Damage Control Resuscitation

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Major Trauma - March 2011

(Local Population/ ANF/ ANP & Coalition Troops)

- 121 trauma admissions (48% IED,28% GSW)
- 23 Amputations (10 single/11 double/2 Triple) -11 with perineal injury
- 28 patients required massive transfusion (> 10 units PRBCs)
- 1066 units PRBCs
- 1015 units FFP
- 165 Platelets & 67 Cryoprecipitate

Damage Control (and) Resuscitation

BATLS

<C> A B C D E

<C> - ***Catastrophic Haemorrhage*** – *Tourniquet/Celox*

A - ***Airway*** – *Basic/RSI/Surgical*

B - ***Breathing*** – *Pneumothorax (Open/Tension) - ICD*

C - ***Circulation*** – *Splint fractures (pelvis/femur)*
*IV/IO to a **Radial Pulse**, 'Haemostatic'*

D - ***Disability*** – *ICP Management*

E - ***Exposure*** – *Temperature*

Hypotensive Resuscitation

- ATLS
  - Animal studies with controlled haemorrhage
- Bickell (1994)
  - Penetrating Trauma
  - 'Permissive Hypotension'
  - Clot disruption 'First Clot'
  - 70% vs 62% survival

Bickell WH,Wall MJ Jr, Pepe PE et al. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. NEJM 1994;331(17):1105-9

“Injection of a fluid that will increase blood pressure has dangers in itself…if the pressure is raised before the surgeon is ready to check any bleeding that might take place, blood that is sorely needed may be lost”

Walter Cannon, 1918

Hypotensive Resuscitation

= Fluids to a radial pulse

…or patient alert and responsive

Until Surgery

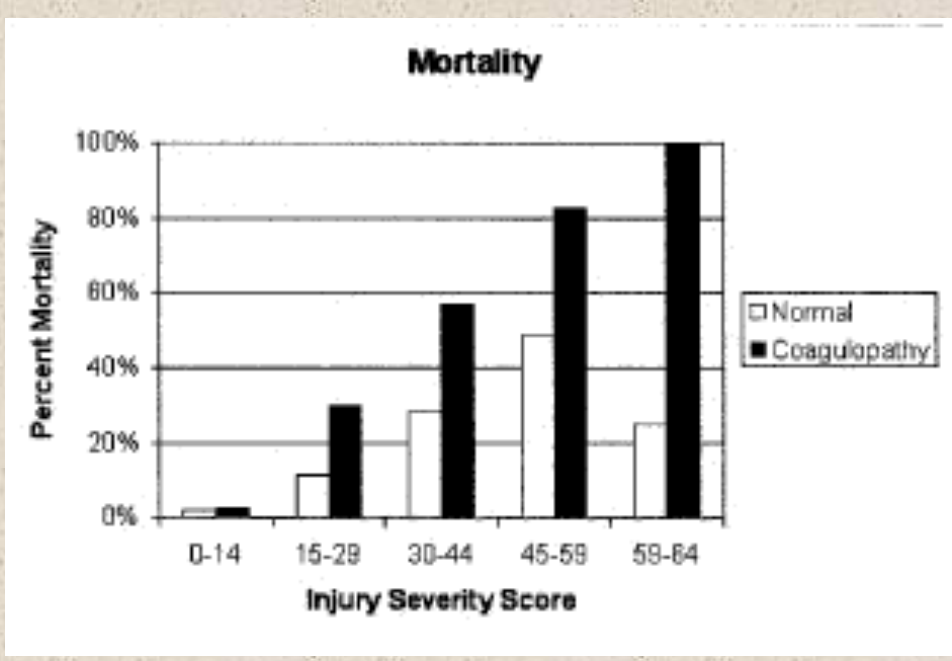
(c.f. Ruptured AAA)

Acute Coagulopathy of Trauma

Brohi et al 2003

- 1088 patients, ISS Median 20
- 24% trauma patients arrived coagulopathic
- Mortality 46%

  (vs. 11% if normal)



