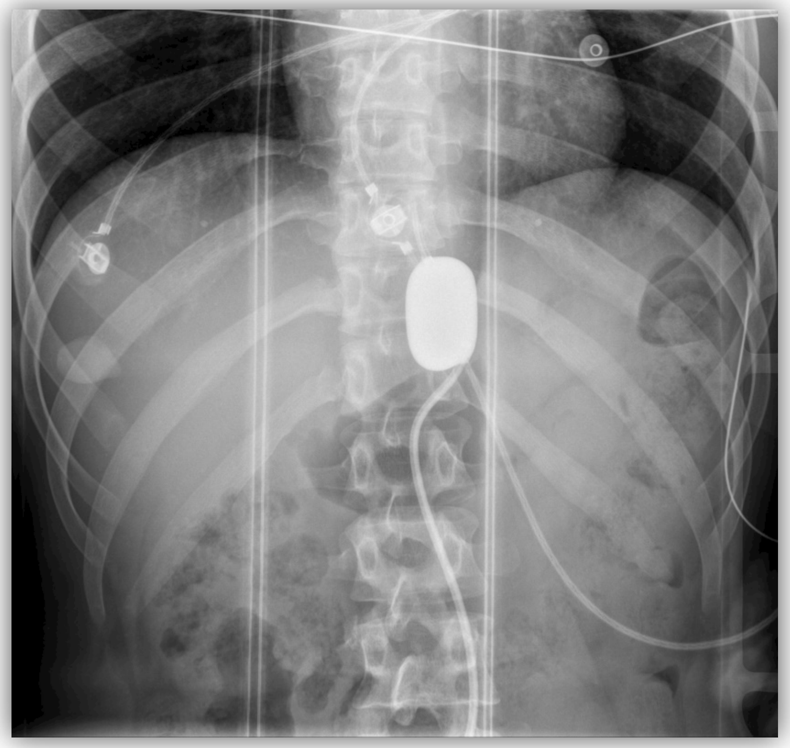
REBOA

Is it Relevant in Australasia?



Dieter G. Weber

FRACS

Trauma and General Surgeon

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Royal Perth Hospital

Injury 2018

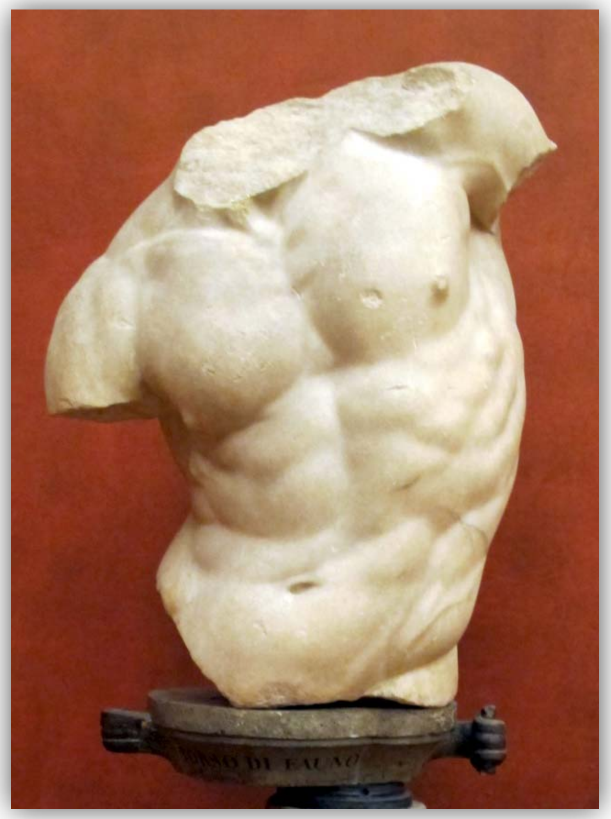
Auckland

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.

