REBOA
Is it Relevant in Australasia?

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FRACS

Trauma and General Surgeon
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Injury 2018
Auckland
2 August, 2018
Introduction

• Non-compressible torso haemorrhage remains a highly lethal and challenging clinical problem

• Definition of NCTH
  – Not completely defined
  – Accepted as haemorrhage from
    • Large axial vessels
    • Solid organ injuries
    • Pulmonary parenchymal injuries
    • Complex pelvic fractures

Gaddi Torso, Uffizi Museum, Florence. 2 Century BC.
Introduction

• Military data
  – Haemorrhage remains the leading cause of preventable death
  – In-hospital mortality rate approx. 20 %
    • Compared with overall mortality rate of approx. 5 %

• Civilian data
  – Approx. 15 % of US Level 1 trauma centre admissions have NCTH
  – Approx. 10 % of these have active haemorrhage
    • Mortality rate of 45 %

Introduction
Introduction

Introduction

- Patients with actively bleeding NCTH are rare
  - High volume centres
  - Well functioning trauma systems
    - Pre-hospital services
    - In-hospital resources
  - Resources
    - Diagnosis, system & treatment
Introduction

• Patients with actively bleeding NCTH are rare
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  – Well functioning trauma systems
    • Pre-hospital services
    • In-hospital resources
  – Resources
    • Diagnosis, system & treatment

• Quantifying the depth of shock remains problematic
  – Vital signs are not adequate
  – Other parameters: not easily measurable
Defining the Critical Patient

[Diagram showing heart, blood pressure scale (SBP), and happy face with arrow indicating resuscitation process]

SBP: 0 60 80 mmHg

In Extremis  Severe Shock
Resuscitative Thoracotomy

• Standard of care:
  – Recent arrest
    • nb. blunt vs penetrating
    • nb. associated injuries
  – In extremis
  – ? In severe shock
Emergency resuscitative thoracotomy performed in European civilian trauma patients with blunt or penetrating injuries: a systematic review

J. K. Narvestad1 · M. Meskinfamfard1 · K. Søreide1,2

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Abstract
Purpose  Emergency resuscitative thoracotomy (ERT) is a lifesaving procedure in selected patients. Indications are still being debated, but outcome in blunt trauma is believed to be poor. Recent reports from European populations, where blunt trauma predominates, have suggested favorable outcome also in blunt trauma. Our aim was to identify all European studies reported over the last decade and compare reported outcomes to existing knowledge.

Methods  We performed a systematic literature search according to PRISMA guidelines (January 1st, 2004 to December 31st, 2014). The “grey literature” was included by searching Google Scholar. Qualitative comparison of studies and outcomes was done.

Results  A total of 8 articles from Europe were included originating from Croatia, Norway (n = 2), Denmark, Iceland, the Netherlands, Scotland, and Switzerland. Of 376 resuscitative thoracotomies, 193 (51.3 %) were for blunt trauma. Male:female distribution was 3.5:1. The collectively reported overall survival was 42.8 % (n = 161), with 25.4 % (49 of 193) blunt trauma and 61.2 % (112 of 183) penetrating injuries. When strictly including those ERTs designated as done in the emergency department for blunt mechanism (n = 130) only, a total of 18 patients survived (12.9 %). Survival after ERTs for penetrating trauma was 41.6 % (37 of 89). Neurological outcome (reported in 5 of 8 studies) reported favorable neurological long-term outcome in the majority of survivors, even after blunt trauma. None referred to Glasgow Outcome Score. Heterogeneity in the studies prevented outcome analyses by formal quantitative meta-analysis.

Conclusion  The reported outcome after ERT in European civilian trauma populations is favorable, with one in every four ERTs in the ED surviving. Notably, outcome is at variance with previously reported collective data, in particular for blunt trauma. Multicenter, prospective, observational data are needed to validate the modern role of ERT in blunt trauma.

