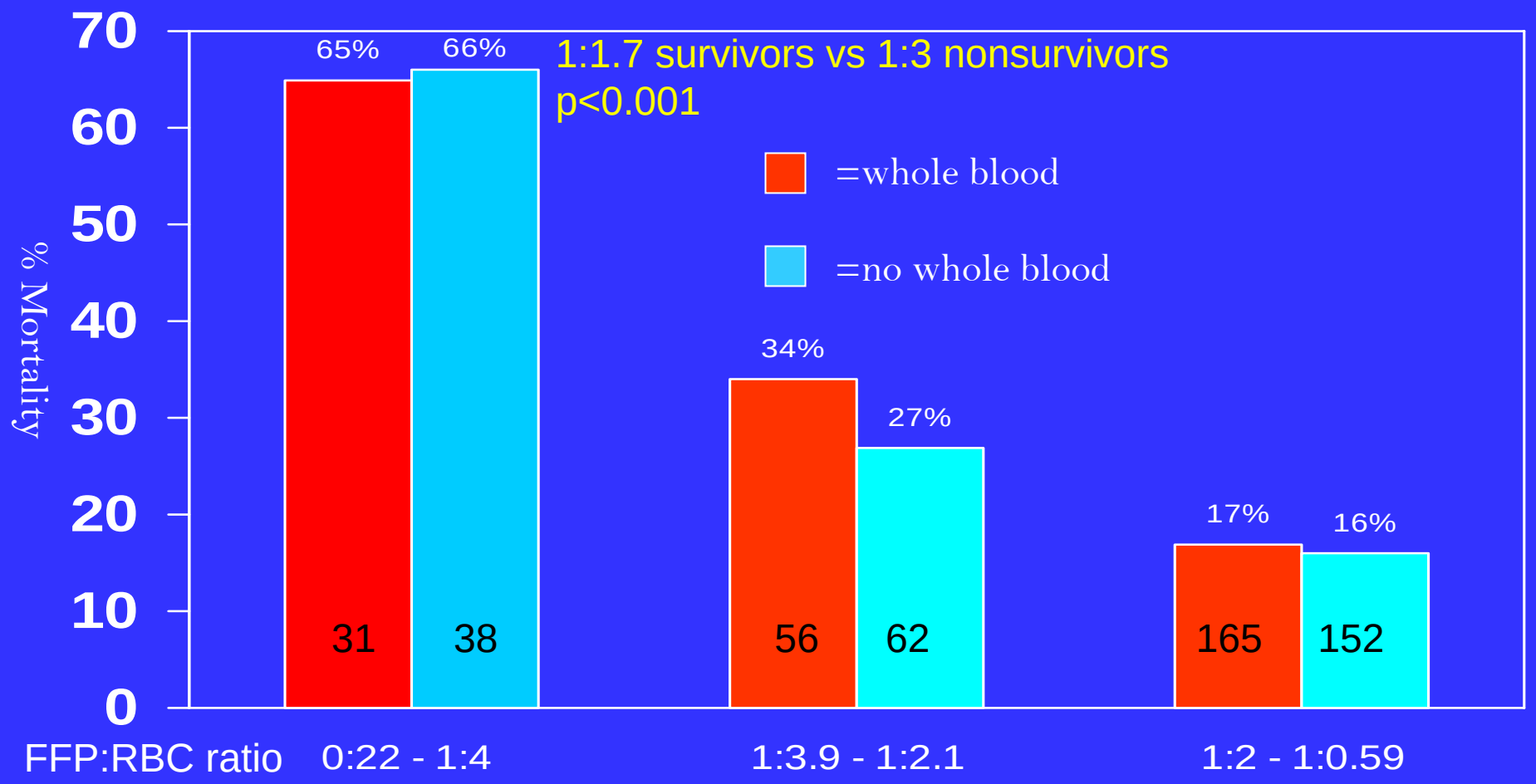
FWB use independently associated with increased survival

- In 111 patients with massive transfusion and ISS>15
- Logistic regression analysis of all variables associated with mortality
  - Admission vitals, labs, all blood products transfused in 7 days, ISS
- Per unit of FWB the OR for survival
  - 1.48, (95th CI, 0.99-2.21, p=.05)

Comparison of variables between FWB and CT cohorts.