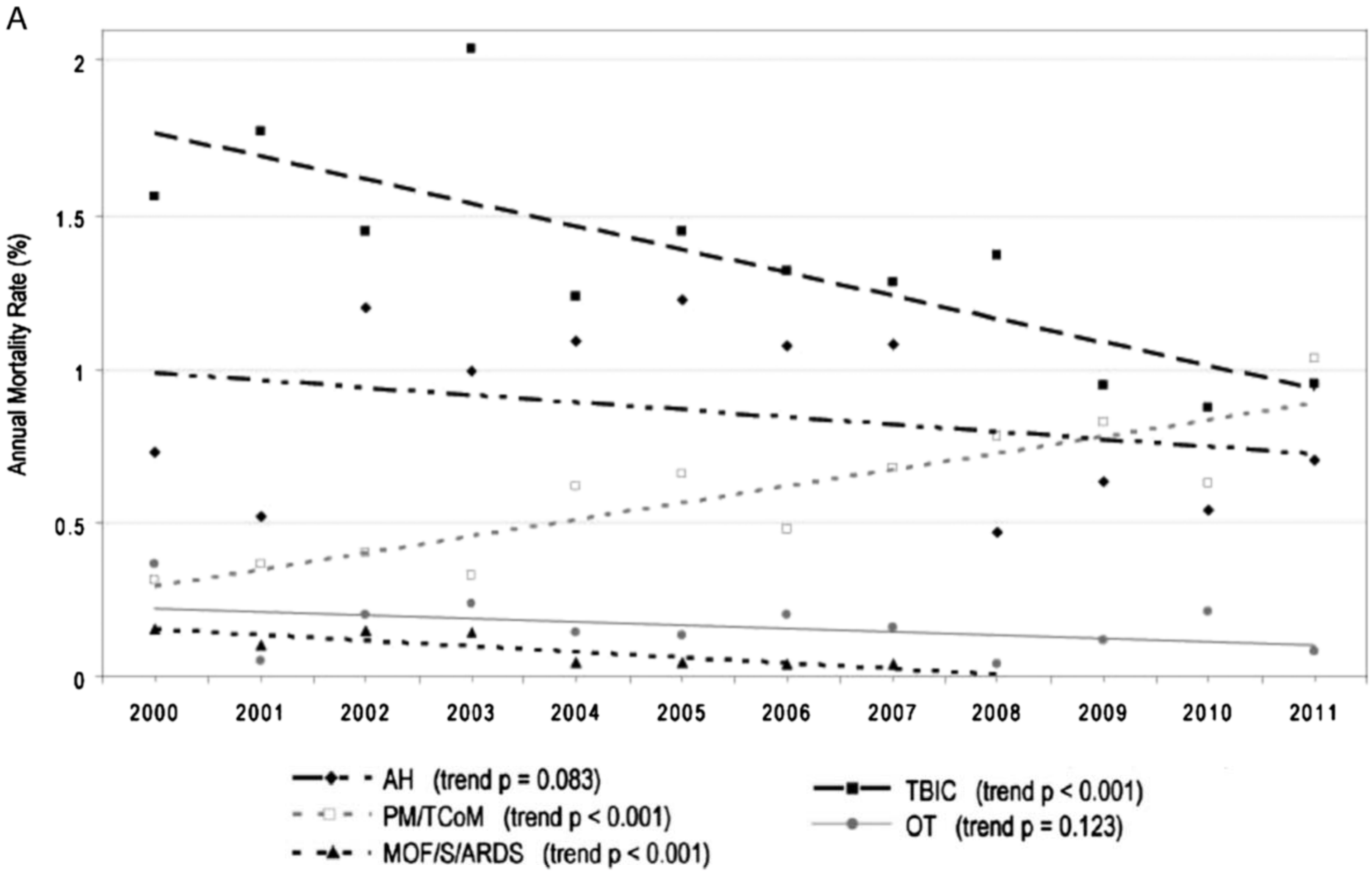
Introduction

- 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 %

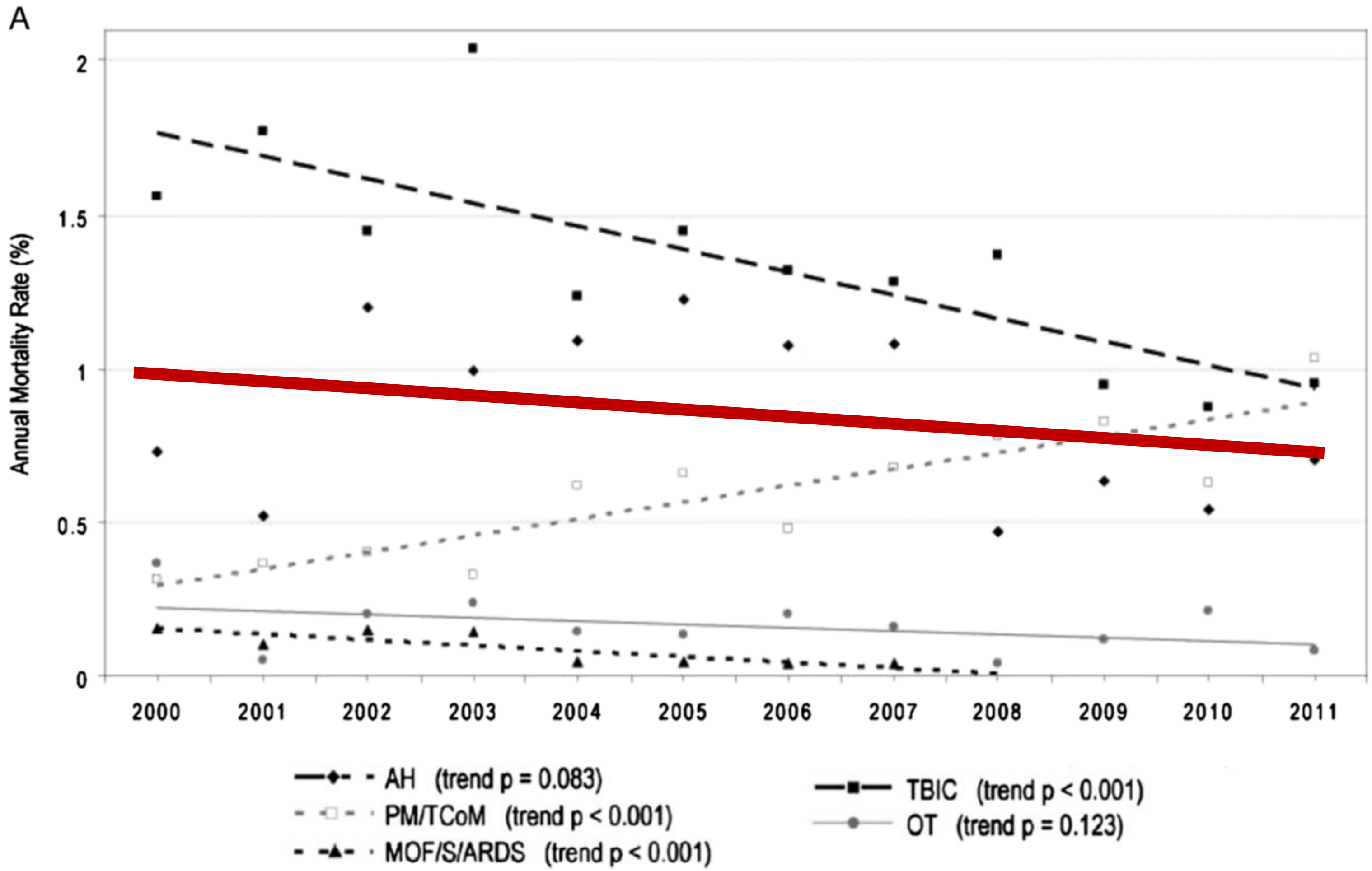
Morrison JJ & Rasmussen TE. Noncompressible torso hemorrhage: a review with contemporary definitions and management strategies. ***Surg Clin North Am.*** 2012; 92: 843
Kisat M, et al. Epidemiology and outcomes of non-compressible torso hemorrhage. ***J Surg Research.*** 2013; 184: 414

Introduction



Kahl JE, et al. The changing nature of death on the trauma service. ***J Trauma.*** 2013; 75: 195

