RESUSCITATION IN TRAUMA

Important things I have learnt
G A (Don) Harrison

“He taught”
Trauma resuscitation through the decades – What was hot and now is not

- 1970s
- 1980s
- 1990s
- 2000s
- Now
1977
Fluids

Progressive Hypovolemia Leading to Shock after Continuous Hemorrhage and 3:1 Crystalloid Replacement

Arturo L. Cervera, PhD, PE, Troy, New York
Gerald Moss, MD, PhD, FACS, Troy, New York

Summary
Dogs subjected to arterial hemorrhage and infused with 3:1 volumes of lactated Ringer’s solution became progressively hypovolemic, to the point of frank shock. Stability and normovolemia were restored only after additional fluid delivery, in a net ratio of 8:1. These were the mathematically predicted values that satisfied Starling’s hypothesis.

Fluids

- More is better
- Resuscitate to the point of pulmonary oedema then use PPV
- Adhere to the 3:1 rule (or more)
The "G-suit," a device for combating hypovolemic shock with external pneumatic counterpressure, represents an application of an old idea to a relatively common medical problem. Its simplicity of use and quick therapeutic effect buys time for the patient with hypovolemic shock, whether the suit is applied in the prehospital or emergency department setting.

Soler, J., Muller, H.A., and Kennedy, T.J. Clinical use of the g-suit. JACEP 5:609-611, August 1976. g-suit; military anti-shock trouser (MAST); hypovolemia.
MAST

- First line treatment for haemorrhagic shock
- Enhanced venous pressure and allowed easier line placement
- Useful for stabilisation of pelvic fractures
Performing Thoracotomy in the Emergency Center

Kenneth L. Mattakx, MD
Rafael Espada, MD
Arthur C. Beall, Jr., MD
George L. Jordan, Jr., MD
Houston, Texas

Urgent thoracotomy in the emergency center environment is an adjunct to resuscitation and allows control of reversible intrathoracic injuries.

Journal of the American College of Emergency Physicians 1974:1;13-14
Goals of ED Thoracotomy

- Stopping bleeding
- Release of tamponade
- Cardiac massage
- Cross clamp aorta
- Preventing air embolism
Emergency Department Thoracotomy

- Worth a try in most circumstances
- Occasional survivors
- Justified for resident training even when survival improbable
Diagnostic Peritoneal Lavage

Fourteen Years and 2,586 Patients Later

Ronald P. Fischer, MD, St. Paul, Minnesota
Bryce C. Beverlin, MD, St. Paul, Minnesota
Loren H. Engrav, MD, St. Paul, Minnesota
Charles I. Benjamin, MD, St. Paul, Minnesota
John F. Perry, Jr, MD, St. Paul, Minnesota

TABLE II  Results of Diagnostic Peritoneal Lavage in 2,586 Patients (1964–1977)

<table>
<thead>
<tr>
<th>Results</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>1,793 (69.4%)</td>
</tr>
<tr>
<td>False-negative</td>
<td>32 (1.2%)</td>
</tr>
<tr>
<td>Positive</td>
<td>755 (29.2%)</td>
</tr>
<tr>
<td>False-positive</td>
<td>6 (0.2%)</td>
</tr>
</tbody>
</table>

Note: Accuracy was 98.5 per cent.

The American Journal of Surgery 1978:136;701-704
Virtually mandatory in unassessable patients with blunt abdominal trauma

Eyeball test used more often than formal evaluation

Low false negative rate but high rate of non-therapeutic laparotomy
1987

TIME
AIDS
The Growing Threat
What's Being Done
Prospective MAST Study in 911 Patients

KENNETH L. MATTOX, M.D., WILLIAM BICKELL M.D.,* PAUL E. PEPE, M.D.,
JON BURCH, M.D., AND DAVID FELICIANO, M.D.

