Direct access to operating room for traumatized patient: a winning model?

Dott. Elena Bigi
U.O. Anestesia-Rianimazione- Emergenza territoriale-118
Ospedale Maggiore – Bologna
Dir. Dott. G. Gordini
IN 2020 IS EXPECTED AS 8.4 MILLION OF DEATHS PER YEAR SECONDARY TO TRAUMA

World Health Organization: road traffic accidents will become the third leading cause of death on the planet

The 2 leading causes of death after trauma are blood loss and neurologic injury, which account for more than three-quarters of injury related mortality.\(^1\) Fifty percent of early deaths (<24 hours from injury) are due to hemorrhage, with hemorrhagic shock an important driver for postresuscitation organ failure and late mortality.\(^1\text{--}^3\) There has
Research questions in pre-hospital trauma care

David J. Lockey¹,² *

Advanced trauma systems are inclusive—they quality assure the whole trauma care pathway from point of injury to rehabilitation. This approach encourages parallel development of pre- and in-hospital services and increases attention on the quality of care outside the major trauma centre, usually the priority site for trauma care initiatives. “Early” trauma care interventions reduce mortality, morbidity and hospital costs. The delivery of advanced interventions on scene is promoted on the basis that, if left untreated until hospital arrival, some patients will die or suffer morbidity from uncorrected time-critical pathology. The in-hospital intensive care principle of “critical care without walls” [7]—that patients should be treated on the basis of their compromise rather than their geography—promotes the delivery of trauma care on scene. The NHMRC’s 2007 trauma care strategy recommends that those regions that do not have access to a major trauma centre should ensure that ‘critical care without walls’ is available within 30 minutes of scene arrival.
Delays in appropriate operative intervention have been identified clearly as sources of preventable mortality and morbidity.\textsuperscript{6,11,12} Fiedler et al\textsuperscript{13} found an average delay of 109 minutes from arrival to the OR in a penetrating trauma cohort and an average delay of 55 minutes among patients who died. A Pennsylvania trauma registry study documented an increased mortality of 1\% for every 3 minutes of delay to laparotomy among hypotensive patients with abdominal injuries.\textsuperscript{14} Similar concerns about the impact of hemorrhage control delay have been reported.
Trauma is a **time-sensitive disease** and minimising prehospital time is appealing

<table>
<thead>
<tr>
<th>Criterion</th>
<th>AOR*</th>
<th>95% CI*</th>
<th>q value**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk adjustment model without extrication or PH intubation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypotension (SBP &lt; 90 mm Hg)</td>
<td>1.40</td>
<td>1.17–1.67</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>PH GCS score ≤ 13</td>
<td>1.14</td>
<td>1.02–1.29</td>
<td>0.04</td>
</tr>
<tr>
<td>Penetrating injury</td>
<td>1.59</td>
<td>1.29–1.97</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flail chest</td>
<td>1.34</td>
<td>1.15–1.56</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Pelvic fracture</td>
<td>1.23</td>
<td>1.03–1.54</td>
<td>0.04</td>
</tr>
<tr>
<td>Risk adjustment model adjusting for extrication and PH intubation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypotension (SBP &lt; 90 mm Hg)</td>
<td>1.25</td>
<td>1.04–1.50</td>
<td>0.04</td>
</tr>
<tr>
<td>Penetrating injury</td>
<td>1.38</td>
<td>1.13–1.69</td>
<td>0.01</td>
</tr>
<tr>
<td>Flail chest</td>
<td>1.21</td>
<td>1.04–1.40</td>
<td>0.03</td>
</tr>
</tbody>
</table>

* AOR and 95% CI, for association of mortality with prolonged scene time.
** False discovery rate–adjusted p values; can be interpreted similarly to standard
p values with significance defined as q ≤ 0.05.

Complete therapy at the accident site, the premise today is to stabilise trauma patients at the accident site and transfer them into the hospital rapidly – not any treatment that is possible should be conducted at the accident site, unless it is vital for life [1,2]. This, for
Clinical Science

A decade of experience with a selective policy for direct to operating room trauma resuscitations

Matthew Martin, M.D.*, Seth Izenberg, M.D., Frederick Cole, M.D., Sue Bergstrom, R.N., William Long, M.D.