Keywords  Emergency thoracotomy · Resuscitation · Survival · Blunt trauma · Penetrating trauma

Introduction
Emergency resuscitative thoracotomy (ERT) may serve as a life-saving procedure in selected patients. Indications are still being debated, but outcome in blunt trauma is believed to be poor. Recent reports from European populations, where blunt trauma predominates, have suggested favorable outcome also in blunt trauma.
Emergency resuscitative thoracotomy performed in European civilian trauma patients with blunt or penetrating injuries: a systematic review

J. K. Narvestad¹ · M. Meskifamfard¹ · K. Soreide¹,²

Fig. 2 Breakdown of injury type, location and outcomes of the included patients in the identified studies. EDT Emergency department thoracotomies, OR operating room

Emergency thoracotomy in trauma resuscitation
N=376
Survivors 161 (42.8%)

Blunt
N=193
Survivors 49 (25.4%)

Penetrating
N=183
Survivors 112 (62.2%)

EDT
N=139
Survivors 18 (12.9%)

OR
N=54
Survivors 31 (57.0%)

EDT
N=89
Survivors 37 (41.6%)

OR
N=94
Survivors 75 (79.8%)

EDTs combined
N=228
Survivors 55 (24.1%)

ORs combined
N=148
Survivors 106 (71.6%)
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Survival after Emergency Department Thoracotomy: Review of Published Data from the Past 25 Years

Peter M Rhee, MD, MPH, FACS, Jose Acosta, MD, FACS, Amy Bridgeman, RN, BSN, Dennis Wang, MD, FACS, Marion Jordan, MD, FACS, Norman Rich, MD, FACS

Background: Emergency department thoracotomy (EDT) has become standard therapy for patients who acutely arrest after injury. Patient selection is vitally important to achieve optimal outcomes without wasting valuable resources. The aim of this study was to determine the main factors that most influence survival after EDT.

Study Design: Twenty-four studies that included 4,620 cases from institutions that reported EDT for both blunt and penetrating trauma during the past 25 years were reviewed. The primary outcomes analyzed were in-hospital survival rates.

Results: EDT had an overall survival rate of 7.4%. Normal neurologic outcomes were noted in 92.4% of surviving patients. Factors reported as influencing outcomes were the mechanism of injury (MOI), location of major injury (LOMI), and signs of life (SOL). Survival rates for MOI were 8.8% for penetrating injuries and 1.4% for blunt injuries. When penetrating injuries were further separated, the survival rates were 16.8% for stab wounds and 4.3% for gunshot wounds. For the LOMI, survival rates were 10.7% for thoracic injuries, 4.5% for abdominal injuries, and 0.7% for multiple injuries. If the LOMI was the heart, the survival rate was the highest at 19.4%. The third factor influencing outcomes was SOL. If SOL were present on arrival at the hospital, survival rate was 11.5% in contrast to 2.6% if none were present. SOL present during transport resulted in a survival rate of 8.9%. Absence of SOL in the field yielded a survival rate of 1.2%. There was no clear single independent preoperative factor that could uniformly predict death.

Conclusions: The best survival results are seen in patients who undergo EDT for thoracic stab injuries and who arrive with SOL in the emergency department. All three factors—MOI, LOMI, and SOL—should be taken into account when deciding whether to perform EDT. Uniform reporting guidelines are needed to further elucidate the role of EDT taking into account the combination of MOI, LOMI, and SOL. (J Am Coll Surg 2000;190:288–298. © 2000 by the American College of Surgeons)

Advances made in prehospital systems have resulted in rapid transport of the severely injured. Improved communications have also allowed receiving physicians to anticipate the needs of patients in distress. These and other advances in trauma care have made emergency department thoracotomy (EDT) a standard procedure. Although there is no doubt as to the usefulness of this procedure, the key is to identify those who will most likely benefit to avoid the high costs associated with this procedure. These costs include loss of the patient dignity, risk to care providers during the procedure, and the use of valuable health care resources.

Since the first recorded successful thoracotomy by Dr Rehn more than 100 years ago for a dying patient stabbed in the heart, there have been many
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Results: EDT had an overall survival rate of 7.4%. Normalized logistic outcomes were noted in 15.4% of surviving patients. Factors reported as influencing outcomes were the mechanism of injury (MOI), location of major injury (LOMI), and signs of life (SOL). Survival rates for MOI were 8.8% for penetrating injuries and 1.4% for blunt injuries. When penetrating injuries were further separated, the survival rates were 16.8% for stab wounds and 4.3% for gunshot wounds. For the LOMI, survival rates were 10.7% for thoracic injuries, 4.5% for abdominal injuries, and 0.7% for multiple injuries. If the LOMI was the heart, the survival rate was the highest at 19.4%. The third factor influencing outcomes was SOL. If SOL were present on arrival at the hospital, survival rate was 11.5% in contrast to 2.6% if none were present. SOL present during transport resulted in a survival rate of 8.9%. Absence of SOL in the field yielded a survival rate of 1.2%. There was no clear single independent preoperative factor that could uniformly predict death.