Introduction



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Introduction

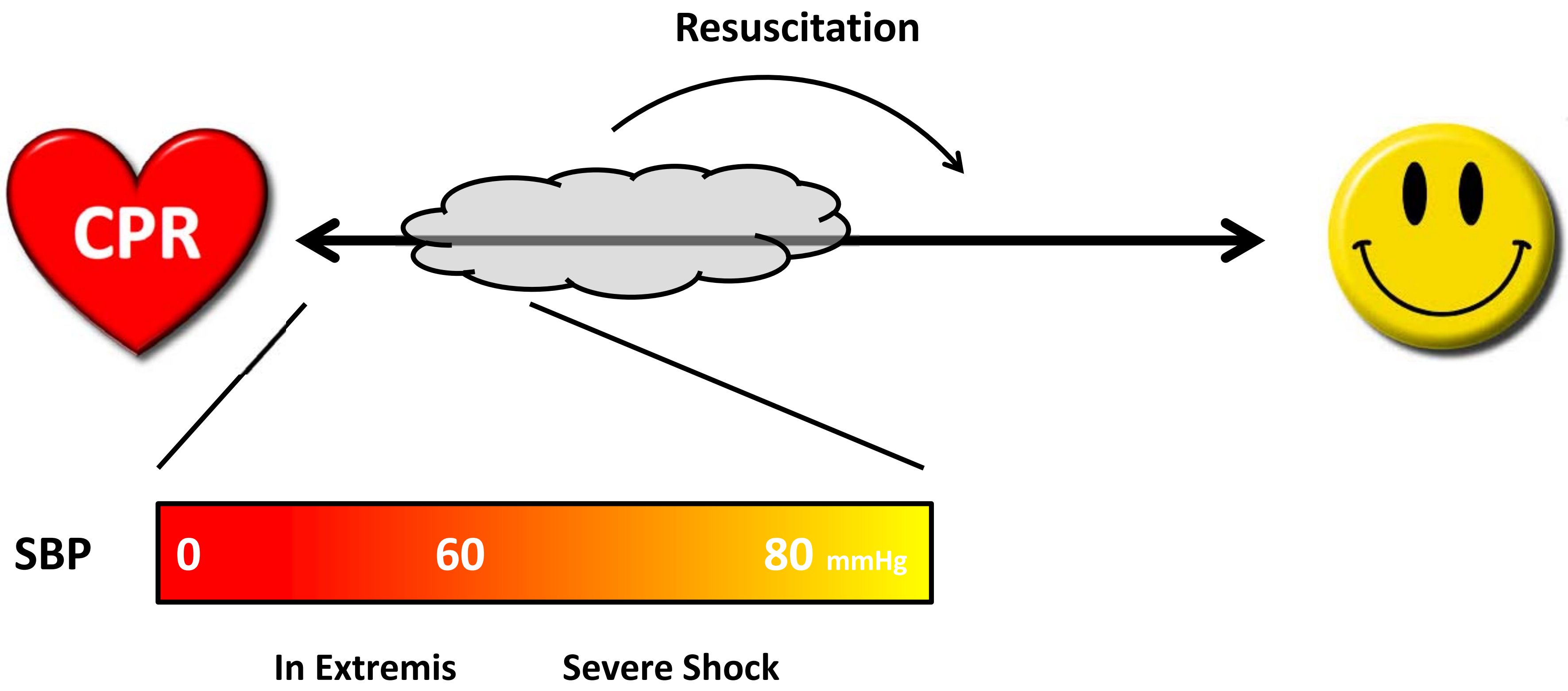
- Patients with actively bleeding NCTH are rare
  - High volume centres
  - Well functioning trauma systems
    - Pre-hospital services
    - In-hospital resources
  - Resources
    - Diagnosis, system & treatment

Introduction

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

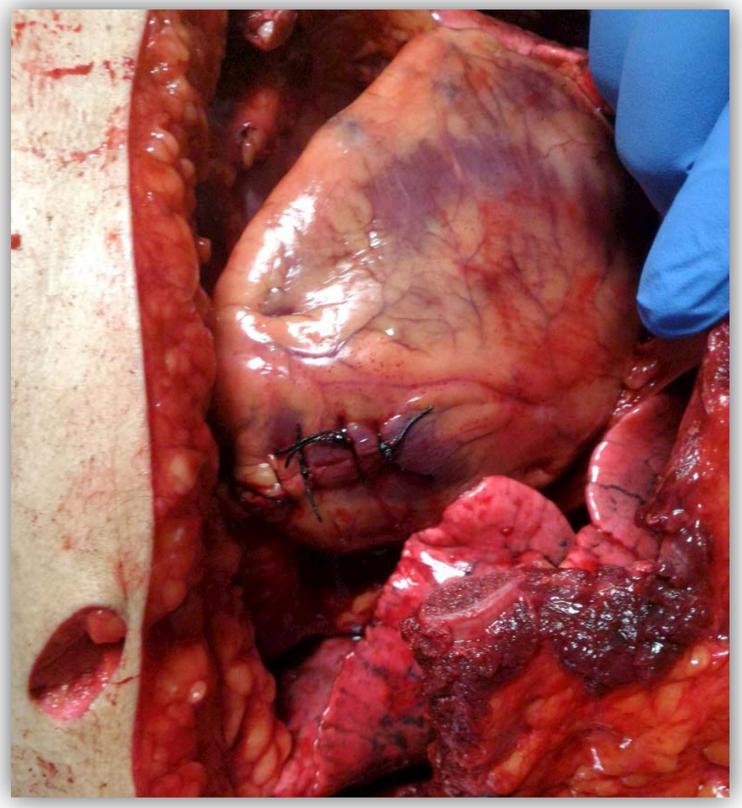
- Quantifying the depth of shock remains problematic
  - Vital signs are not adequate
  - Other parameters: not easily measurable

Defining the Critical Patient



Resuscitative Thoracotomy

- Standard of care:
  - Recent arrest
    - nb. blunt vs penetrating
    - nb. associated injuries
  - In extremis
  - ? In severe shock



Eur J Trauma Emerg Surg
DOI 10.1007/s00068-015-0559-z

CrossMark

ORIGINAL ARTICLE

Emergency resuscitative thoracotomy performed in European civilian trauma patients with blunt or penetrating injuries: a systematic review