<table>
<thead>
<tr>
<th>TABLE V</th>
<th>Hospital course comparison for No-MAST and MAST patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No-MAST (N = 439)</td>
</tr>
<tr>
<td>Length of stay in ICU (days)</td>
<td>1.9 ± 6.5</td>
</tr>
<tr>
<td>Length of stay in hospital (days)</td>
<td>8.1 ± 16.2</td>
</tr>
<tr>
<td>Survival</td>
<td>75%</td>
</tr>
</tbody>
</table>
MAST

“We discovered when you put on MAST, you increase the chance the patient would die, you increase their length of stay in the hospital, you increase their cost of hospitalization, increase their complications and it didn’t save their life at all,”
Crystalloids vs colloids

Comparison of the Relative Effectiveness of Colloids and Crystalloids in Emergency Resuscitation

William C. Shoemaker, MD, Torrance, California
Mark Schluchter, MS, Los Angeles, California
Judith A. Hopkins, BS, Torrance, California
Paul L. Appel, MPA, Torrance, California
Sandra Schwartz, MS, Torrance, California
Potter C. Chang, PhD, Los Angeles, California

The American Journal of Surgery
Volume 142, Issue 1, July 1981, Pages 73–84
Crystalloids vs colloids

“The resuscitation times were almost always shorter with a regimen of about one-fourth colloids than with crystalloids only. This is consistent with the observations of greater increases in hemodynamic and oxygen transport variables after albumin than after lactated Ringer's solution when the latter was given in either 2 or 4 times the volume”.
In this study meta-analysis was used to pool mortality data from reports of eight previously published, randomized, clinical trials, in which the efficacy of crystalloid and colloid fluid resuscitation was compared. The overall treatment effect when the data from all the clinical trails were pooled showed a 5.7% relative difference in mortality rate in favor of crystalloid therapy.
Crystalloids vs colloids

- When the data from only those studies using trauma patients were pooled, the overall treatment effect showed a 12.3% difference in mortality rate in favor of crystalloid therapy.
ED Thoracotomy

### Survival after ED Thoracotomy

**Signs of life and Mechanism of injury**

<table>
<thead>
<tr>
<th>SOL</th>
<th>Penetrating</th>
<th>Blunt</th>
<th>Unknown</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC- ER-</td>
<td>0/35 (0%)</td>
<td>0/7 (0%)</td>
<td>0/23 (0%)</td>
<td>0/65 (0%)</td>
</tr>
<tr>
<td>SC? ER-</td>
<td>13/290 (4%)</td>
<td>5/361 (1%)</td>
<td>11/213 (5%)</td>
<td>29/864 (3%)</td>
</tr>
<tr>
<td>SC+ ER-</td>
<td>21/112 (19%)</td>
<td>0/51 (0%)</td>
<td>0/27 (0%)</td>
<td>21/190 (11%)</td>
</tr>
<tr>
<td>SC+ ER+</td>
<td>33/127 (26%)</td>
<td>4/113 (4%)</td>
<td>69/230 (30%)</td>
<td>106/470 (23%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>77/496 (16%)</td>
<td>3/108 (3%)</td>
<td>10/101 (10%)</td>
<td>90/705 (13%)</td>
</tr>
<tr>
<td>Totals</td>
<td>144/1060 (14%)</td>
<td>12/640 (2%)</td>
<td>90/594 (15%)</td>
<td>246/2294 (11%)</td>
</tr>
</tbody>
</table>

ED Thoracotomy

- Of very limited utility in blunt trauma
- Unless signs of life are present at least shortly before admission to ED unlikely to be successful even in penetrating trauma
- In the post-HIV period significant risks to staff recognised
- Cost of procedure recognised as an important issue where true success uncommon
‘DAMAGE CONTROL’: AN APPROACH FOR IMPROVED SURVIVAL IN EXSANGUINATING PENETRATING ABDOMINAL INJURY

Michael F. Rotondo, MD, C. William Schwab, MD, FACS, Michael D. McGonigal, MD, FACS, Gordon R. Phillips, III, MD, Todd M. Fruchterman, BA, Donald R. Kauder, MD, FACS, Barbara A. Latenser, MD, and Peter A. Angood, MD
### Table 6
Injury scoring and survivorship for patients with one or more major vascular injury and two or more visceral injuries—the maximum injury subset (n = 22)

<table>
<thead>
<tr>
<th></th>
<th>DLM (n = 9)</th>
<th>DCM (n = 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTS</td>
<td>5.29 ± 2.8</td>
<td>6.22 ± 2.6</td>
</tr>
<tr>
<td>ISS</td>
<td>23.8 ± 10.8</td>
<td>22.9 ± 6.2</td>
</tr>
<tr>
<td>Ps</td>
<td>0.670 ± 0.396</td>
<td>0.810 ± 0.295</td>
</tr>
<tr>
<td>PATI</td>
<td>40.9 ± 12.4</td>
<td>43.6 ± 11.0</td>
</tr>
<tr>
<td>Actual Survival</td>
<td>1 (11%)</td>
<td>10 (77%)</td>
</tr>
</tbody>
</table>

Reported as mean ± standard deviation.