Brohi K,Singh J,Heron M et al.Acute Traumatic Coagulopathy. J Trauma 2003; 54: 1127-30

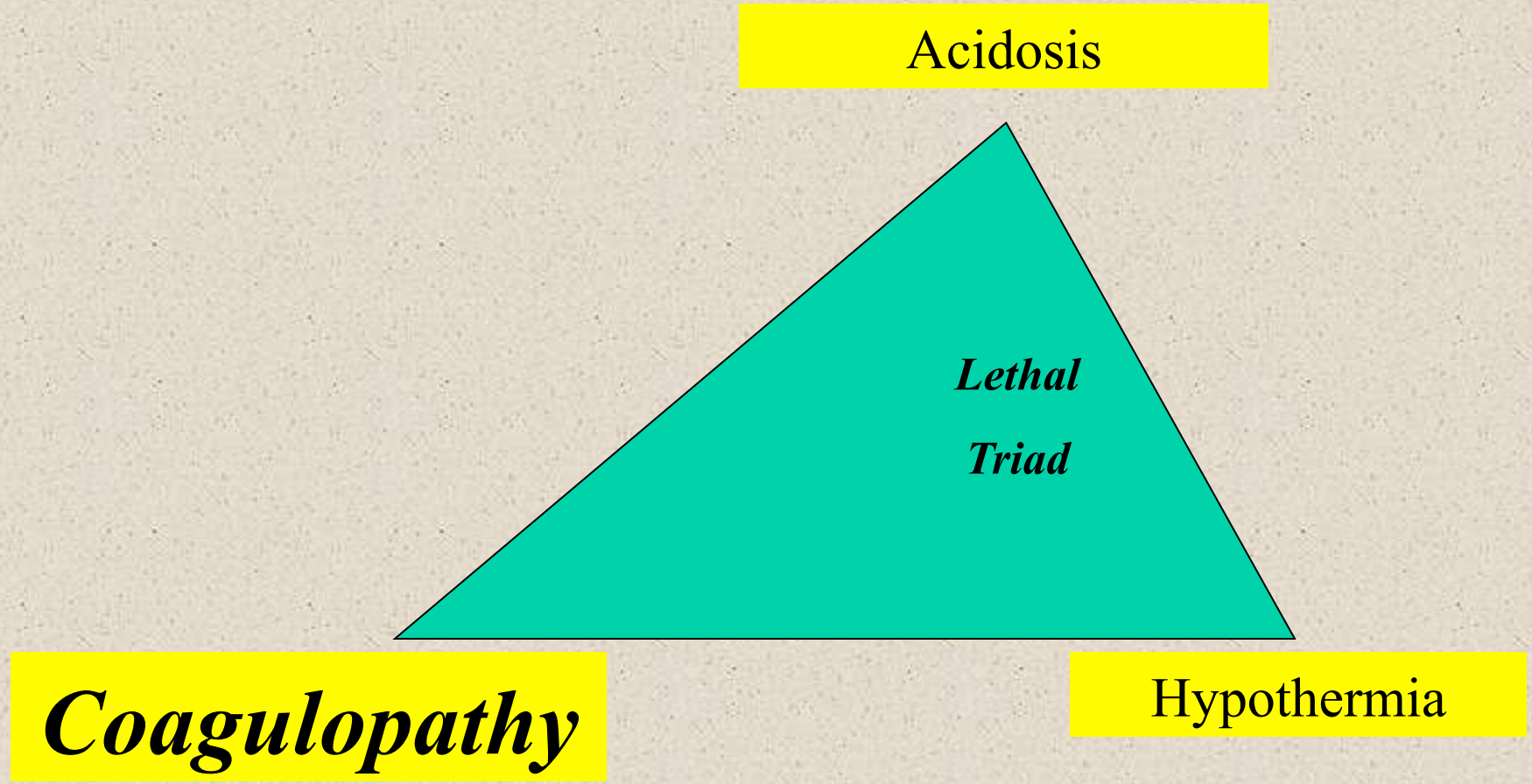
Acute Coagulopathy of Trauma

Brohi et al 2003

- Coagulopathy was an independent predictor of mortality after trauma
- Occurs before and independently of fluid administration i.e. Not Dilutional