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Since the first recorded successful thoracotomy by Dr. Rehn more than 100 years ago for a dying patient stabbed in the heart, there have been many
An evidence-based approach to patient selection for emergency department thoracotomy: A practice management guideline from the Eastern Association for the Surgery of Trauma

Mark J. Seamon, MD, Elliott R. Haut, MD, PhD, Kyle Van Arendonk, MD, Ronald R. Barbosa, MD, William C. Chiu, MD, Christopher J. Dente, MD, Nicole Fox, MD, Randeep S. Jawa, MD, Kosar Khwaja, MD, J. Kayle Lee, MD, Louis J. Magnotti, MD, Julie A. Mayglothling, MD, Amy A. McDonald, MD, Susan Rowell, MD, MCR, Kathleen B. To, MD, Yngve Falck-Ytter, MD, and Peter Rhue, MD, MPH, Philadelphia, Pennsylvania

BACKGROUND:

Within the GRADE (Grading of Recommendations Assessment, Development and Evaluation) framework, we performed a systematic review and developed evidence-based recommendations to answer the following PICO (Population, Intervention, Comparator, Outcome) question: should patients who present pulseless after critical injuries (with and without signs of life after penetrating thoracic, extrathoracic, or blunt injuries) undergo emergency department thoracotomy (EDT) vs. resuscitation without EDT to improve survival and neurologically intact survival?

METHODS:

All patients who underwent EDT were included while those involving either prehospital resuscitative thoracotomy or operating room thoracotomy were excluded. Quantitative synthesis via meta-analysis was not possible because no comparison or control group (i.e., survival or neurologically intact survival data for similar patients who did not undergo EDT) was available for the PICO questions of interest.

RESULTS:

The 72 included studies provided 10,238 patients who underwent EDT. Patients presenting pulseless after penetrating thoracic injury had the most favorable EDT outcomes both with (survival, 182 [21.3%] of 853; neurologically intact survival, 53 [11.7%] of 454) and without survival, 76 [8.3%] of 920; neurologically intact survival, 25 [3.9%] of 641) signs of life. In patients presenting pulseless after penetrating extrathoracic injury, EDT outcomes were more favorable with signs of life (survival, 25 [15.6%] of 160; neurologically intact survival, 14 [16.5%] of 85) than without survival, 4 [2.9%] of 139; neurologically intact survival, 3 [5.0%] of 60). Outcomes after EDT in pulseless blunt injury patients were limited with signs of life (survival, 21 [4.6%] of 454; neurologically intact survival, 7 [2.4%] of 298) and dismal without signs of life (survival, 7 [0.7%] of 995; neurologically intact survival, 1 [0.1%] of 825).

CONCLUSION:

We strongly recommend that patients who present pulseless with signs of life after penetrating thoracic injury undergo EDT. We conditionally recommend EDT for patients who present pulseless and have absent signs of life after penetrating thoracic injury, present or absent signs of life after penetrating extrathoracic injury, or present signs of life after blunt injury. Lastly, we conditionally recommend against EDT for pulseless patients without signs of life after blunt injury. (J Trauma Acute Care Surg. 2015;79: 159–173. Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE:

Systematic review/guideline, level III.

KEY WORDS:

Emergency department thoracotomy; resuscitative thoracotomy; practice management guideline; evidence-based medicine.
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Resuscitative Thoracotomy

• Historical problems
  – ? Wrong threshold
  – ? System issues
  – ? Lack of critical care support
    • Haemostatic resuscitation
    • Modern transfusion practices
    • Damage control surgery
    • Modern intensive care

Duchesne JC et al. Damage control resuscitation: from emergency department to the operating room. Am Surg. 2011; 77: 201
REBOA

• History
  – 1954: 2 cases of aortic balloon occlusion
  – 1970s: Descending aortic clamping established for massive haemoperitoneum
  – 1980s: Brachial and femoral routes
    High complication rates
    • Paraplegia, aortic injuries, femoral artery thrombosis
  – 2000s: Sporadic case reports
  – 2011: “REBOA” coined