* Fisher’s exact test, p < 0.02.
Damage Control

**PART I – OR**
- control of hemorrhage
- control of contamination
- abbreviation/packing
- temporary closure

**PART II – ICU**
- restoration of physiology

**PART III – OR**
- definitive reconstruction

Rotondo et al, Journal of Trauma 1993
The US surgeons response

“... a technique that is the procedure of choice with the threat of exsanguination from a coagulopathy...”

Pachter 1992

“...it requires more sound cognitive judgement to terminate an operation...”

Mattox 1993

“... it’s judgement, not genital insufficiency that leads one to pack a patient...”

Richardson 1993
Fluids out (a bit)

The New England Journal of Medicine

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Volume 331 OCTOBER 27, 1994 Number 17

IMMEDIATE VERSUS DELAYED FLUID RESUSCITATION FOR HYPOTENSIVE PATIENTS WITH PENETRATING TORSO INJURIES

WILLIAM H. BICKELL, M.D., MATTHEW J. WALL, JR., M.D., PAUL E. PEPE, M.D.,
R. RUSSELL MARTIN, M.D., VICTORIA F. GINGER, M.S.N., MARY K. ALLEN, B.A.,
AND KENNETH L. MATTOX, M.D.
Table 5. Outcome of Patients with Penetrating Torso Injuries, According to Treatment Group.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>IMMEDIATE RESUSCITATION</th>
<th>DELAYED RESUSCITATION</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival to discharge — no. of patients/total patients (%)</td>
<td>193/309 (62) *</td>
<td>203/289 (70) †</td>
<td>0.04</td>
</tr>
<tr>
<td>Estimated intraoperative blood loss — ml ‡</td>
<td>3127 ± 4937</td>
<td>2555 ± 3546</td>
<td>0.11</td>
</tr>
<tr>
<td>Length of hospital stay — days §</td>
<td>14 ± 24</td>
<td>11 ± 19</td>
<td>0.006</td>
</tr>
<tr>
<td>Length of ICU stay — days §</td>
<td>8 ± 16</td>
<td>7 ± 11</td>
<td>0.30</td>
</tr>
</tbody>
</table>

*95 percent confidence interval, 57 to 68 percent.
†95 percent confidence interval, 65 to 75 percent.
‡The estimated intraoperative blood loss was calculated for patients who survived the operation: 268 in the immediate-resuscitation group and 260 in the delayed-resuscitation group.
§The lengths of stays in the hospital and intensive care unit (ICU) were calculated for patients who survived the operation: 227 in the immediate-resuscitation group and 238 in the delayed-resuscitation group.
PROSPECTIVE COMPARISON OF DIAGNOSTIC PERITONEAL LAVAGE, COMPUTED TOMOGRAPHIC SCANNING, AND ULTRASONOGRAPHY FOR THE DIAGNOSIS OF BLUNT ABDOMINAL TRAUMA

Ming Liu, MD, Chen-Hsen Lee, MD, and Fang-Ku P’eng, MD
**Table 4**
Sensitivity, specificity, accuracy of DPL, CT, and US

<table>
<thead>
<tr>
<th></th>
<th>DPL</th>
<th>CT</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>True positive</td>
<td>36</td>
<td>35</td>
<td>33</td>
</tr>
<tr>
<td>False positive</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>True negative</td>
<td>16</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>False negative</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>100</td>
<td>97.2</td>
<td>91.7</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>84.2</td>
<td>94.7</td>
<td>94.7</td>
</tr>
<tr>
<td>Accuracy (%)</td>
<td>94.5</td>
<td>96.4</td>
<td>92.7</td>
</tr>
</tbody>
</table>

DPL = diagnostic peritoneal lavage; CT = computed tomography; US = ultrasonography.
2007
REVIEW

Resuscitation and transfusion principles for traumatic hemorrhagic shock

Philip C. Spinella, John B. Holcomb

*Associate Professor of Pediatrics, University of Connecticut, Pediatric Intensivist, Department of Pediatrics, Medical Director Surgical Critical Care, Department of Surgery, Connecticut Children’s Medical Center, 282 Washington St., Hartford, CT 06106, United States