J. K. Narvestad[1] · M. Meskinfamfard[1] · K. Søreide[1,2]

Received: 27 April 2015 / Accepted: 31 July 2015

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 ($n = 139$) only, a total of 18 patients survived (12.9 %). Survival after EDTs 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

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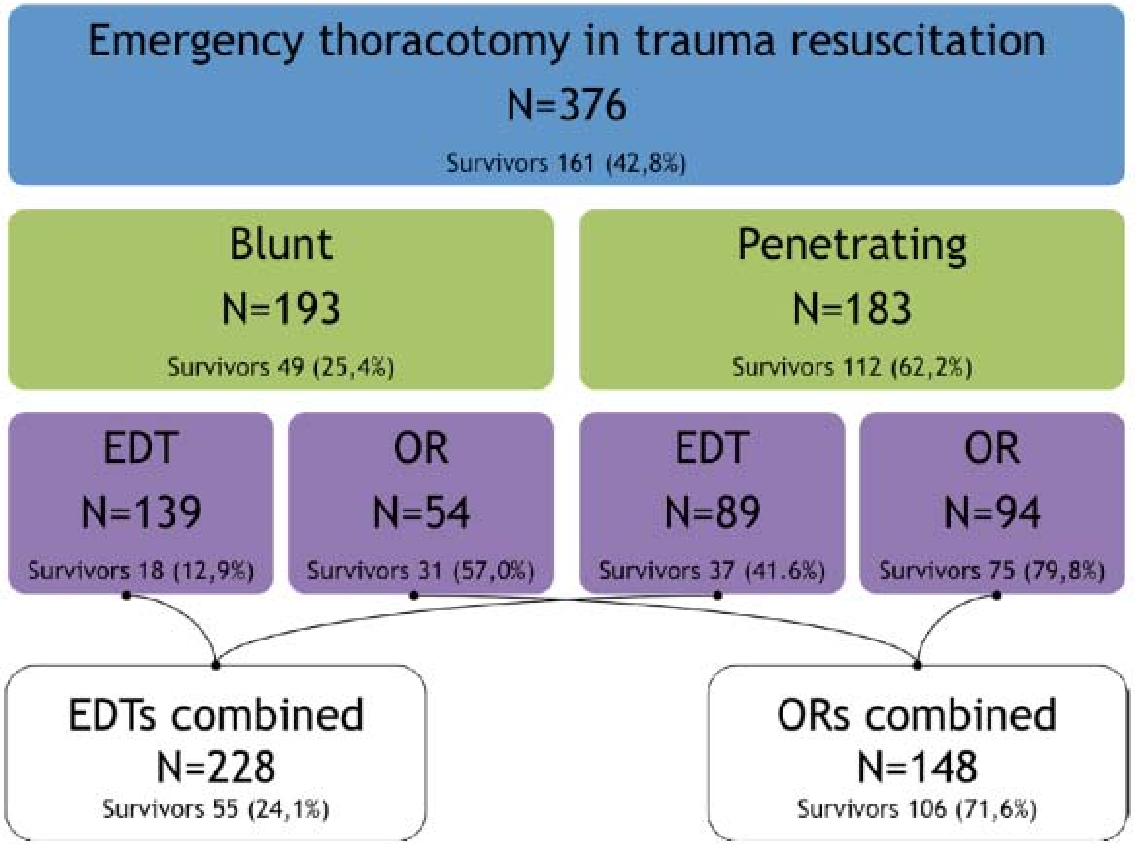
Fig. 2 Breakdown of injury type, location and outcomes of the included patients in the identified studies. *EDT* Emergency department thoracotomies, *OR* operating room



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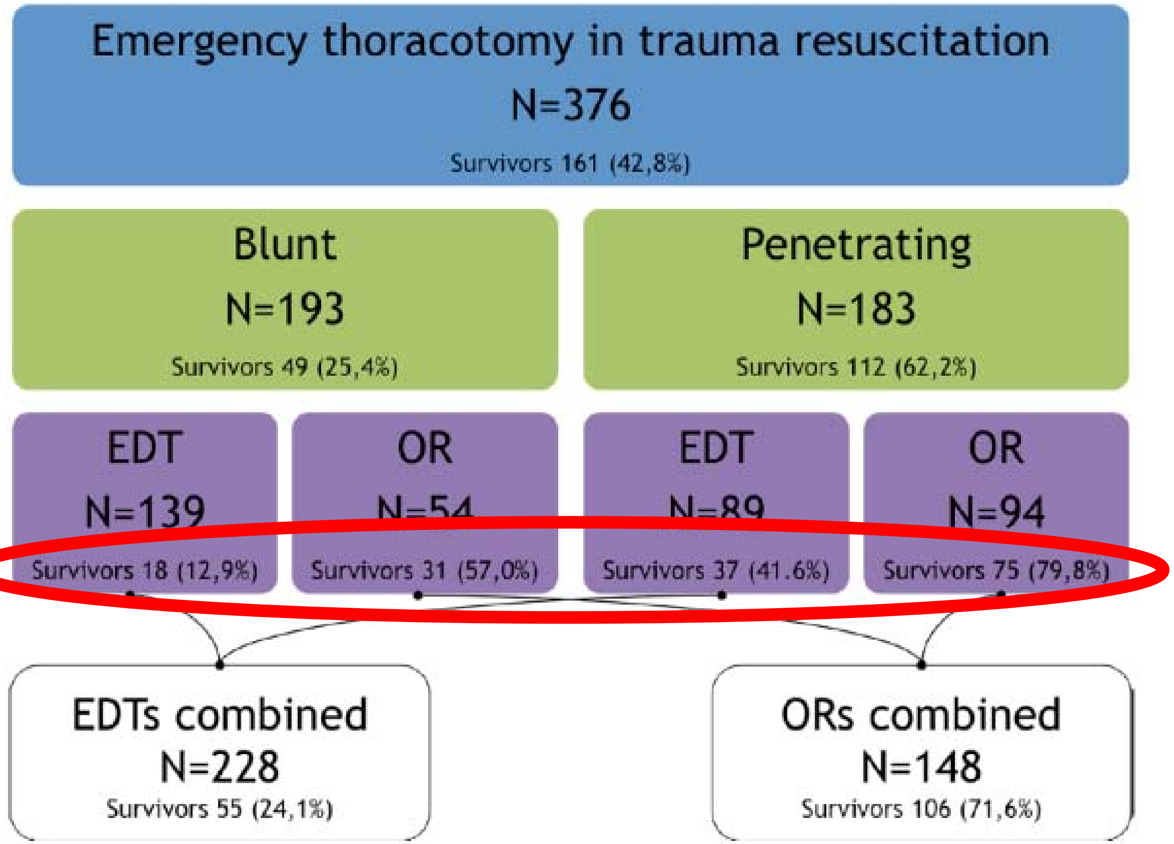

Survival after Emergency Department Thoracotomy: Review of Published Data from the Past 25 Years

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.