The initial evaluation and management of the severely injured patient stands in marked contrast with nearly all other areas of medicine and surgery. A prioritized, rapid, and abbreviated search for specific life- or limb-threatening injuries coupled with immediate decision making and interventions is required to avoid preventable morbidity and mortality. This includes prehospital identification of the patient needing urgent trauma care, transportation to a trauma center, and activation of the appropriate in-hospital personnel and resources. The importance of minimizing any unnecessary delays in transportation and the initial treat-
DCR is a systematic approach to the management of the TRAUMA PATIENT with severe injuries.

Damage control resuscitation

Damage control resuscitation (DCR) forms part of an overall approach to patient care rather than a specific intervention and has evolved from damage control surgery. It is characterised by early blood product administration and haemorrhage control with restoration of blood volume and physiologic stability [1]. This approach should be initiated at first contact with the patient in the prehospital environment and continue through their initial reception and treatment until haemorrhage is arrested and physiology corrected. Recognition of patients at high risk is therefore critical. It has repeatedly been shown that early intervention
TABLE 1. Principles of Damage Control Resuscitation (DCR)

<table>
<thead>
<tr>
<th>Principle</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid/reverse hypothermia</td>
<td>Gentilello,¹ Shafti²</td>
</tr>
<tr>
<td>Minimize blood loss with early hemorrhage control measures during transport and initial evaluation</td>
<td>Kragh,³ Schroll,⁴ Inaba,⁵ Leonard,⁶ Yong,⁷ Dubose⁸</td>
</tr>
<tr>
<td>Delay resuscitation/target low-normal blood pressure before definitive hemostasis</td>
<td>Bickell,⁹ Dutton¹⁰</td>
</tr>
<tr>
<td>Minimize crystalloid administration</td>
<td>Duchesne,¹¹ Schreiber¹²</td>
</tr>
<tr>
<td>Use MT protocol to ensure sufficient blood products are available in a prespecified ratio</td>
<td>O'Keeffe,¹³ Cotton¹⁴</td>
</tr>
<tr>
<td>Avoid delays in surgical or angiographic hemostasis</td>
<td>Meizoso,¹⁵ Schwartz,¹⁶ Tesoriero¹⁷</td>
</tr>
<tr>
<td>Transfuse blood components that optimize hemostasis</td>
<td>Borgman,¹⁸ Holcomb,¹⁹ Holcomb²⁰</td>
</tr>
<tr>
<td>Obtain functional laboratory measures of coagulation (e.g., TEG or TEM) to guide ongoing resuscitation</td>
<td>Gonzalez,²¹ Tapia²² CRASH-2,²³ Morrison,²⁴ Hauser²⁵</td>
</tr>
<tr>
<td>Give pharmacologic adjuncts to safely promote hemostasis</td>
<td></td>
</tr>
</tbody>
</table>

TEG, thromboelastography; TEM, thromboelastometry.

Permissive hypotension has become a central component of the DCR approach. It must be understood as a passive process that is temporarily tolerated until hemorrhage control is achieved. Basal coronary–cerebral circulation is maintained by avoiding crystalloids and the judicious use of balanced blood product transfusions. At all times, hemorrhage control is the goal, not normalization of blood pressure.
STOP THE BLEEDING

Tourniquet use

Recommendation 2: We recommend adjunct tourniquet use to stop life-threatening bleeding from open extremity injuries in the pre-surgical setting. (Grade 1B)

Tourniquets

Recommendation 1: We recommend the use of tourniquets in the prehospital setting for the control of significant extremity hemorrhage if direct pressure is ineffective or impractical.

Local haemostatic measures

Recommendation 22: We recommend the use of topical haemostatic agents in combination with other surgical measures or with packing for venous or moderate arterial bleeding associated with parenchymal injuries. (Grade 1B)
Early management of the severely injured major trauma patient

A. L. McCullough*, J. C. Haycock, D. P. Forward and C. G. Moran

Hypotension with associated pelvic fracture

Pelvic fracture can result in catastrophic haemorrhage with associated occult coagulopathy. Early splinting of pelvic fractures reduces movement and protects clot formation. The use of pelvic binders is now routine in the pre-hospital setting.