†Professor of Surgery, Chief, Division of Acute Care Surgery, Director, Center for Translational Injury Research, University of Texas Health Science Center, 6410 Fannin St., Suite 1100 Houston, TX 77030, United States
We are excited to bring to you two international trauma

John Holcomb
Professor and Vice Chair, Department of Surgery, Director, Center for Translational Injury Research (CeTIR) University of Texas Health Science, Houston, USA

Before leading the charge for trauma care at the Texas Trauma Institute, Col. (ret. U.S. Army) John B. Holcomb, M.D., F.A.C.S., spent 23 years as an active-duty Army surgeon. Having deployed six times to Operation Iraqi Freedom, John was awarded numerous commendations and combat awards including the Army’s Greatest Invention award, the Honorary Medal for Combat Surgical Care by the American Association for Surgeons of Trauma, the Defense Meritorious Service Medal and the United States Special Operations Command Medal.

John is a national leader in the research and development of next-generation medical technologies for trauma patients. Among these groundbreaking studies are novel therapies using frozen blood, implementing state-of-the-art ultrasound equipment in air ambulances, looking at new ways of utilizing stem cells for traumatic injury, using hyperbaric medicine to treat patients with traumatic brain injuries and pioneering new devices to fix broken bones in a better way.
Table 1
Damage control resuscitation principles.

- Rapid recognition of high risk for trauma-induced coagulopathy (massive transfusion prediction)
  - Permissive hypotension
- Rapid definitive/surgical control of bleeding
- Prevention/treatment of hypothermia, acidosis, and hypocalcemia
- Avoidance of hemodilution by minimizing use of crystalloids
- Early transfusion of red blood cells:plasma:platelets in a 1:1:1 unit ratio
- Use of thawed plasma and fresh whole blood when available
- Appropriate use of coagulation factor products (rFVIIa) and fibrinogen-containing products (fibrinogen concentrates, cryoprecipitate)
  - Use of fresh RBCs (storage age of <14 days)
  - When available thromboelastography to direct blood product and the hemostatic adjunct (anti-fibrinolytics and coagulation factor) administration

Abbreviations: RBCs, red blood cells; rFVIIa, recombinant activated factor VII.
* Added components of DCR since original description that can be considered.
Damage control resuscitation

Damage Control Resuscitation: Directly Addressing the Early Coagulopathy of Trauma

John B. Holcomb, MD, FACS, Don Jenkins, MD, FACS, Peter Rhee, MD, FACS, Jay Johannigman, MD, FS, FACS, Peter Mahoney, FRCA, RAMC, Sumeru Mehta, MD, E. Darrin Cox, MD, FACS, Michael J. Gehrke, MD, Greg J. Beilman, MD, FACS, Martin Schreiber, MD, FACS, Stephen F. Flaherty, MD, FACS, Kurt W. Grathwohl, MD, Phillip C. Spinella, MD, Jeremy G. Perkins, MD, Alec C. Beekley, MD, FACS, Neil R. McMullin, MD, Myung S. Park, MD, FACS, Ernest A. Gonzalez, MD, FACS, Charles E. Wade, PhD, Michael A. Dubick, PhD, C. William Schwab, MD, FACS, Fred A. Moore, MD, FACS, Howard R. Champion, FRCS, David B. Hoyt, MD, FACS, and John R. Hess, MD, MPH, FACP

Records of 467 MT patients transferred to Level 1 Trauma Centers in 05-06

Records were analysed for products used in resuscitation

ISS and outcome correlated
Damage control surgery

Damage control surgery and the abdomen

M. Sugrue*, S.K. D’Amours, M. Joshipura

Trauma Department, Liverpool Hospital, Elizabeth Street, Liverpool, NSW 2170, Australia

Damage control surgery for thoracic injuries

Michael F. Rotondo*, Michael R. Bard1

School of Medicine, East Carolina University, 600 Moye Blvd. Greenville, NC 27858-4354, USA

Damage control neurosurgery

Jeffrey V. Rosenfeld*

Department of Neurosurgery and Surgery, The Alfred Hospital, Monash University, Commercial Road, Prahran 3181, Vic., Australia