	FWB (n=55)	**CT (n=56)**	**p-value**
HR (bpm)	121 (68-190)	113.5 (38-163)	0.15
SBP (mmHg)	107 (43-225)	97 (42-250)	0.88
Deficit	10 (0-30)	7 (0-23)	0.25
INR	1.7 (1-4.48)	1.45 (.8-10)	0.23
Hb (g/dl)	8.5 (2.8-13.9)	10.9 (4-17.9)	0.001
PLT ($x10^{3/mm3}$)	57 (16-406)	196 (8-476)	<0.001
FWB (units)	4 (1-35)	0 (0-0)	<0.001
RBC (units)	15 (6-47)	18 (10-59)	0.04
FFP (units)	9 (2-41)	11 (0-57)	0.04
PLT (units)	0 (0-0)	1 (0-8)	<0.001
Cryo (units)	10 (0-23)	10 (0-62)	0.05
rFVIIa use	24/55 (44%)	21/56 (38%)	0.57
ISS	25 (16-50)	19 (16-35)	0.005
Death	12/55 (21.8%)	19/56 (33.9%)*	0.09

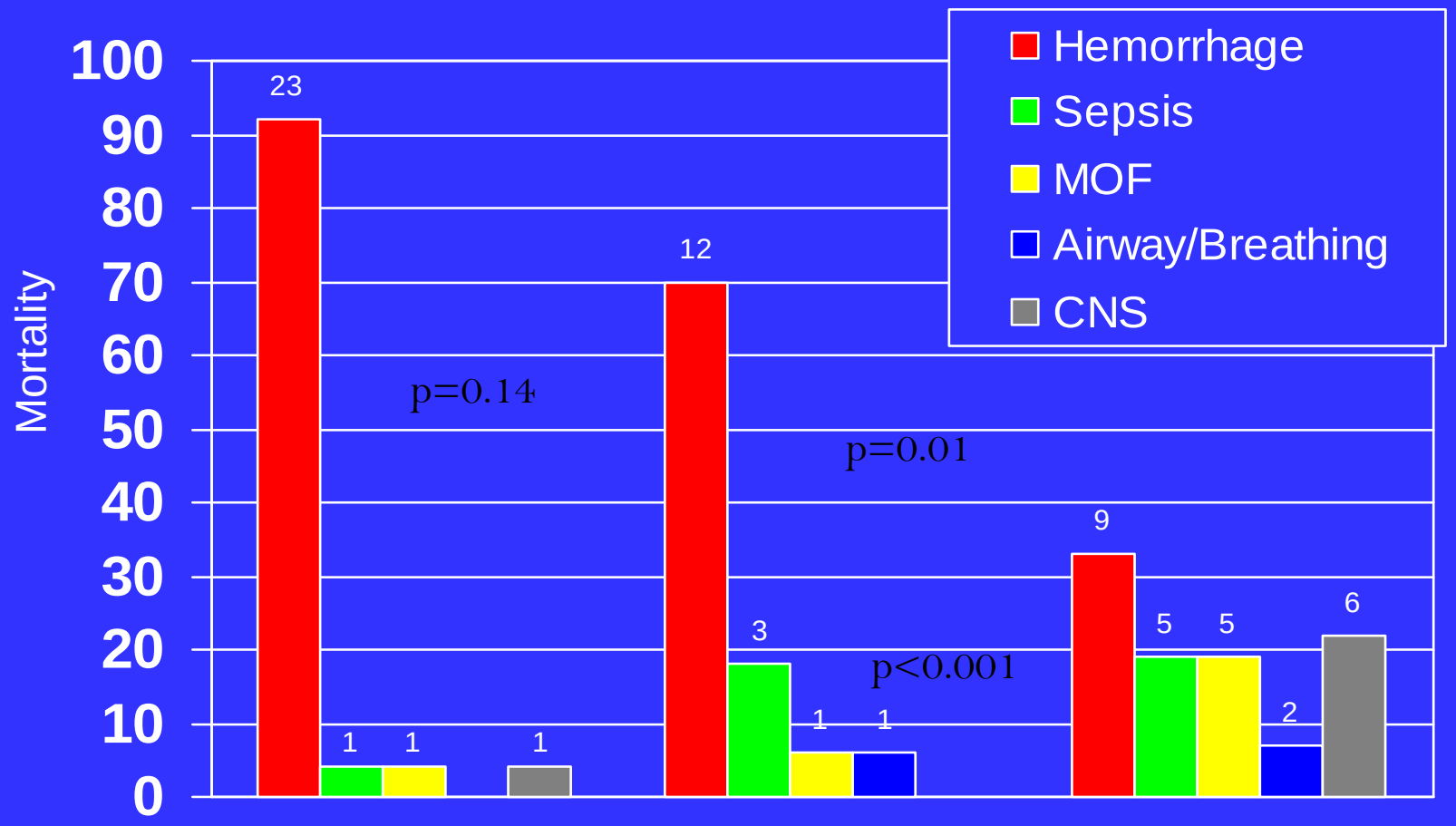
FFP:RBC ratio Level 3 mortality



ISS (IQR)	16 (11-20)	17 (12-30)	17 (14-25)
%ISS >25	13%	20%	21%

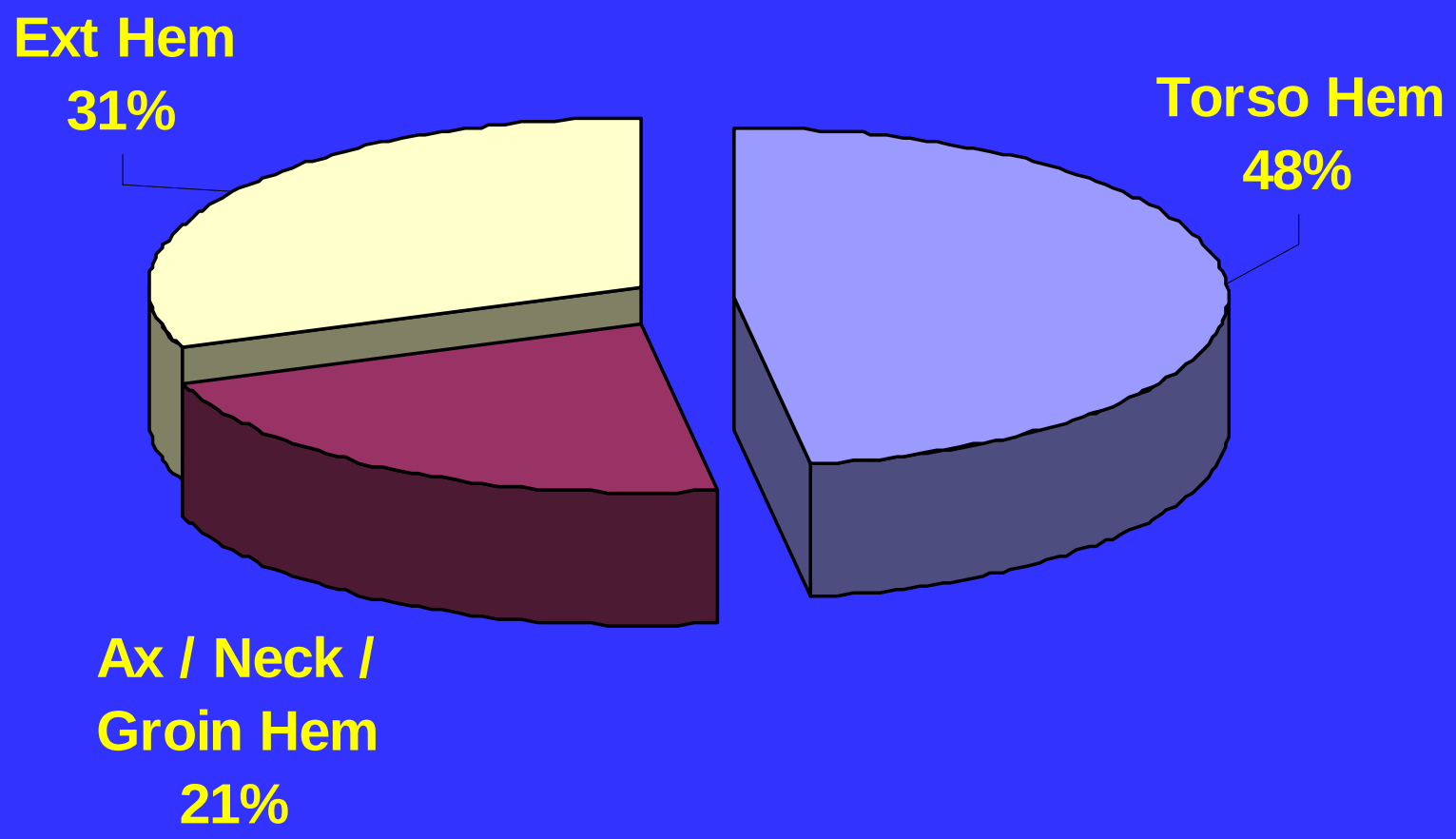
Borgman M, Spinella, P, et al. Blood product replacement affects survival in patients receiving massive transfusions at a combat support hospital. Submitted CCM, 2006