Pelvic ring closure and stabilisation

Recommendation 20 We recommend that patients with pelvic ring disruption in haemorrhagic shock undergo immediate pelvic ring closure and stabilisation. (Grade 1B)
RESUSCITATIVE ENOVASCULAR BALLOON OCCLUSION OF THE AORTA

REBOA

Balloon is inserted on a catheter into blood vessel in the leg. Guided to the bottom end of the aorta and inflated, it cuts off the blood supply to damaged vessels in the crushed pelvis. This reduces internal bleeding. The idea is to maintain blood pressure above the balloon.

Aortic Zone I

Aortic Zone II

Aortic Zone III

STOP THE BLEEDING
Prehospital administration of tranexamic acid in trauma patients

Arasch Wafaisade¹, Rolf Lefering², Bertil Bouillon¹, Andreas B. Böhmer³, Michael Gäßler⁴, Matthias Ruppert⁴ and TraumaRegister DGU

Conclusions

In the present study of trauma patients, prehospital use of TXA was associated with prolonged time to death and significantly improved early survival, suggesting benefits of TXA on haemostatic resuscitation. Until further evidence emerges, the results support the use of TXA during prehospital treatment of severely injured patients.
Tranexamic Acid Use in Prehospital Uncontrolled Hemorrhage

Benjamin R. Huebner, MD, Warren C. Dorlac, MD, and Chris Cribari, MD
Department of Surgery, University of Cincinnati, Cincinnati, OH (Dr Huebner); the University of Colorado Health, Loveland, CO and Volunteer Clinical Faculty, Department of Surgery, University of Cincinnati, Cincinnati, OH (Dr Dorlac); and the University of Colorado Health, Loveland, CO (Dr Cribari)

The use of prehospital TXA in the severely injured trauma patient will become more clear with the trauma studies currently underway, the current literature supports the use of prehospital TXA in this high-risk population. We recommend considering a 1 g TXA bolus en route to definitive care in high-risk patients and withholding subsequent doses until hyperfibrinolysis is confirmed by thromboelastography.

Box 2 Prehospital TXA recommendations from US guidelines (from Fischer et al26)

TXA administration to bleeding patients
Objective measurements should be used to guide prehospital TXA administration protocols. The focus for management of compressible, external bleeding should be on direct pressure, tourniquets, hemostatic agents, and/or wound packing. Evidence of injury consistent with non-compressible hemorrhage (eg, penetrating thoracoabdominal trauma or unstable pelvis fractures) along with heart rate >120 bpm and SBP <90 mm Hg are suggested criteria. Agencies may consider vital sign adjustments for the geriatric population.

Don’t forget the basics
In the bleeding patient, hemorrhage control and appropriate resuscitation remain the priority. Prehospital TXA use should never supersede field bleeding control techniques, rapid transport to a trauma center, or the administration of blood or plasma.
“don’t pop the clot”

RESTRICTIVE FLUID ADMINISTRATION

In sharp contrast to the historic practice of “keeping the fluids running,” the current evidence strongly suggests that the use of intravenous fluids in hemorrhagic shock patients should be minimized. Aggressive fluid resuscitation results in worse coagulopathy, an exaggerated trauma-related systemic inflammatory response syndrome (SIRS), an increased incidence of adult respiratory distress syndrome (ARDS), pulmonary edema, compartment syndrome, anemia, thrombocytopenia, pneumonia, electrolyte disturbances, and overall worse survival (27–32).
Does prehospital ultrasound improve treatment of the trauma patient? A systematic review
Henrik Jørgensen\textsuperscript{a}, Carsten H. Jensen\textsuperscript{b} and Jesper Dirks\textsuperscript{a}

The prehospital FAST led to streamline of patient care, change to admitting hospital and makes diagnosis more accurate \[6,17\].