Advances made in prehospital systems have resulted in rapid transport of the severely injured.[1,2,3] 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[4] more than 100 years ago for a dying patient stabbed in the heart, there have been many

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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 Rhee, MD, MPH,** *Philadelphia, Pennsylvania*

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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, Outcomes) 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

Morrison CA, et al. Hypotensive resuscitation strategy reduces transfusion requirements and severe postoperative coagulopathy in trauma patients. ***J Trauma.*** 2011; 70: 652

Bickell WH, et al. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. ***NEJM.*** 1994; 331: 1105

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

Hughes CW. Use of an intra-aortic balloon catheter tramponade for controlling intra-abdominal haemorrhage in man. ***Surgery.*** 1954; 36: 65
Stannard A et al. Resuscitative endovascular balloon occlusion of the aorta (REBOA) as an adjunct for hemorrhagic shock. ***J Trauma.*** 2011; 71: 1869
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
Biffl WL et al. The role of REBOA in the control of exsanguinating torso hemorrhage. ***J Trauma.*** 2015; 78: 1054


REBOA
REBOA
REBOA

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

- <u>Mechanism</u>
  - 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

Royal Perth RT & REBOA

	Number	RT Procedures	REBOA Procedures	Survivors
Penetrating Injuries				
Stab	7	7	0	1
Gunshot	1	1	0	1
Angle grinder	1	1	0	1
Impalement	1	1	0	0
Total penetrating force	**10**	**10**	**0**	**3 (30%)**
Blunt injuries				
MVC	7	6	1	2
MBC	5	3	3	2
Pedestrian	5	5	0	0
Falls	2	1	1	1
Total blunt force	**19**	**15**	**5**	**5 (26%)**
Burns	**1**	**1**	**0**	**0**
All Patients	**30**	**26**	**5**	**8 (27%)**

Royal Perth RT & REBOA

	Number	RT Procedures	RT Survivors	REBOA Procedures	REBOA Survivors	Survivors
Penetrating Injuries						
Stab	7	7	1	0	0	1
Gunshot	1	1	1	0	0	1
Angle grinder	1	1	1	0	0	1
Impalement	1	1	0	0	0	0
Total penetrating force	**10**	**10**	**3**	**0**	**0**	**3 (30%)**
Blunt injuries						
MVC	7	6	1	1	1	2
MBC	5	3	0	3	2	2
Pedestrian	5	5	0	0	0	0
Falls	2	1	0	1	1	1
Total blunt force	**19**	**15**	**1**	**5**	**4**	**5 (26%)**
Burns	**1**	**1**	**0**	**0**	**0**	**0**
All Patients	**30**	**26**	**4**	**5**	**4**	**8 (27%)**

Royal Perth RT & REBOA

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

Royal Perth RT & REBOA Outcomes

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

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} ***p* < 0.01**

Royal Perth RT & REBOA Outcomes

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  - REBOA survivors: 80 %
  - RT survivors: 18 %
    - Penetrating: 30 %
    - Blunt: 5 %

$p < 0.01$

- Physiological effect of REBOA

	Pre-inflation	Post-inflation	*p* – value
SBP (mmHg)	55.8 (12.3)	99.6 (20.2)	< 0.01
GCS	10.4 (3.8)	11.4 (4.3)	NS

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-surviable 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

JOURNAL OF SURGICAL RESEARCH 191 (2014) 423–431

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journal homepage: www.JournalofSurgicalResearch.com

JSR

The inflammatory sequelae of aortic balloon occlusion in hemorrhagic shock

CrossMark

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A R T I C L E I N F O

Article history:
Received 20 October 2013
Received in revised form
11 March 2014
Accepted 4 April 2014
Available online 13 April 2014

Keywords:
Resuscitative endovascular balloon occlusion of the aorta
REBOA
Noncompressible torso hemorrhage
Hemorrhagic shock
Resuscitation

A B S T R A C T

Background: Resuscitative endovascular balloon occlusion of the aorta (REBOA) is a hemorrhage control and resuscitative adjunct that has been demonstrated to improve central perfusion during hemorrhagic shock. The aim of this study was to characterize the systemic inflammatory response associated and cardiopulmonary sequelae with 30, 60, and 90 min of balloon occlusion and shock on the release of interleukin 6 (IL-6) and tumor necrosis factor alpha.