Cause of Death by Group



FFP/RBC ratio	0:22 - 1:4	1:3.9 - 1:2.1	1:2 - 1:0.59
ISS (IQR)	16 (11-20)	17 (12-30)	17 (14-25)
%ISS >25	13%	20%	21%

Breakout of Potentially Survivable Hemorrhagic Deaths: n=85



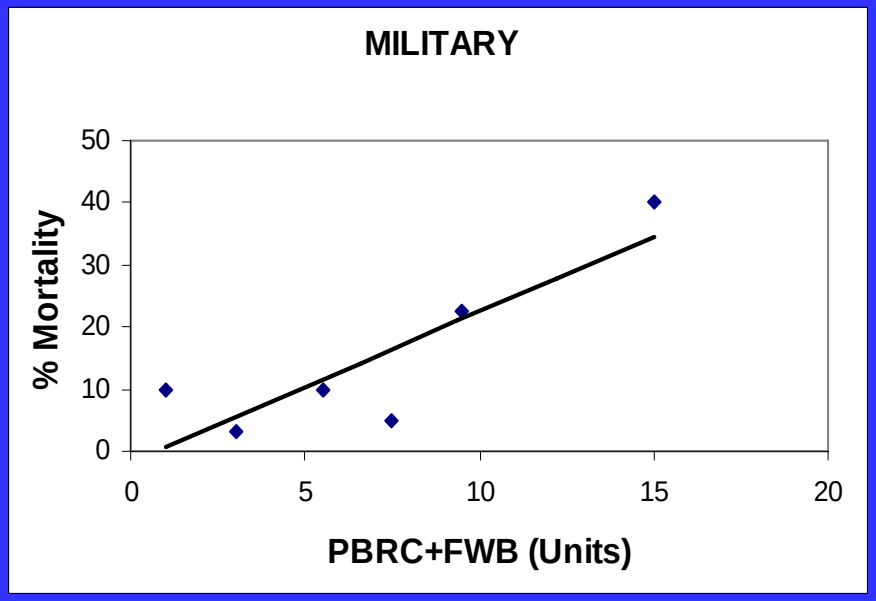
Damage Control Resuscitation

1. Use TCCC concepts
   - Tourniquets for extremities
   - Hemostatic dressings for axilla/groin/neck
   - Manual pressure, etc
   - Evacuation
2. Hypotensive resuscitation
3. Hemostatic resuscitation
   - Prevent coagulopathy in high risk patients
   - Treat coagulopathy as early as possible