An early diagnosis will provide the prehospital physician with the knowledge to prioritize the relevant initial treatment. Furthermore, early diagnosis helps the physician to choose the closest appropriate hospital and transportation form. In the study by Walcher \textit{et al.} \[6\], prehospital US resulted in a change of choice of admitting hospital in 20\% of patients. This may have a great impact especially in rural areas.
at least neutral to the involved patient. The only possible harm to the patient could be a time delay. Some investigators perform the examination during transfer; others reported duration of US to be between 2 and 6 min [6,17,25].
ABCDE of prehospital ultrasonography: a narrative review

Rein Ketelaars\textsuperscript{1,2*}, Gabby Reijnders\textsuperscript{3}, Geert-Jan van Geffen\textsuperscript{1,2}, Gert Jan Scheffer\textsuperscript{1}\textsuperscript{1}, Nico Hoogerwerf\textsuperscript{1,2}

13–15]. It has been found to be feasible to enhance clinical assessment in a variety of out-of-hospital settings [15]. Price was among the first to show that ultrasonography (US) is also feasible during helicopter transport and that focused assessment with sonography for trauma (FAST) can be rapidly performed in-flight and has no influence on aircraft avionics [16].

Prehospital point-of-care ultrasound used by nonradiologists in emergency medicine is gaining ground. It is feasible on-scene and during aeromedical transport and allows health-care professionals to detect or rule out potential harmful conditions. Consequently, it impacts decision-making in prioritizing care, selecting the best treatment, and the most suitable transport mode and destination. This increasing relevance of prehospital ultrasonography is due to
The role of point of care ultrasound in prehospital critical care: a systematic review

Morten Thingemann Bøtker 1,2*, Lars Jacobsen 3,4, Søren Steemann Rudolph 5,6 and Lars Knudsen 7

...negative predictive values from 69 to 90%. The same patterns apply to prehospital trauma ultrasound, although positive predictive value is generally lower for hemoperitoneum (around 50%) than for pneumothorax [24]. A positive POCUS finding is highly predictive of a need for intervention and seems useful for prehospital triage [18, 24]. The negative predictive values are not sufficiently high to recommend POCUS-based rule-out of serious injuries.

Conclusion: Prehospital POCUS is feasible and changes patient management in trauma, breathing difficulties and cardiac arrest, but it is unknown if this improves outcome. Expertise in POCUS requires extensive training by a combination of theory, hands-on training and a substantial amount of clinical examinations – a large part of these needs to be supervised.
Increasing time to operation is associated with decreased survival in patients with a positive FAST exam requiring emergent laparotomy

Ronald R. Barbosa, MD1, Susan E. Rowell, MD2, Erin E. Fox, PhD3, John B. Holcomb, MD4, Eileen M. Bulger, MD5, Herbert A. Phelan, MD, MSCS6, Louis H. Alarcon, MD7, John G. Myers, MD8, Karen J. Brasel, MD9, Peter C. Muskat, MD10, Deborah J. del Junco, PhD4, Bryan A. Cotton, MD, MPH4, Charles E. Wade, PhD4, Mohammad H. Rahbar, PhD3,11, Mitchell J. Cohen, MD12, Martin A. Schreiber, MD1, and on behalf of the PROMMitt Study Group

Conclusion—In patients with a positive FAST who required emergent laparotomy, delay in operation was associated with increased early and late in-hospital mortality. Delays in time to operation in trauma patients with a positive FAST should be minimized.

the trauma community. Trauma systems and clinical protocols are designed to minimize the time required to obtain definitive surgical control of hemorrhage. The time from hospital arrival to emergent surgical intervention has been used as an audit filter for assessment of trauma systems in several different countries.4,12
• NO therapy free interval
• DCR

Continuity of care
Injuries [5]. Haemorrhage is responsible for 30–40% of all trauma mortality, accounts for 80% of early in-hospital deaths [5–8]. Thus, bleeding to death has been labelled as the leading cause of potentially preventable, injured-related death worldwide [6].