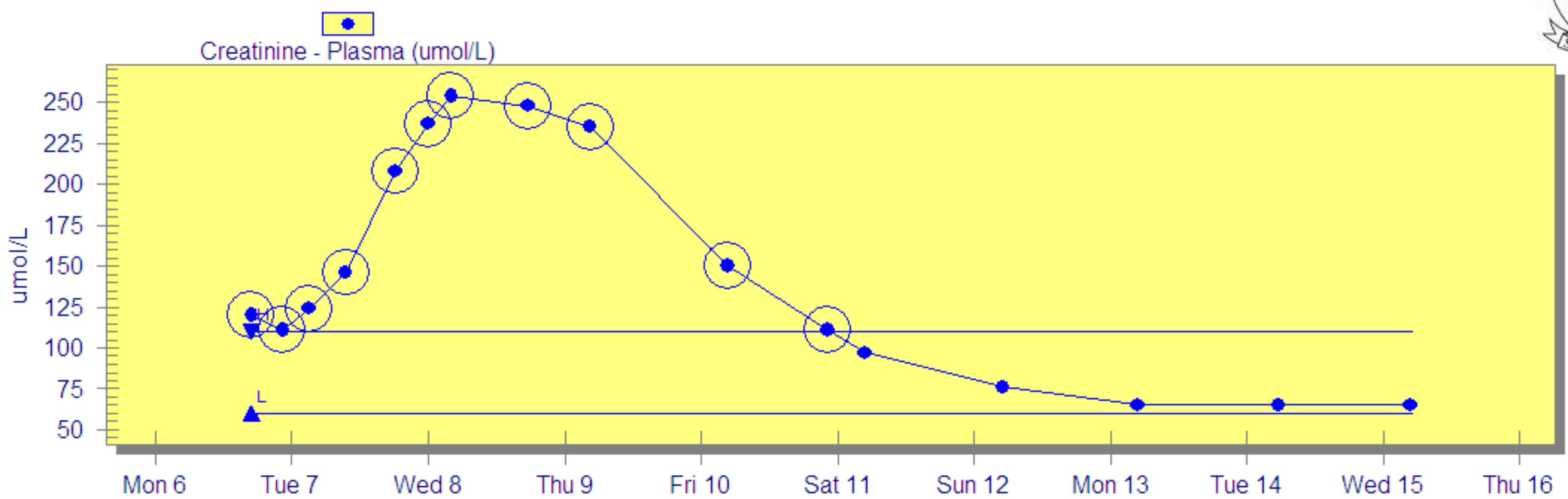
Materials and methods: Anesthetized female Yorkshire swine (*Sus scrofa*, weight 70–90 kg) underwent a 35% blood volume–controlled hemorrhage followed by thoracic aortic balloon occlusion of 30 (30-REBOA, $n = 6$), 60 (60-REBOA, $n = 8$), and 90 min (90-REBOA, $n = 6$). This was followed by resuscitation with whole blood and crystalloid over 6 h. Animals then underwent 48 h of critical care with sedation, fluid, and vasopressor support.

Results: All animals were successfully induced into hemorrhagic shock without mortality. All groups responded to aortic occlusion with a rise in blood pressure above baseline values. IL-6, as measured (picogram per milliliter) at 8 h, was significantly elevated from baseline values in the 60-REBOA and 90-REBOA groups: 289 ± 258 *versus* 10 ± 5; $P = 0.018$ and 630 ± 348; $P = 0.007$, respectively. There was a trend toward greater vasopressor use ($P = 0.183$) and increased incidence of acute respiratory distress syndrome ($P = 0.052$) across the groups.

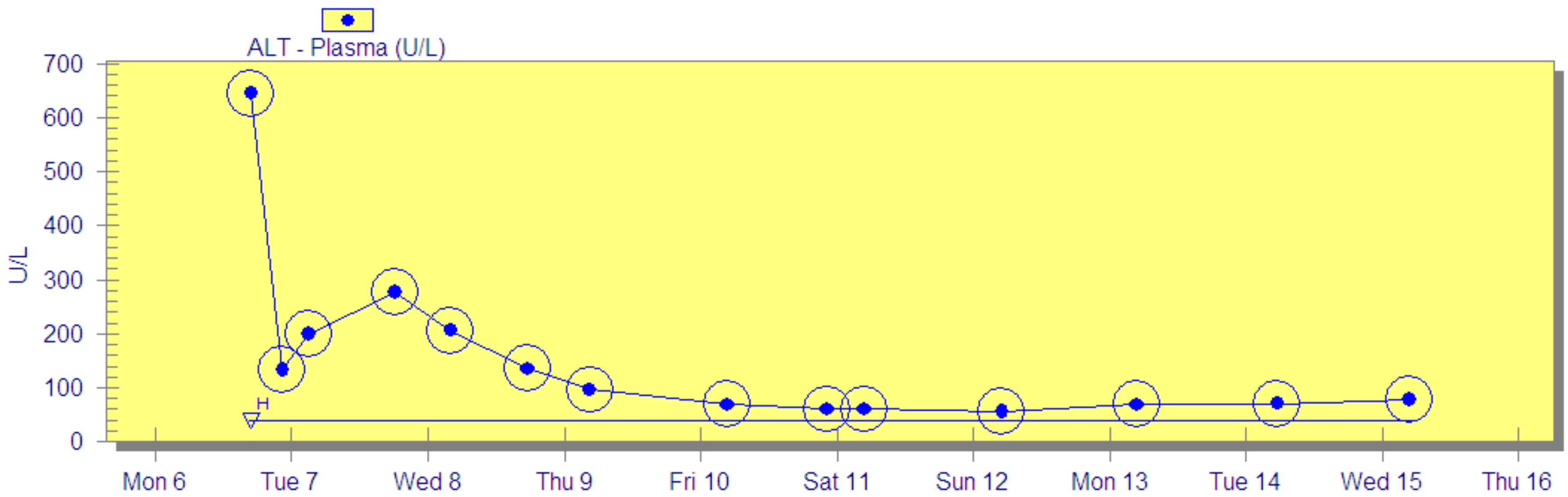
Conclusions: REBOA is a useful adjunct in supporting central perfusion during hemorrhagic shock; however, increasing occlusion time and shock results in a greater IL-6 release. Clinicians must anticipate inflammation-mediated organ failure in post-REBOA use patients.