Brohi K,Singh J,Heron M et al.Acute Traumatic Coagulopathy. J Trauma 2003; 54: 1127-30

Acute Coagulopathy of Trauma



Acute Coagulopathy of Trauma

Brohi et al *2007*

- 208 patients
- No patient with normal Base deficit (BD) had prolonged PT or PTT
- High Thrombomodulin & Low Protein C levels associated with increased mortality

Brohi K,Cohen MJ, Ganter MT et al. Acute Traumatic Coagulopathy. Ann Surg 2007; 245:812-818

Acute Coagulopathy of Trauma

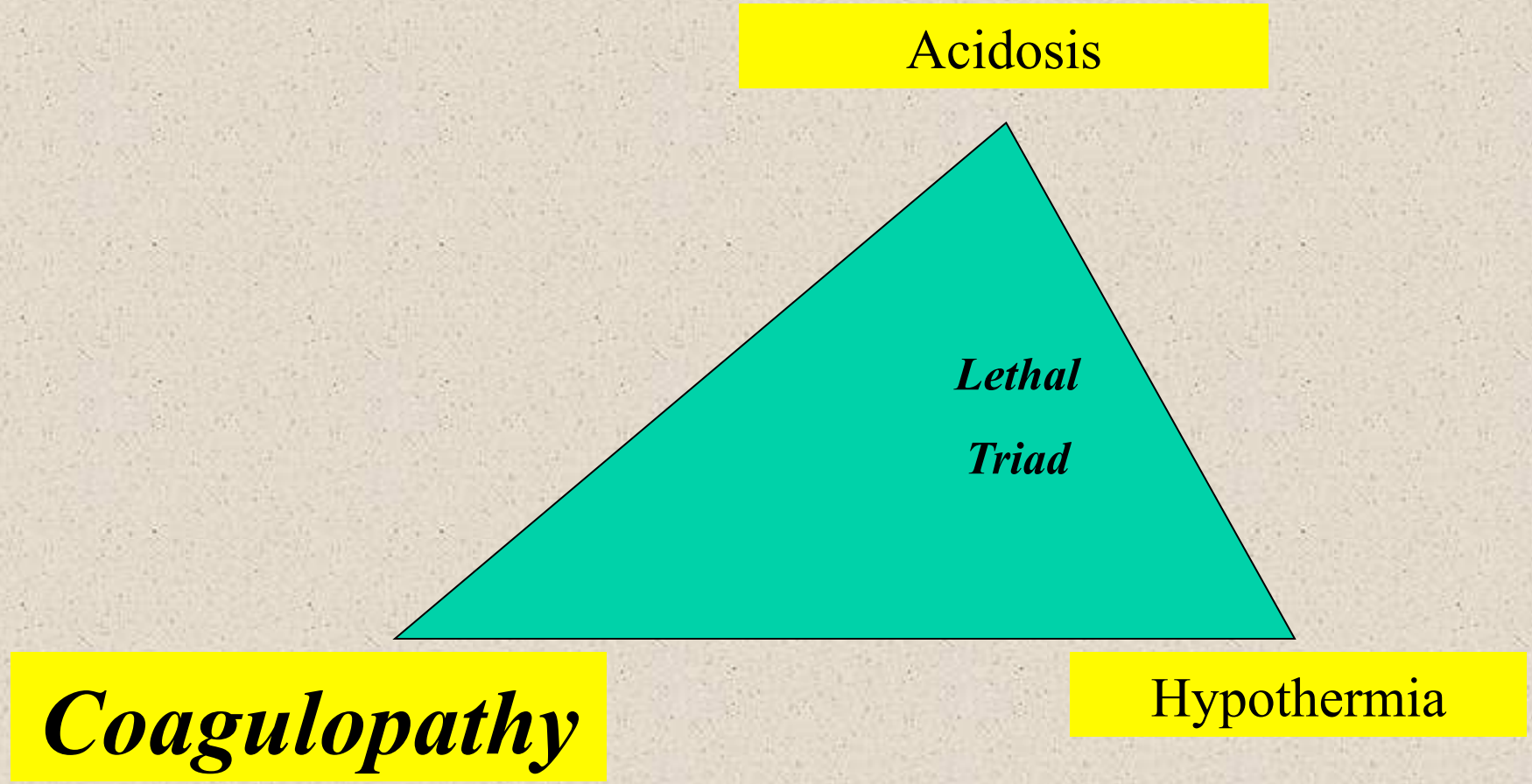
Brohi et al 2007

- Requires Tissue injury as initiator
- Main driver is hypoperfusion
  - Release thrombomodulin
  - Combines with thrombin to Activate Protein C
  - APC consumes PAI-1 (= more Plasmin)
  - Systemic anticoagulation and hyperfibrinolysis

  (Exhausting Protein C later leads to clot formation?)

Brohi K,Cohen MJ, Ganter MT et al. Acute Traumatic Coagulopathy. Ann Surg 2007; 245:812-818

Early Coagulopathy Predicts Mortality in Trauma



Acidosis & Hypothermia

Acidosis

– Little effect on protease function until < pH 7.2

– Correcting acidosis with buffer does not improve coagulation

Hypothermia

– Little clinical effect on protease function until < 34 degrees

Hess JR,Brohi K,Dutton RP et al. The coagulopathy of trauma: a review of mechanisms J Trauma 2008; 65: 748-54

Novel Hybrid Resuscitation

- Permissive Hypotension

vs.

- Coagulopathy/ Tissue Hypoperfusion

Pigs…..= Limit to 1hr

Haemostatic Resuscitation

Haemostatic Resuscitation

Holcomb JB, Jenkins D et al. Damage Control Resuscitation: directly addressing the early coagulopathy of trauma. J Trauma. 2007;62:307-10

Haemostatic Resuscitation

- Borgman *2007*