Exsanguination demands immediate haemorrhage control. Given the importance of minimising every minute of delay, efforts to minimise the time to operative haemorrhage control include the earliest selection of those requiring open surgery and providing for the conduct of resuscitation within an operative-capable suite.
The evolution of a purpose designed hybrid trauma operating room from the trauma service perspective: The RAPTOR (resuscitation with angiography percutaneous treatments and operative resuscitations)

Andrew W. Kirkpatrick a,d,e,f,x, Christine Vis b, Mirette Dubé f, Susan Biesbroek f, Chad G. Ball a,d,e, Jason Laberge f, Jonas Shultz f, Ken Rea g, David Sadler h, John B. Holcomb h, John Kortbeek a,c,d,e,f

for every 3 min delay to the operating room (OR) [9]. While resuscitation after haemorrhagic shock is critical to survival, haemorrhage control must occur simultaneously with resuscitation. By resuscitating rather than controlling haemorrhage, other iatrogenic diseases such as coagulopathies and secondary compartment syndromes, either of the extremities or the uninjured abdomen may be induced [10,11]. Errors in haemorrhage control

Time saved = Life saved
intervention. Direct to operating room resuscitation facilitated their operative treatment without using trauma bay resources or unnecessary transfer time. Furthermore, instituting a DOR resuscitation protocol for these patients was not more expensive than the standard trauma bay resuscitation protocol.

Classical Approach

Integrated DCS and resuscitation - DCR

(a) resuscitation — DCS — critical care

transfusion / resuscitation protocol

(b) DCR — DCS

individually tailored, goal-directed resuscitation. Sequencing DCR–DCS based on near-patient, real-time assessment of tissue perfusion and haemostasis
A decade of experience with a selective policy for direct to operating room trauma resuscitations

Matthew Martin, M.D.*, Seth Izenberg, M.D., Frederick Cole, M.D., Sue Bergstrom, R.N., William Long, M.D.

The standard paradigm for acutely injured patients at most centers involves an initial evaluation in an emergency department (ED) setting, which typically involves direct patient assessment coupled with basic imaging and laboratory studies. This assessment then sets the stage for deciding

ADVANTAGES OR

- EQUIPMENT OPTIONS
- STERILITY
- FULL WELL TRAINED STAFF PRESENT
- ↓ CHAOS AND NOISE

Although improved equipment and training have allowed a variety of life-saving procedures to be performed in the prehospital or ED setting, many severely injured patients will require urgent surgical intervention that requires a fully equipped OR. Despite the nature and severity of injuries
The first report of immediate transport to the OR was by Griswold and Drye in 1953.

A decade of experience with a selective policy for direct to operating room trauma resuscitations

Matthew Martin, M.D.*, Seth Izenberg, M.D., Frederick Cole, M.D., Sue Bergstrom, R.N., William Long, M.D.

Impacts patient outcomes. There is no level 1 evidence supporting an outcome benefit associated with DOR programs. However, multiple retrospective studies and expert opinions have concluded that there likely is a benefit in terms of survival and major morbidity.\(^3,8-10,17\) The exact triage criteria remains an area of debate, but most of the published experience agrees that high-yield populations include penetrating trauma, blunt thoracoabdominal trauma with hypotension, and major extremity trauma.\(^3,8,9\) Our study results found that the survival among the DOR cohort was significantly better than predicted (by TRISS), with an overall 50% reduction from expected to observed mortality.

1978 Fischer
1989 Rhodes
1997 Steele

Overage time to incision for all patients was 38.4' compared to 99.4' in the group resuscitated in the trauma bay.
Impact of urgent resuscitative surgery for life-threatening torso trauma

Hisashi Matsumoto1,2 · Yoshiaki Hara1,2 · Takanori Yagi1,2 · Nobuyuki Saito1,2 · Kazuki Mashiko1,2 · Hiroaki Iida1,2 · Tomokazu Motomura1,2 · Fumihiko Nakayama1,2 · Kazuhiro Okada1,2 · Hiroshi Yasumatsu1,2 · Taigo Sakamoto1,2 · Takao Seo1,2 · Yusuke Konda1,2 · You Hattori1,2 · Hiroyuki Yokota2

Fig. 1 Observed survival rates in each Trauma and Injury Severity Score (TRISS) category: ≥0.95 (n = 103), ≥0.9 (n = 28), ≥0.7 (n = 40), ≥0.5 (n = 18), ≥0.25 (n = 27), and <0.25 (n = 48)

- Observed survival
- Predicted survival by TRISS

# p=0.012, ## p=0.011
Clinical Science

A decade of experience with a selective policy for direct to operating room trauma resuscitations

Matthew Martin, M.D.*, Seth Izenberg, M.D., Frederick Cole, M.D., Sue Bergstrom, R.N., William Long, M.D.