	Time	pH	pCO_2	BE
	16:40			-7
	16:47	7.26	37	-10
REBOA up →	16:54	7.26	36	-11
	17:30	7.16	42	-14
REBOA down →	18:02	7.03	55	-15
	18:27	7.09	47	-14
	18:55	7.10	46	-14
	19:24	7.29	43	-6
	22:25	7.29	49	-3

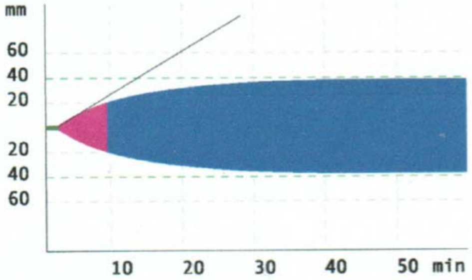
Creatinine - Plasma



ALT - Plasma



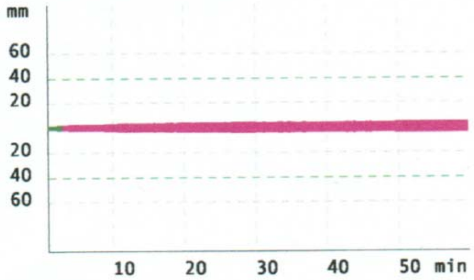
at 2 hours



EXTEM
J5570716

RT: 01:31:25

CT	:	119	s
CFT	:	407	s
A10	:	25	mm
A20	:	33	mm
MCF	:	38	mm
ML	:*	4	%
α	:	42	°
LI60	:	99	%
A5	:	17	mm
LI30	:	100	%

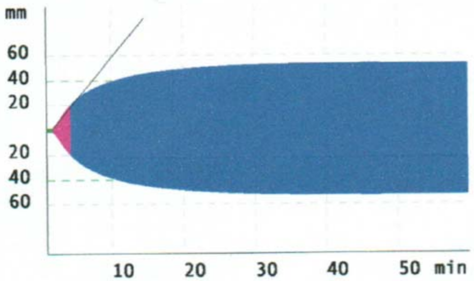


FIBTEM
J5570716

RT: 01:32:36

CT	:	129	s
CFT	:		s
A10	:	3	mm
A20	:	4	mm
MCF	:	3	mm
ML	:*	0	%
α	:		°
LI60	:	100	%
A5	:	2	mm
LI30	:	100	%

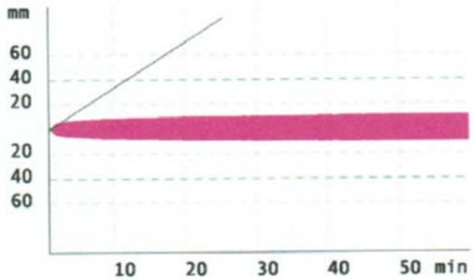
at 3.5 hours



EXTEM
J5570716

RT: 01:17:29

CT	:	62	s
CFT	:	148	s
A10	:	42	mm
A20	:	49	mm
MCF	:	53	mm
ML	:*	3	%
α	:	62	°
LI60	:	99	%
A5	:	31	mm
LI30	:	100	%

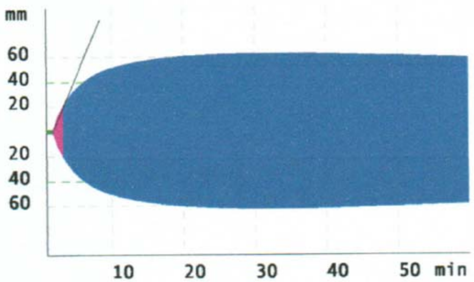


FIBTEM
J5570716

RT: 01:15:15

CT	:	45	s
CFT	:		s
A10	:	8	mm
A20	:	9	mm
MCF	:	9	mm
ML	:*	0	%
α	:	44	°
LI60	:	100	%
A5	:	7	mm
LI30	:	100	%

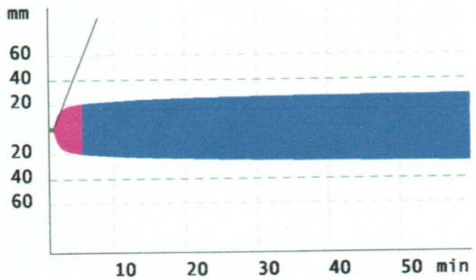
at 37 hours



EXTEM
J5570716

RT: 01:53:43

CT	:	64	s
CFT	:	83	s
A10	:	54	mm
A20	:	61	mm
MCF	:	63	mm
ML	:*	14	%
α	:	76	°
LI60	:	94	%
A5	:	43	mm
LI30	:	100	%