  - 246 patients US CSH, massive transfusion
  - 3 gps, Median ISS 18
  - Mortality 1:8 = 65%, 1:2.5 = 34%, 1:1.4 = 19%
- Holcomb *2008*
  - 467 civilian, massive transfusion
  - Mortality > or < 1:2 40.4% vs 59.6%

Borgman MA et al. The ratio of blood products transfused affects mortality in patients receiving massive transfusions at a CSH. J Trauma 2007;63:805-13.
Holcomb et al. Increased Plasma and platelet to RBC ratios improves outcome in 466 massively transfused civilian trauma patients. Ann Surg 2008;248: 447-58

Haemostatic Resuscitation

Cotton BA, Reddy N et al, Ann Surg 2011

- 2004- 2010 (390 pts)
- Adult trauma patients undergoing DCL
- Promoted DCR (Jan 2009 – Aug 2010)
  - Permissive hypotension, minimise crystalloid, higher plasma & platelet ratios
  - 30 day survival 86% vs 76%
  - Crystalloid median 5 litres vs. 13.9 litres
  - PRBCs: 8 vs. 13 units, FFP 8 vs. 11 units

Haemostatic Resuscitation

- FFP:Platelets:PRBC

  1 : 1 : 1

- Or is it:

  1 : 1 : 2 ??

Meta-analysis of FFP:RBC ratios - 2013

- Plasma to RBC ratios
- 6 Observational studies (5 civilian)
- Patients matched for ISS

- **Ratios of ≥ 1:2 (FFP/RBC) gave a significant reduction in mortality vs < 1:2**
- **No significant** further reduction in mortality for 1:1 vs 1:2 (*OR 0.5 vs OR 0.56)*

Bhangu et al. Meta-analysis of plasma to RBC ratios and mortality in massive blood transfusions for truama. Injury 2013; 44(12); 1693-9

PROMMTT Study 2013

- 10 US Level 1 Trauma Centres
- Prospective *Cohort Study* – 905 Patients
- Adult trauma – received *at least* 1 unit RBCs in 6hrs AND at least 3 total units of any product within 24hrs