Figure 3  Comparison of actual mortality rates with predicted mortality based on TRISS methodology. *P < .05.
Direct to operating room trauma resuscitation decreases mortality among severely injured children

Minna M. Wieck, MD, Aaron J. Cunningham, MD, Brandon Behrens, MD, Erika T. Ohm, Bryan G. Maxwell, MD, MPH, Nicholas A. Hamilton, MD, M. Christopher Adams, MD, Frederick J. Cole, Jr., MD, and Mubeen A. Jafri, MD. Portland, Oregon

<table>
<thead>
<tr>
<th>Table 1. Indications for DOR Admission (n = 82)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>Chest injury</td>
</tr>
<tr>
<td>Rigid, distended abdomen</td>
</tr>
<tr>
<td>Evisceration of abdominal contents</td>
</tr>
<tr>
<td>Penetrating injury, including impaled object, in neck, chest, abdomen, or pelvis</td>
</tr>
<tr>
<td>Traumatic amputations</td>
</tr>
<tr>
<td>Age-specific hypotension as defined by pediatric ATLS criteria</td>
</tr>
<tr>
<td>Significant blood loss on scene or en route</td>
</tr>
<tr>
<td>Cardiopulmonary arrest due to trauma</td>
</tr>
<tr>
<td>Physician discretion</td>
</tr>
</tbody>
</table>

![Graph showing mortality comparison](image)

**Figure 1.** Observed vs expected mortality by mechanism (*p < 0.01*).

For the most severely injured children, a selective policy of resuscitation in the OR can decrease mortality, particularly for those with penetrating trauma. Patients with the highest
Trauma Timeline

- Trauma
- PreH
- ED
- OR
- ICU
- ANGIO
- HYBRID-OR
- ICU
- ANGIO
CRITERIA FOR DIRECT TRANSPORT TO THE OPERATING ROOM

- Blunt thoracic/abdominal trauma with hypotension and FAST +
- Penetrating trauma with hypotension
- Major external hemorrhage/traumatic amputation of a limb
- Thoracic trauma cardiac periarrest/arrest
- Direct injury to neck with airway compromise

Trauma is a time-sensitive disease
Case report 2017

M 45y
Thoracic abdominal trauma

- SpO2 ? Left surgical emphysema
- BP 60/40, HR 150
- GCS 7 1-2-4

- RSI e OTI Ketamina + Rocuronio
- Minithoracotomy left
- E-FAST +++ abdomen
- Crystalloid 500 cc
- Tranex 1 gr

- Hypotension
- Take-off
- DOR

23’
Time on scene

11’
Time flight

10’
Time helipad to laparotomy
Case report 2017

- Splenectomy
- Liver Packing
- Atypical lung lobar resection

- RBC 7 UI
- Plasma 1800 CC
- Fibrinogen 2 gr → ROTEM + 2 gr
- Crystalloid 1000 cc
- T° 35,5 BP 95/52

CT

OR

BE -8,9
Ac Latt 5,1

70’

25’

CT TOTAL BODY

2h35’

IN ICU

CT total body

4 H
BP 130/80
BE -0,8, Ac Latt 1,7

TOT. RBC 7UI, Plasma 1800

CRISTALLOIDI 1500
CONCLUSION

• Prompt identification of injuries and hemorrhage control is critical in the management of severe trauma patients

• Triage directly to the OR speeds the time to incision and hemorrhage control

• Ongoing research is need to continue to define the ideal patients and injury patterns that will gain the most benefit from OR resuscitation

• Advanced in endovascular hemorrhage control techniques and the use of hybrid trauma operating room may further improve the benefit of OR resuscitation
With a clear strategy and robust support, we can greatly increase the chances not only that the injured survive, but that survivors have an opportunity to resume meaningful lives.