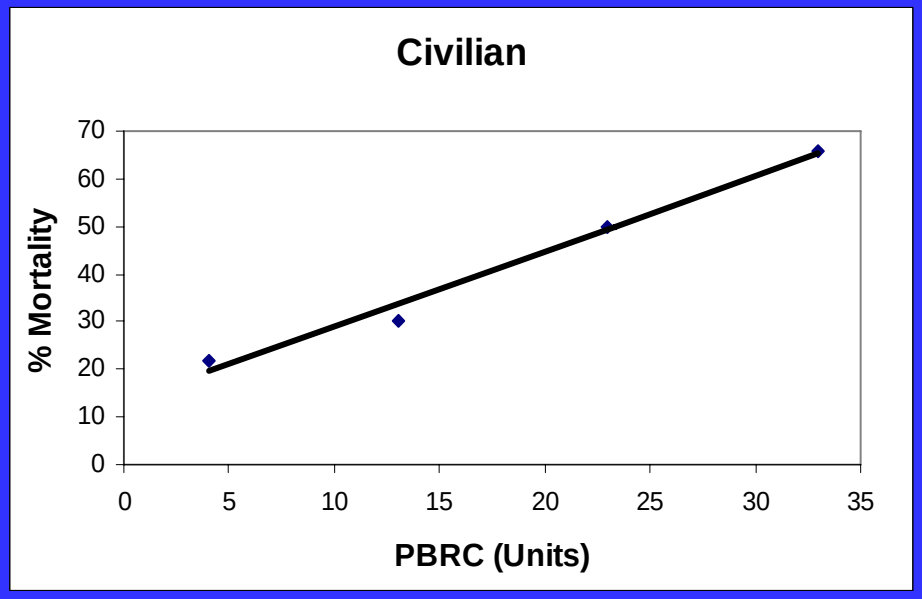
Its all about stopping bleeding

Stopping bleeding is important- Mortality Increases as Transfusion Increases

Military and Civilian casualties



•Eastridge et al, submitted, 2005



Como et al. Blood transfusion rates in the care of acute trauma. Transfusion. 2004 Jun;44(6):809-13.

Damage Control Resuscitation Overarching Goals

- Avoid dilution of coagulation factors, edema and worsening acidosis by the standard serial escalation resuscitation practices
  - LR (3:1) PRBC (10 units) FFP platelets cryo
- Simultaneous Restoration of Coagulation and Intravascular Volume Deficit
  - metabolic resuscitation
  - coagulation resuscitation
- Apply currently existing coagulation products/methods in optimal ratios and volumes that provide hemostatic and metabolic stabilization of the combat casualty
- **Avoid dilution and edema by minimizing crystalloid**

Hemostatic Resuscitation Tools

1. Early Dx in ED
2. 1:1:1 ratio (RBC:thawed plasma:PLT)
3. ED use of cryoprecipitate and rFVIIa
4. Call for FWB from the ED
5. Correction acidosis, hypothermia, hypocalcemia
6. Repeated doses of rFVIIa in OR and ICU as required
7. Minimize crystalloid
8. TEG

Plasma Composition

Electrolytes (mmol/L) average unit of FFP ~ 300cc

Na	165 (48mmol/unit)
K	3.3 (1.0mmol/unit)
Glucose	20
Calcium	1.8
Citrate	20
Lactate	3
pH	7.2-7.4 (LR 6.5, NS 5.0)
Phosphate	3.63

British Society for Hematology 1994

Predictors of Massive Transfusion and Death

- BD ≥ -6
- INR ≥ 1.5
- SBP ≤ 90 mm Hg
- Hgb ≤ 11
- Temp ≤ 96°F

- Weak or absent radial pulse
- Abn mental status
- Age ≥ 55

5 minutes

- Pattern recognition
  - Bilat prox amputations
  - Truncal bleeding and one prox amputation
  - Large Chest tube output

- All associated with MT or death ~ 10-25%
- Normal values, minimal injury, usually associated with very low death rates (~ 1%)

Schreiber MA, Perkins JP, Kiraly L, Underwood SJ, Wade CE, Holcomb JB.