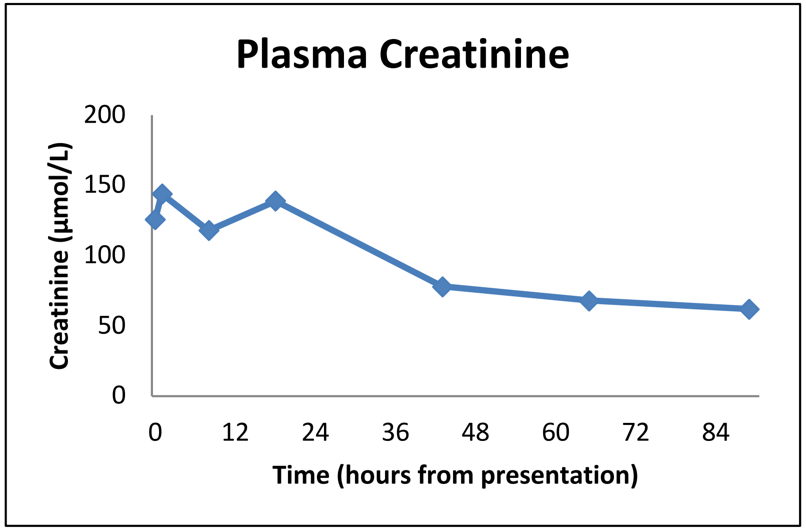
FIBTEM
J5570716

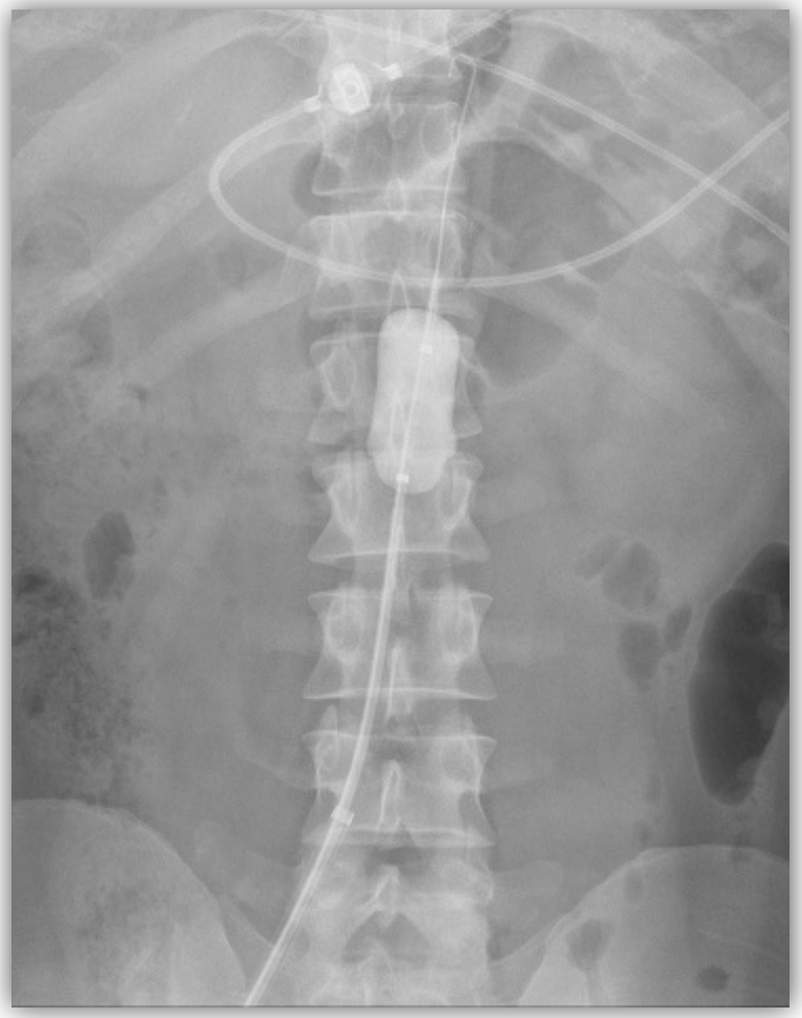
RT: 01:52:25

CT	:	52	s
CFT	:	241	s
A10	:	22	mm
A20	:	24	mm
MCF	:	27	mm
ML	:*	0	%
α	:	77	°
LI60	:	100	%
A5	:	21	mm
LI30	:	100	%

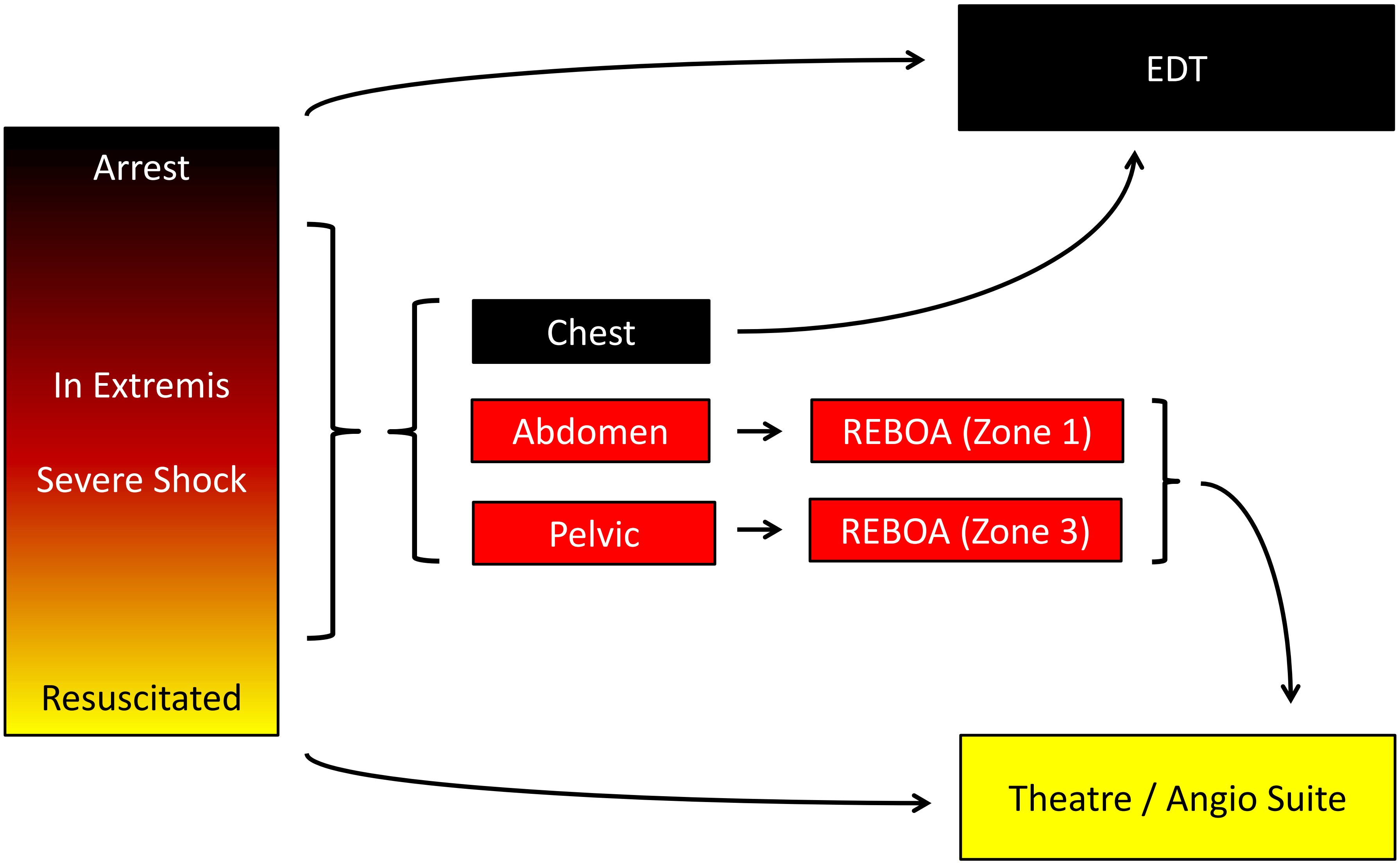
Acute Kidney Injury

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





Resuscitation Algorithm



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


Royal Perth Hospital