Result: Of those surviving to 6hrs

- Ratio of Platelets:RBC *and* ratios of FFP:RBC of < 1:2 independently = **3-4 x mortality**

FFP Ratios **1:2 – 1:1** *OR 0.79*, **≥ 1:1** *OR 0.55*

Plts Ratios **1:2 – 1:1** *OR 0.66,* **≥ 1:1** *OR* 0.37

Holcomb et al. The PROMMTT Study. JAMA Surg 2013;148(2): 127-136

PROPPR Trial, JAMA 2015

Method

- Pragmatic Multi-centre RCT
- Mortality with 2 different blood product ratios (1:1:1) vs 1:1:2 (FFP/Plts/RBC)
- 12 Level 1 Trauma Centres
- 680 severely injured patients – expected ≥ 10 units RBCs

Holcomb et al. Transfusion of Plasma, Platelets etc. JAMA 2015; 313(5): 471-482

PROPPR Trial, JAMA 2015

Results

- **Fewer deaths from exsanguination** in 24hrs
- **More achieved haemostasis**
- **No** significance:
  in **mortality at 24hrs** (**12.7**% vs **17**%)
  in mortality at 30 days (22.4% vs 26.1%)
- **No** increased ARDS/Sepsis/DVT/PE in 1:1:1

***Note**:* 1:1:2 gp approached 1:1:1 after lab-directed transfusion (following initial haemostasis)

Camp Bastion Experience

- UK Mil Massive transfusion guidance initially based on US
- US Platelets = 6 patient pool

  so 6+6 give platelets

- *But* UK Platelets = 4 patient pool. We still gave after 6+6

  *…*so actually giving 1:1.5:1.5 (or 2:3)

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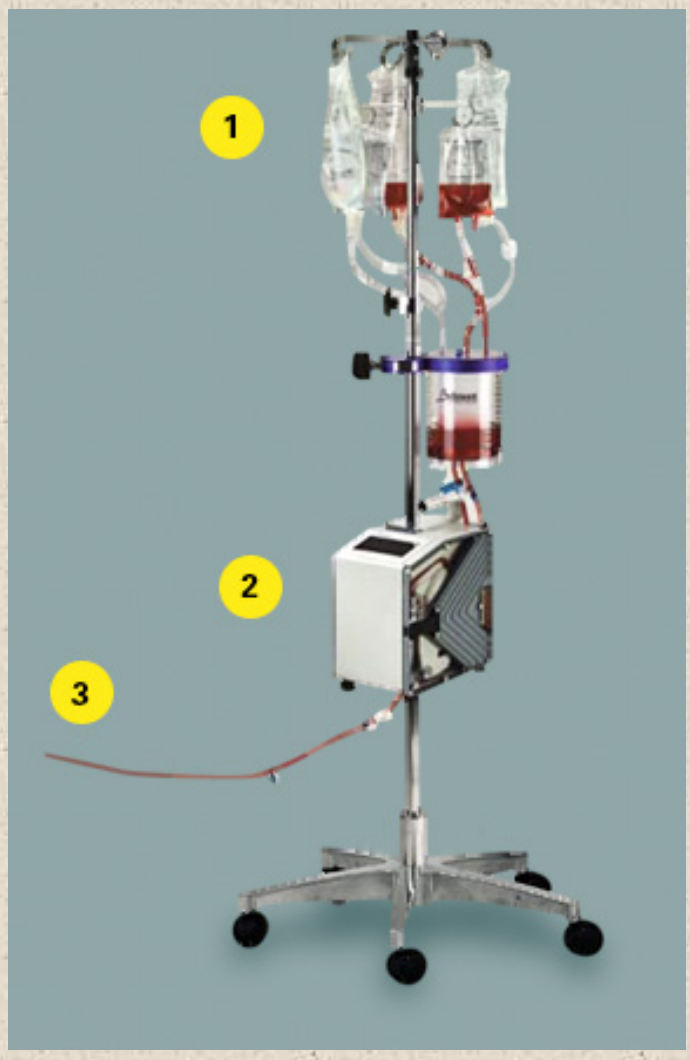