Early Predictors of Massive Transfusion in Combat Casualties. Submitted, J Trauma

rFVIIa impact

- n = 236 massive transfusion
- No rFVIIa mortality = 29.5%
  - ISS = 32.4
- Received rFVIIa mortality = 20%
  - ISS = 33.5

- p= 0.13

rFVIIa

- ED use of rFVIIa (90-120 µg/kg) with similar follow up doses in the OR and ICU
  - if INR is abnormal.
- In military casualties requiring massive transfusion, early administration of rFVIIa decreased pRBC use by 23%
- rFVIIa increases the SBP at which arterial rebleeding occurs
  - suggesting the formation of a tighter, stronger fibrin plug in the presence of high concentrations of rFVIIa
- Seven prospective, randomized surgical trials have documented the safety of this drug.
- The clinical goal is a subnormal PT or INR, ensuring that if bleeding is still occurring then surgical intervention is required.

Boffard K, et al. Recombinant factor VIIa as adjunctive therapy for bleeding control in severely injured trauma patients: two parallel randomized, placebo-controlled, double-blind clinical trials. J Trauma. 2005.

Perkins JG, Schreiber MA, Wade CE, Holcomb JB. Early vs Late recombinant factor VIIa in combat trauma patients requiring massive transfusion. Submitted, J Trauma.

Damage Control Resuscitation

In Massively Transfused Casualties (10th CSH)

- Early use of use of FFP, rFVIIa and FWB decreases bleeding and improves survival. DCR is now being practiced in theater. We hypothesized that the final coagulation status of trauma patients treated with DCR would improve.

- Damage control resuscitation reverses coagulopathy and minimizes crystalloid use.

	Group #1 (n=252)	Group #2 (n=27)
Age (yrs)	27 ± 8	29 ± 7
ISS	29 ± 10	34 ± 20*
24 hr Survival (%)	82	85
Hgb (g/dL)	10.4 ± 2.7	10.0±2.3
T (°C)	35.3 ± 1.5	36.8 ± 0.9*
BD (mEq/L)	9 ± 7	11± 8
INR (admission)	1.9 ± 1.3	1.7 ± 0.8
INR (post-resus)	1.7 ± 0.7	1.2 ± 0.5 *
PRBC (U)	17 ± 9	21 ± 14*
FFP (U)	10 ± 7	16 ± 11*
Platelets (U)	0.5 ± 1.3	11 ± 11.3*
Crystalloid (L)	10 ± 7	8 ± 5*
Fresh Whole Blood (U)	2.3 ± 4.4	2.7 ± 5.4
Cryo (U)	8 ± 11	15 ± 19*

ED Cox, et. al. Submitted to EAST, 2006

FWB Program

- Donor Screening
  - Eligibility by questionnaire if not previously done
  - Donors tested for anemia
    - Screened with copper sulfate test
    - 5% of female donors excluded
  - Donor blood was typed and crossed to the recipient's blood.

FWB Program

- Infectious Disease Screening
  - HIV, HBsAg, Hep C, RPR
  - Immunochromatography
    - Non-FDA approved test (Biokit, Spain)
    - 15-20 minutes to perform
    - Can be purchased from Iraq
    - frusso@biokitusa.com

FWB Risks

- Transfusion Reactions
  - No difference between FWB and RBC's
  - FWB: 2/545 (0.36%)
    - 1 febrile non-hemolytic reaction
    - 1 TRALI
  - RBC's: 12/5294 (0.22%), (p=.52).
    - 9 febrile non-hemolytic reaction
    - 1 TRALI
    - 2 hemolytic reactions

FWB Risks

- Infectious risks
  - Formal infectious disease screening of 2831 donor samples from May 2003 – Feb 2006
  - Both Afghanistan and Iraq
    - 3 positive HCV RIBA
    - 2 HTLV by western blot
    - 1 inconclusive RPR
    - 0 HIV, HBsAg

FWB - ID Transmission Risk

Comparison of infectious disease formal testing results of transfused FWWB units that were screened or not screened prior to administration

	Total Samples	Screened prior to transfusion	Not screened prior to transfusion
HIV	0/2831 (0%)	0/460 (0%)	0/2371 (0%)
HCV	3/2831 (.11%)	0/404 (0%)	3/2427 (.12%)
HBsAg	0/2831 (0%)	0/404 (0%)	0/2427 (0%)
HTLV	2/2831 (.07%)	NA	2/2831 (.07%)
Syphilis	1/2831* (.04%)	NA	1/2831* (.004%)