Brenner M et al. Basic endovascular skills for trauma course: bridging the gap between endovascular techniques and the acute care surgeon. *J Trauma*. 2014; 77: 286
Biffi WL et al. The role of REBOA in the control of exsanguinating torso hemorrhage. *J Trauma*. 2015; 78: 1054
Our Experience
Royal Perth Hospital

- **Prospective series**
  - All Resuscitative Thoracotomies and REBOA procedures
  - 2.5 years

- **30 patients**
  - 5 REBOA
  - 26 RT
Injuries

• Injury Severity Score
  – Mean 39.4 (SD 18.9)
  – Median 38 (IQR 25 – 49)

• Gender
  – 27 male
  – 3 female
    • All blunt force injuries

• Mechanism
  – 10 Penetrating force
    • Stab  7
    • Gunshot  1
    • Impale  1
    • Angle grinder  1
  – 19 Blunt force
    • MVC  7
    • MBC  5
    • Pedestrian  5
    • Falls  3

  – 1 Burn
<table>
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<tr>
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<th>Number</th>
<th>RT Procedures</th>
<th>REBOA Procedures</th>
<th>Survivors</th>
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<td><strong>Penetrating Injuries</strong></td>
<td></td>
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<tr>
<td>Stab</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Gunshot</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Angle grinder</td>
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<td>0</td>
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<td>Impalement</td>
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<td>10</td>
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<td>MVC</td>
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<td>Falls</td>
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<td><strong>Total blunt force</strong></td>
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<td>15</td>
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<td>5 (26%)</td>
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<tr>
<td><strong>Burns</strong></td>
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<td>1</td>
<td>0</td>
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<td><strong>All Patients</strong></td>
<td>30</td>
<td>26</td>
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<td>8 (27%)</td>
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## Royal Perth RT & REBOA

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<th>Number</th>
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<td>15</td>
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<td>5</td>
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<td>5 (26%)</td>
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<td></td>
<td>Resuscitative Thoracotomy</td>
<td>REBOA</td>
<td>p - value</td>
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<td><strong>(n = 26)</strong></td>
<td>(n = 5)</td>
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<tr>
<td><strong>Age (years)</strong></td>
<td>42.9 (16.7)</td>
<td>33.2 (11.1)</td>
<td>0.22</td>
<td></td>
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<tr>
<td><strong>Penetrating injury</strong></td>
<td>10 / 26</td>
<td>0 / 5</td>
<td>0.14</td>
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<tr>
<td><strong>Blunt injury</strong></td>
<td>15 / 26</td>
<td>5 / 5</td>
<td>0.15</td>
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<tr>
<td><strong>ISS</strong></td>
<td>39.4 (18.9)</td>
<td>44 (4.3)</td>
<td>0.60</td>
<td></td>
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<td><strong>pH</strong></td>
<td>6.87 (0.20)</td>
<td>7.00 (0.30)</td>
<td>0.23</td>
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<td><strong>BE</strong></td>
<td>-22.7 (2.8)</td>
<td>-15.4 (6.8)</td>
<td>&lt;0.001</td>
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<tr>
<td><strong>CPR on arrival</strong></td>
<td>20 / 26</td>
<td>0 / 5</td>
<td>&lt;0.01</td>
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<tr>
<td><strong>HR (bpm)</strong></td>
<td>15.0 (41.0)</td>
<td>124.6 (20.0)</td>
<td>&lt;0.001</td>
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<tr>
<td><strong>SBP (mmHg)</strong></td>
<td>17.3 (35.9)</td>
<td>55.8 (12.3)</td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GCS</strong></td>
<td>3 (0)</td>
<td>10.4 (3.8)</td>
<td>&lt;0.001</td>
<td></td>
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</tr>
<tr>
<td><strong>Temperature (°C)</strong></td>
<td>34.5 (2.3)</td>
<td>35.1 (1.4)</td>
<td>0.58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hb (gm/L)</strong></td>
<td>104.8 (38.0)</td>
<td>88.3 (29.1)</td>
<td>0.37</td>
<td></td>
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</tr>
<tr>
<td><strong>INR</strong></td>
<td>2.6 (1.4)</td>
<td>3.1 (2.0)</td>
<td>0.50</td>
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<td></td>
</tr>
</tbody>
</table>
Royal Perth RT & REBOA Outcomes