Damage control orthopaedics in unstable pelvic ring injuries

P.V. Giannoudis*, H.C. Papeb

aDepartments of Trauma and Orthopaedic Surgery, St. James’s University Hospital, University of Leeds, Leeds LS9 7TF, UK
bHannover Medical School, Hannover, Germany
During a 30-month period ending July 1997, 2,576 patients had abdominal US in the evaluation of BAT and were entered into our trauma US database. This database was analyzed to determine the utility of US in the evaluation of BAT.
### Table 2 Results of Patients with Positive US

<table>
<thead>
<tr>
<th>True Positives</th>
<th>False Positives</th>
</tr>
</thead>
<tbody>
<tr>
<td>US (+) and CT (+)</td>
<td>US (+) and CT (-)</td>
</tr>
<tr>
<td></td>
<td>206</td>
</tr>
<tr>
<td>US (+) and E. lap (+)</td>
<td>US (+) and E. lap (-)</td>
</tr>
<tr>
<td></td>
<td>58</td>
</tr>
<tr>
<td>US (+) and DPL (+)</td>
<td>US (+) and DPL (-)</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>Total</td>
</tr>
<tr>
<td>272</td>
<td>39</td>
</tr>
</tbody>
</table>

US, ultrasound; CT, computed tomography; DPL, diagnostic peritoneal lavage; E. lap, exploratory laparotomy.
Table 3  Results of Patients with Negative US

<table>
<thead>
<tr>
<th>True Negatives</th>
<th>False Negatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>US (-) and CT (-)</td>
<td>264</td>
</tr>
<tr>
<td>US (-) and DPL (-)</td>
<td>18</td>
</tr>
<tr>
<td>US (-) and E. lap (-)</td>
<td>8</td>
</tr>
<tr>
<td>US (-) and observation (-)</td>
<td>1,909</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,199</strong></td>
</tr>
</tbody>
</table>

US, ultrasound; CT, computed tomography; E. lap, exploratory laparotomy

Table 4  Results of Patients with False-Negative US

<table>
<thead>
<tr>
<th>Injury</th>
<th>Operative</th>
<th>Nonoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Spleen</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Kidney</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Diaphragm</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Small bowel</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Pancreas</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Retroperitoneal hematoma</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>
Traumatic coagulopathy
Monitoring of coagulopathy

- Traditional tests (INR, fibrinogen) too slow and unproven
- Thromboelastography
  - Improved outcome in CABG, Liver Tx, Trauma
- **Gold standard** is the presence of non-surgical bleeding
APPARATUS

Point-of-care testing  Measurement of coagulation

J. Hirsch, T. Wendt, P. Kuhly and W. Schaffartzik

Can RapidTEG Accelerate the Search for Coagulopathies in the Patient With Multiple Injuries?

Victor Jeger, MS, Heinz Zimmermann, MD, and Aristomenis K. Exadaktylos, MD

Hypothesis: Early recognition of coagulopathy may improve the care of patients with multiple injuries. Rapid thrombelastography (RapidTEG) is a new variant of thrombelastography (TEG), in which coagulation is initiated by the addition of protein tissue factor. The kinetics of coagulation and the times of measurement were compared for two variants of TEG—RapidTEG and conventional TEG, in which coagulation was initiated with kaolin. The measurements were performed on blood samples from 20 patients with multiple injuries. The RapidTEG results were also compared with conventional measurements of blood coagulation. The mean time for the RapidTEG test was 19.2 ± 3.1 minutes (mean ± SD), in comparison with 20.9 ± 4.3 minutes for kaolin TEG and 34.1 ± 14.5 minutes for conventional coagulation tests. The mean time for the RapidTEG test was 30.8 ± 5.7 minutes, in comparison with 41.5 ± 5.6 minutes for kaolin TEG and 64.9 ± 18.8 minutes for conventional coagulation tests—measured from admission of the patients to the resuscitation bay until the results were available. There were significant correlations between the RapidTEG results and those from kaolin TEG and conventional coagulation tests. RapidTEG is the most rapid available test for providing reliable information on coagulopathy in patients with multiple injuries. This has implications for improving patient care.

Keywords: Thrombelastography, Traumatic coagulopathy, Multiple injuries, tissue factor.