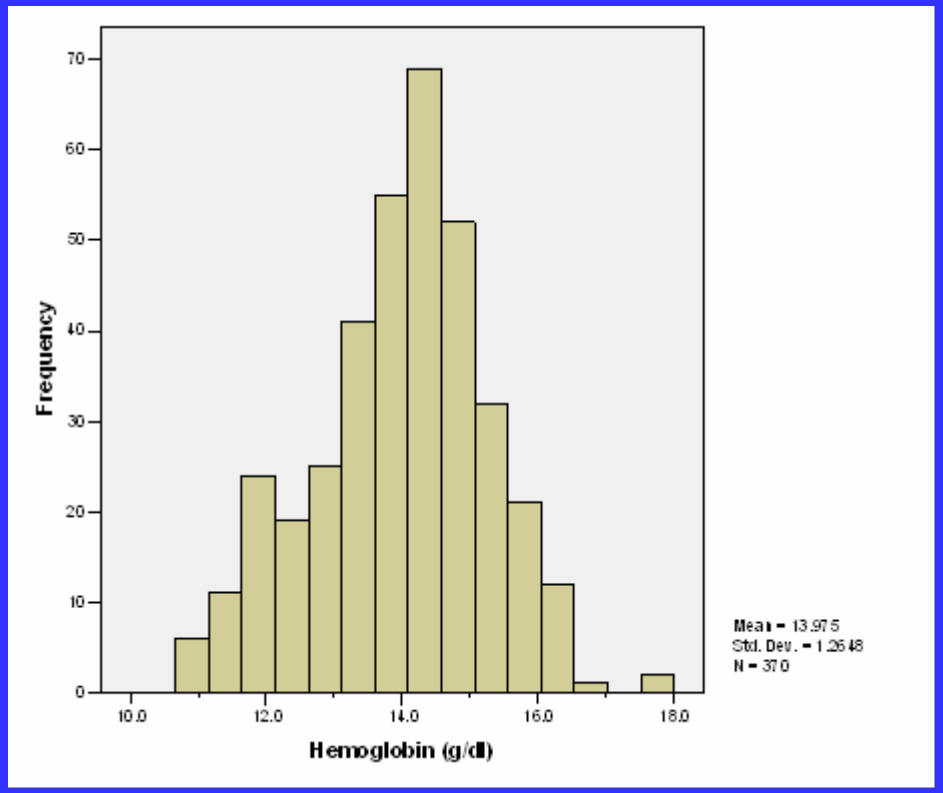
Rapid screening at the 31st prevented the transfusion of 2 donors who tested HCV positive

FWB - ID Transmission Risk

- Use of rapid screening tests minimizes risk of ID transmission
  - Prevalence of HCV in US is 1.6%
  - Specificity of HCV test is 98.7%
- Expect 1 / 4800 donor units to be HCV with use of rapid screening tests
- 1/809 donors HCV + when not screened
- 600% decrease in HCV transmission with screening

FWB Risks

- Donor Anemia
- Male (n=303) post-donation results
  - Hb: 14.3 g% (+/- 1)
  - 22% anemia (Hb < 13.5 g%)
- Female (n=67) post-donation results
  - Hb: 12.3 g% (+/- 1)
  - 37% anemia, (Hb <12 g%)
- No donors with Hb < 10g/dl
  - Result of using copper sulfate test to screen for anemia prior to donation



What is Thrombelastography?

- Test of coagulation
- Provides a global assessment of hemostatic function from initiation of protein coagulation through clot lysis

What are the theoretic advantages of TEG?