9 Fr distal lumen (with 12 G proximal lumen)

Principles of the Defence Medical Services Operational Massive Transfusion Protocol

- FFP to PRBC in a 1:1 ratio
- Platelets 1 pool per 4 FFP/PRBC (or 6) -maintain above100 x 10^9/l
- Early use of cryoprecipitate -maintain fibrinogen level above 1.5g/l (1.0g/l)

Principles of the DMS Operational Massive Transfusion Protocol (MTP)

- Maintain the Hct at 0.3 (Hb 10g/dl)
- Frequent measurement of:
  FBC (plts) and coag (fibrinogen) +/- ROTEM
- Calcium $^{2+}$ > 1.0 mmol/l
- Base Excess (Lactate) – Fentanyl/Transfusion

Tranexamic Acid

- Antifibrinolytic
- Reduced blood loss in major surgery
- Reduced transfusion
- CRASH-2
  - Multicentre
  - 20000 patients
  - 1g 1st 8hrs,plus 1g (8hrs)

CRASH-2 trial collaborators. Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma. Lancet 2010; 376: 23-32

CRASH-2

- Reduced all cause mortality 14.5% v 16.0%
- Risk of death due to bleeding 4.9% v 5.7%

- Subgroup analysis showed **most effective if given within first hour**.
- Mortality increased if given ***after 3hrs***

Damage Control Resuscitation

- Buddy-Buddy Aid

  Tourniquet/dressing/open airway

- CMT/GDMO

  Splint #s, IV&IO access

  Fluid to Radial pulse (TXA)

- MERT

  RSI/Blood/FFP/TXA **(1hr)**

- ED

  Platelets/Cryo/ROTEM → Damage Control Surgery

  …and continued Resuscitation

Fibrinogen Concentrate

- Freeze-dried Fibrinogen
- No thawing needed (c.f. Cryo ppt)
- Pooled human plasma
- Shelf Life 30 months

Fibrinogen concentrate – Cochrane Summary

- 6 RCTs of elective surgery (cardiac)
- Appeared to reduce transfusion reqts
- Low quality & underpowered to detect harm/benefit
- **Weak evidence to support use in bleeding patients**

Canadian review stated:

NOT cost-effective vs Cryo in trauma

Fibrinogen in Pregnancy

- Multicentre, double-blind RCT
- 249 patients with severe PPH (Est. > 1 litre)
- Either 2g Fibrinogen or Placebo

Result – No difference in outcomes (transfusion)

Wikkelsø et al. Pre-emptive treatment etc. BJA 2015; 114(4): 623-33

Fibrinogen in Trauma

- Dietmar Fries
- Multi-Centre
- Severe trauma with:
  - Significant visible
  - Clinical signs of significant internal
- 50mg/kg Fibrinogen vs Placebo
- Complete Dec 2015

Also: **Fibrinogen Early In Severe Trauma studY (FEISTY) (**Aus)
E-FIT1 (Oxford & Cambridge)

1975 – Lt Col MA Melsom RAMC et al

Salalah, Oman 1972-1973

Treatment of abnormal bleeding

- 2 bottles of fresh blood
- Calcium supplements
- 2 bottles of fibrinogen concentrate
- If oozing assume fibrinolysis - ε-aminocaproic acid
- Keep items close to Theatre
- Emergency Donor Panel

Transfusion Medicine Handbook

"Successful management of major haemorrhage requires a protocol-driven multidisciplinary team approach…"

"…staff of sufficient seniority & experience underpinned by clear lines of communication between clinicians and the transfusion laboratory"

Capt Oswald Hope Robertson

- Born in England
- Emigrated to US
- WW1 – Western Front
- First ‘blood bank’ transfusion service
- ‘universal’ donors
- Glass bottles
  - citrate & dextrose
- Stored on ice 26 days