Linda Shore-Lessers, Sanjeev Francis, BS,
Departments of *Anesthesia

T. C. Collyer*, D. J. Gray, R. Sandhu, J. Berridge and G. Lyons

1 Academic Unit of Anaesthesia, Royal Perth Hospital, Perth, Australia, 2Department of Anaesthesia, St James's University Hospital, Leeds, UK. 3Department of Anaesthesia, Leeds General Infirmary, Leeds, UK

*Corresponding author. E-mail: tomcollyer@doctors.org.uk

Clopidogrel and patients measured

BJA

Does Thromboelastography Predict Postoperative Thromboembolic Events? A Systematic Review of the Literature

Yue Dai, MB, MSc*
Anna Lee, PhD*
Lester A. H. Critchley, MD*
Paul F. White, PhD, MD*

BACKGROUND: Since thromboelastography (TEG) can detect hypercoagulable states, it is a potentially useful test for predicting postoperative thromboembolic complications. Therefore, we performed a systematic review of the literature to evaluate the accuracy of TEG in predicting postoperative thromboembolic events.

METHODS: PUBMED and EMBASE electronic databases were searched by two independent investigators to identify prospective studies involving adult patients undergoing operative procedures in which a TEG test was performed perioperatively and outcomes were measured by reference standards. The quality of included studies was assessed and measures of diagnostic test accuracy were
The place of TEG?

### Appendix 1: Thrombelastography (TEG) treatment algorithm for patients with ongoing bleeding

<table>
<thead>
<tr>
<th>TEG Parameter</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>R 11–14 min</td>
<td>2 × FFP or 10 ml/kg</td>
</tr>
<tr>
<td>R &gt; 14 min</td>
<td>4 × FFP or 20 ml/kg</td>
</tr>
<tr>
<td>MA 46–50 mm</td>
<td>1 platelet concentrate</td>
</tr>
<tr>
<td>MA &lt; 46 mm</td>
<td>2 platelet concentrates</td>
</tr>
<tr>
<td>Angle &lt; 52</td>
<td>2 × FFP or fibrinogen</td>
</tr>
<tr>
<td>Ly30 &gt; 8%</td>
<td>Antifibrinolytics</td>
</tr>
</tbody>
</table>

R, R-time, minutes; MA, maximum amplitude; Ly30, lysis in percent 30 min after MA is reached; FFP, fresh-frozen plasma.

One platelet concentrate pooled from the buffy-coat from four donors.

*Johannon Vox Sanguinis* 96 111-118
What about Massive Transfusion Protocols?

**ADHB Adult Massive Transfusion Protocol (MTP)**

**Team Leader Responsibilities**
- Team leader should be a registrar or consultant
- Notify Coag Lab and send Coag requests on the Labplus Urgent form (orange border)
- Activate protocol by ringing Blood Bank (ext 24015) and say “I am activating the Massive Transfusion Protocol”
- Call for each box as required
- Make a decision to cease MTP and contact Blood Bank

**Process Flow**
1. Massive bleeding with either shock or abnormal coagulopathy
2. Ensure delivery of X-match specimen to Blood Bank
3. Give 3 Units O-neg or type specific RBC
4. Ring Blood Bank to Activate Massive Transfusion Protocol

**Request, Deliver and Transfuse as Below:**
Timing is everything
Stanford before and after MTP introduction study
Always had a good ratio of plasma to RBCs
40 activated of MTP in each arm (8 months)
Level 1 Trauma Center

In 2004 changed to a MTP with 1:1.5 ratio FFP:PRBC

40 patients before and 37 after change

Transfusion ratios 1:1.8 — same before and after

Figure 2. Patient survival by year. MTP, massive transfusion protocol.
<table>
<thead>
<tr>
<th>Product</th>
<th>Pre-MTP, mean (95% CI)</th>
<th>Post-MTP, mean (95% CI)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRBCs</td>
<td>115 (85–146)</td>
<td>71 (49–93)</td>
<td>0.02*</td>
</tr>
<tr>
<td>FFP</td>
<td>254 (185–323)</td>
<td>169 (130–209)</td>
<td>0.04*</td>
</tr>
<tr>
<td>Platelets</td>
<td>418 (316–519)</td>
<td>241 (169–311)</td>
<td>0.01*</td>
</tr>
</tbody>
</table>

*Statistically significant; p ≤ 0.05.
FFP, fresh frozen plasma; MTP, massive transfusion protocol; PRBCs, packed red blood cells.
PROMMTT - PRospective, Observational, Multi-center Massive Transfusion Study

The U.S. Department of Defense, Army Institute of Surgical Research has awarded The University of Texas Health Science Center at Houston funds to conduct a multi-site observational study of severely injured trauma patients who require blood transfusions.