- Yields information on the cumulative effect of multiple components of coagulation
- More accurate assessment of clotting factor, fibrinogen, and platelet activity than provided by PT, PTT, fibrinogen, & platelet levels
- Allows for more judicious & patient specific delivery of blood products

Case

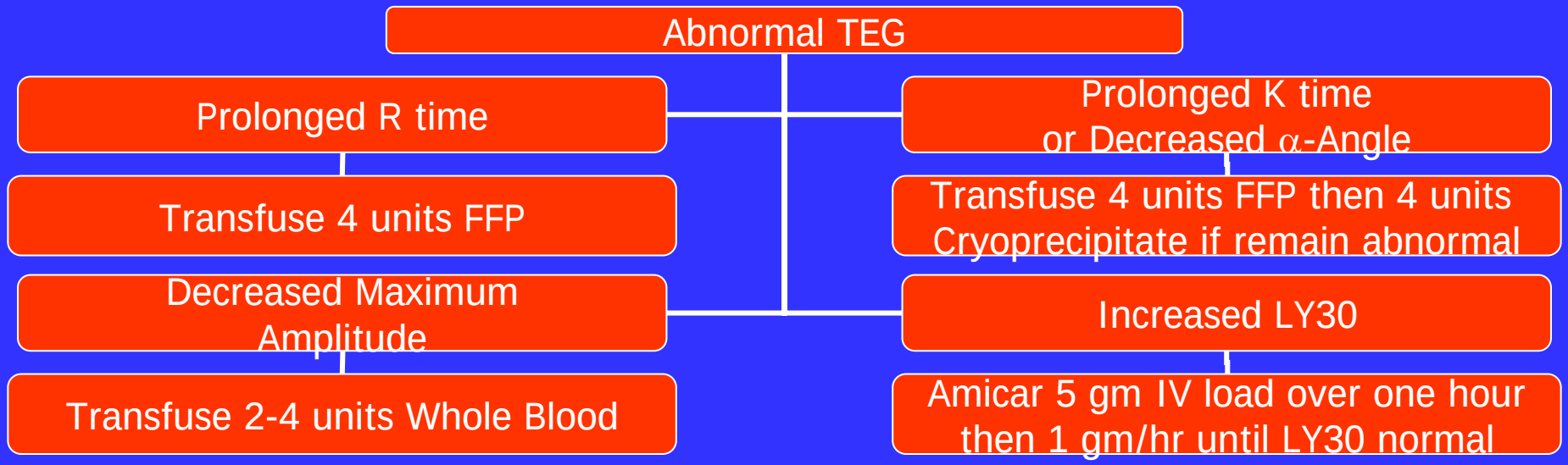
- GSW to Pelvis & RLE
- Rectal, Small Bowel, Sacral, & Open Femur Fx
- Arrived in Class IV Shock

TEG to Guide Resuscitation

- Intra-op after 11 PRBC, 2 Plt, 4 Cryo, 6 FFP, 3 WB, & 1 Factor VIIa
- Post-op after 19 PRBC, 2 Plt, 4 Cryo, 6 FFP, 6 WB, & 1 Factor VIIa

TEG Directed Transfusion

- Repeat TEG after each phase of blood product resuscitation to monitor clinical response and direct further blood product administration



Future Product – Artificial whole blood

- Shelf stable product with hemostatic and metabolic resuscitative properties
- Will be used by all levels as the primary resuscitative fluid
  - No storage or mixing issues
    - Lyophilized plasma
    - Lyophilized platelets
    - Lyophilized/recombinant fibrinogen
    - rFVIIa
    - Hemoglobin substitute
  - Currently either approved or ongoing studies

Combat Research Unit

Maj Jeremy Perkins

Endpoints of Resuscitation
Whole Blood vs Component Therapy
rFVIIa
TEG

Ongoing Research:Early Damage Control Resuscitation

- Mortality
- Medical Complications
  - Late deaths (ARDS, MOF, sepsis)
  - Ventilator days, ICU days, LOS
  - Reduction in blood product use
- Outcome

Conclusions

- FWB transfusion programs need
  - Organization to increase speed of collection
  - Attention to safety to minimize
    - Donor anemia and infectious disease transmission
      - Formal testing for HIV,HBV,HCV, HTLV, RPR
        - » Prior to deployment
        - » During deployment
      - Must screen all donors with rapid test
- rFVIIa and Lyophilized plasma as the primary resuscitative fluid for the 10% of casualties that are significantly injured
  - Level 1, 2 and 3