- Overall 8 / 30 survivors (27%)
  - REBOA survivors: 80%
  - RT survivors: 18%
    - Penetrating: 30%
    - Blunt: 5%
Royal Perth RT & REBOA Outcomes

• Overall 8 / 30 survivors (27%)
  – REBOA survivors: 80 %
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\[
p < 0.01
\]
Royal Perth RT & REBOA Outcomes

- Overall 8 / 30 survivors (27%)
  - REBOA survivors: 80% 
  - RT survivors: 18% 
    - Penetrating: 30% 
    - Blunt: 5% 

\[ p < 0.01 \]

- Physiological effect of REBOA

<table>
<thead>
<tr>
<th></th>
<th>Pre-inflation</th>
<th>Post-inflation</th>
<th>( p ) – value</th>
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<tbody>
<tr>
<td>SBP (mmHg)</td>
<td>55.8 (12.3)</td>
<td>99.6 (20.2)</td>
<td>&lt; 0.01</td>
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<tr>
<td>GCS</td>
<td>10.4 (3.8)</td>
<td>11.4 (4.3)</td>
<td>NS</td>
</tr>
</tbody>
</table>
Royal Perth RT & REBOA Outcomes

• **5 transient survivors** *(4 RT, 1 REBOA & RT)*
  – 2 for several hours
  – 1 for 2 days
  – 1 for 6 days
  – 4 deaths due to metabolic dysregulation / organ failure
  – 1 patient palliated

• **Causes of death** *(n = 22)*
  – Haemorrhage 13
  – Organ Failure / Metabolic 4
  – Neurological injury 4
  – Palliated (non-survivable burn) 1
REBOA Complications

• Vascular access – no issues
  – All percutaneous puncture, by palpation

• MOF / Inflammatory response
  – ?

• One IVC cannulation

• One case with little effect
  – Major venous injuries
Inflammatory Sequelae

- Uncertain inflammatory consequences from aortic occlusion

- EDT vs REBOA
  - Occlusion levels
  - Different clinical thresholds

- RPH REBOA occlusion times
  - Mean 62.75 min
  - SD 4.2 min
<table>
<thead>
<tr>
<th>Time</th>
<th>pH</th>
<th>pCO₂</th>
<th>BE</th>
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</thead>
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<tr>
<td>16:40</td>
<td></td>
<td></td>
<td>-7</td>
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<tr>
<td>16:47</td>
<td>7.26</td>
<td>37</td>
<td>-10</td>
</tr>
<tr>
<td>16:54</td>
<td>7.26</td>
<td>36</td>
<td>-11</td>
</tr>
<tr>
<td>17:30</td>
<td>7.16</td>
<td>42</td>
<td>-14</td>
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<tr>
<td>18:02</td>
<td>7.03</td>
<td>55</td>
<td>-15</td>
</tr>
<tr>
<td>18:27</td>
<td>7.09</td>
<td>47</td>
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</tr>
<tr>
<td>18:55</td>
<td>7.10</td>
<td>46</td>
<td>-14</td>
</tr>
<tr>
<td>19:24</td>
<td>7.29</td>
<td>43</td>
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</tr>
<tr>
<td>22:25</td>
<td>7.29</td>
<td>49</td>
<td>-3</td>
</tr>
</tbody>
</table>
Acute Kidney Injury

- Inadvertent zone II inflation
- 70 min aortic occlusion
  - SBP from 64 to 103 mmHg
  - No aberrant renal vessels
Resuscitation Algorithm

- Arrest
  - In Extremis
  - Severe Shock
  - Resuscitated

- Chest
  - Abdomen → REBOA (Zone 1)
  - Pelvic → REBOA (Zone 3)

- EDT

- Theatre / Angio Suite

Dieter G. Weber, Dept. of Trauma Surgery, Royal Perth Hospital, May 2015
Conclusions

• Established & feasible at our trauma centre
  – ? Applicability elsewhere
  – ? Applicability prehospital

• Dependent on excellent trauma systems both pre- and in-house

• 7 Fr options may extend application

• New roles in
  – Non-trauma pathology (GI bleed, obstetric haemorrhage)
  – Reducing transfusion requirements