Rationale

This study will benefit future severely injured trauma patients by helping determine the best early method of identifying patients who would benefit from receiving different ratios of red blood cells to plasma to platelets. This study will also identify what massive transfusion protocols exist in 10 leading trauma centers and which protocols are associated with better survival. Results of this study will inform development of a future randomized clinical trial which will test these protocols.
OBJECTIVE To relate in-hospital mortality to early transfusion of plasma and/or platelets and to time-varying plasma:red blood cell (RBC) and platelet:RBC ratios.

DESIGN Prospective cohort study documenting the timing of transfusions during active resuscitation and patient outcomes

SETTING Ten US level I trauma centers.

PATIENTS Adult trauma patients surviving for 30 minutes after admission who received a transfusion of at least 1 unit of RBCs within 6 hours of admission (n = 1245, the original study group) and at least 3 total units (of RBCs, plasma, or platelets) within 24 hours (n = 905, the analysis group).

MAIN OUTCOME MEASURE In-hospital mortality
RESULTS Plasma:RBC and platelet:RBC ratios were not constant during the first 24 hours.

Increased ratios of plasma:RBCs (adjusted hazard ratio = 0.31; 95% CI, 0.16-0.58) and platelets:RBCs (adjusted hazard ratio = 0.55; 95% CI, 0.31-0.98) were independently associated with decreased 6-hour mortality, when hemorrhagic death predominated. In the first 6 hours, patients with ratios less than 1:2 were 3 to 4 times more likely to die than patients with ratios of 1:1 or higher. After 24 hours, plasma and platelet ratios were unassociated with mortality, when competing risks from nonhemorrhagic causes prevailed.
CONCLUSIONS Higher plasma and platelet ratios early in resuscitation were associated with decreased mortality in patients who received transfusions of at least 3 units of blood products during the first 24 hours after admission.
**Tranexamic Acid**

![Tranexamic Acid](image)

<table>
<thead>
<tr>
<th>Systematic (IUPAC) name</th>
<th>trans-4-(aminomethyl)cyclohexanecarboxylic acid</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Clinical data</th>
</tr>
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<tbody>
<tr>
<td><strong>AHFS/Drugs.com</strong></td>
</tr>
<tr>
<td><strong>Pregnancy cat.</strong></td>
</tr>
<tr>
<td><strong>Legal status</strong></td>
</tr>
<tr>
<td><strong>Routes</strong></td>
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</tbody>
</table>

<table>
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<tr>
<th>Pharmacokinetic data</th>
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</thead>
<tbody>
<tr>
<td><strong>Bioavailability</strong></td>
</tr>
<tr>
<td><strong>Half-life</strong></td>
</tr>
</tbody>
</table>
What’s confusing?

- What is this group of patients and is 16% mortality OK?
- Who should we give it to here?
- Where is its place with an MTP?
Pre-hospital Anti-fibrinolytics for Traumatic Coagulopathy and Haemorrhage (The PATCH Study)
What about interventional radiology (IR) in trauma resuscitation?

- Bleeding anywhere!
  - Pelvic fractures
  - Abdominal solid organ injury
- Specific vascular injury
  - Aortic/arch vessel rupture
  - Peripheral vascular trauma
IR for stopping bleeding and treating injuries
Role of interventional radiology in trauma care: retrospective study from single trauma center experience

Nam Yeol Yim, MD a,*, Yong Tae Kim, MD a, Hyoung Ook Kim, MD a, Jae Kyu Kim, MD a, Yang Jun Kang, MD a, Yun Chul Park, MD b, Chan Yong Park, MD c

a Department of Radiology, Chonnam National University Hospital, Gwangju, Republic of Korea
b Department of Trauma Surgery, Chonnam National University Hospital, Gwangju, Republic of Korea
c Department of Trauma Surgery, Pusan National University Hospital, Pusan, Republic of Korea

Fig. 2. Significant increasing number of IR management for trauma victims (P = .002, χ² test).
IR for stopping bleeding and treating injuries

- Head and neck
- Chest
- Abdomen
- Pelvis
- Extremities
Abdominal solid organ injury

• AE has a well established role in abdominal trauma
• Haemodynamically unstable patients with a positive FAST or relevant clinical signs should still undergo urgent laparotomy
• However, more stable patients can be imaged with MD-CT
• Patients with solid organ injuries may have CT features that indicate a high risk of re-bleeding. AE should be considered in these cases:
  - High grade injury
  - Contrast extravasation
  - Pseudoaneurysm
  - Arteriovenous fistula
Timing

Retrospective TNDB study involving 635 patients 2002-2006

In unstable trauma patients undergoing therapeutic IR, delay beyond 60 minutes was associated with a twofold increase in mortality. For each additional hour, risk of mortality increased 47%
## Timing

<table>
<thead>
<tr>
<th>TABLE 2. Rapid and Delayed Group Comparison</th>
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</thead>
<tbody>
<tr>
<td><strong>RAPID</strong> (n = 379)</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Age (yr)</td>
</tr>
<tr>
<td>Gender (% male)</td>
</tr>
<tr>
<td>Injury mechanism (% penetrating)</td>
</tr>
<tr>
<td>Injury Severity Score</td>
</tr>
<tr>
<td>ED GCS</td>
</tr>
<tr>
<td>Head/neck AIS</td>
</tr>
<tr>
<td>ED systolic blood pressure (mm Hg)</td>
</tr>
<tr>
<td>Trauma center designation (% level I)</td>
</tr>
<tr>
<td>Length of stay (d)</td>
</tr>
<tr>
<td>ICU days</td>
</tr>
<tr>
<td>Ventilation days</td>
</tr>
</tbody>
</table>
Timing

Figure 2. Independent risk of mortality associated with delay to intervention radiology procedures soon after injury.

Figure 3. Independent risks of mortality associated with delay to intervention radiology procedures when stratified by injury mechanism.
Therapeutic angioembolisation


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Review

The role of arterial embolization in controlling pelvic fracture haemorrhage: A systematic review of the literature

Costas Papakostidis a,*, Nikolaos Kanakaris b, Rozalia Dimitriou b, Peter V. Giannoudis b

a Department of Trauma and Orthopaedics “G. Hatzikostas” General Hospital, Makryianni Avenue, 45001 Ioannina, Greece
b Academic Unit of Trauma and Orthopaedic Surgery, Clarendon Wing, Leeds General Infirmary, Great George Street, Leeds LS1 3EX, UK

• Efficacy rate 81-100%
Embolisation for pelvic fractures

- Angiography and TAE represent effective acute interventions for arterial haemorrhage control.
- Drawbacks are delays, time consuming and requirement for specialised personnel and appropriate equipment.
- Robust evidence of a comparative analysis between TAE and emergency pelvic stabilisation and pelvic tamponade are currently lacking.
Aortic rupture

- High prehospital mortality
- Associated with severe multiple injuries
- Traditional surgery associated with risks of bleeding, paraplegia, stroke, pulmonary insufficiency, renal failure etc
A paradigm shift...

- Move to stent graft repair throughout 2000s, becoming almost universal after 2005

What do you see?
By shifting perspective you might see an old woman or a young woman.
An outcome analysis of endovascular versus open repair of blunt traumatic aortic injuries

Ali Azizzadeh, MD, Kristofer M. Charlton-Ouw, MD, Zhongxue Chen, PhD, Mohammad H. Rahbar, PhD, Anthony L. Estrera, MD, Hammad Amer, MD, Sheila M. Coogan, MD, and Hazim J. Safi, MD, Houston, Tex
The changing approach to blunt aortic injury at ACH

Interventions for BAI at ACH 1995-2013

OR  TEVAR  Nonop/D
What do you need to make this work?

- Good collaboration
  - Between IR and trauma team
  - Between IR and vasc surg
  - Between vasc surg and trauma
IR for other arterial injuries

- Traumatic injuries of the subclavian or axillary artery are associated with high morbidity and mortality rates.
- The management of these injuries has traditionally required morbid operative surgical intervention, with surgical exposures that can prove challenging.
Resuscitation in trauma –
important things I have learnt

- Knowledge is a relative thing
- Always study what you are doing
- Never assume what you are doing now is the best way to treat patients
- Timing is critical
It is easier to get older...

than it is to get wiser.