Cardiac Arrest due to Trauma

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University of Queensland & ADF Joint Health Command
Director of Clinical Services, 2nd General Health Battalion
Queensland data 2000-2012

Number (& %) of total (42,677) pre-hospital cardiac arrests, by aetiology.

Trauma was the second commonest aetiology of cardiac arrest.
Can bystanders help?

Prehospital deaths from trauma: Are injuries survivable and do bystanders help?

GJ Oliver*, DP Walter, AD Redmond

Breakdown of those DAS and DOA with a probability of survival in potentially preventable or preventable ranges.

<table>
<thead>
<tr>
<th></th>
<th>Cheshire (134)</th>
<th>Manchester (44)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAS (58, 43%)</td>
<td>DOA (14, 10%)</td>
</tr>
<tr>
<td></td>
<td>Ps 25–50%</td>
<td>Ps &gt;50%</td>
</tr>
<tr>
<td>N</td>
<td>18/58</td>
<td>13/58</td>
</tr>
<tr>
<td>Male</td>
<td>16/18</td>
<td>10/13</td>
</tr>
<tr>
<td>Average Age</td>
<td>44</td>
<td>54</td>
</tr>
<tr>
<td>Bystander present</td>
<td>16/18</td>
<td>13/13</td>
</tr>
<tr>
<td>immediately or within</td>
<td></td>
<td></td>
</tr>
<tr>
<td>minutes of injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call for assistance</td>
<td>18/18</td>
<td>13/13</td>
</tr>
<tr>
<td>made by bystander/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>those involved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Aid attempted</td>
<td>7/18</td>
<td>6/13</td>
</tr>
<tr>
<td>Traumatic Brain Injury</td>
<td>14/18</td>
<td>7/13</td>
</tr>
<tr>
<td>Dominating type of</td>
<td>17/18</td>
<td>12/13</td>
</tr>
<tr>
<td>injury: Blunt</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusions: A high number of prehospital deaths from trauma occur with injuries that are potentially survivable, yet first aid intervention is infrequent. Following injury there is a potential window of opportunity for the provision of bystander assistance, particularly in the context of head injury, for simple first-aid manoeuvres to save lives.
US Civilian Guidelines

1. Resuscitation efforts may be withheld in any blunt trauma patient who, based on out-of-hospital personnel’s thorough primary patient assessment, is found apneic, pulseless, and without organized ECG activity upon the arrival of EMS at the scene.

2. Victims of penetrating trauma found apneic and pulseless by EMS, based on their patient assessment, should be rapidly assessed for the presence of other signs of life, such as pupillary reflexes, spontaneous movement, or organized ECG activity. If any of these signs are present, the patient should have resuscitation performed and be transported to the nearest emergency department or trauma center. If these signs of life are absent, resuscitation efforts may be withheld.
Guidelines – questions...

Outcomes following military traumatic cardiorespiratory arrest: A prospective observational study

Nicholas T. Tarmey, Claire L. Park, Oliver J. Bartels, Thomas C. Konig, Peter F. Mahoney, Adrian J. Mellor

Resuscitation 82 (2011) 1194–1197

Camp Bastion, NOV 09 – JUN 10:
52 patients in traumatic cardiac arrest:
• 14 attained ROSC (27%)
• 4 survived to discharge (8%)

Resuscitative thoracotomy following wartime injury

Jonathan J. Morrison, MRCS, Henrietta Poon, MRCS, Todd E. Rasmussen, MD, Mansoor A. Khan, FRCR, Mark J. Midwinter, MR, FRCS, Lorne H. Blackbourne, MD, and Jeffery P. Garner, MD, FRCS, Rotterham, United Kingdom

J Trauma Acute Care Surg
Volume 74, Number 3

Camp Bastion, 2006 – 2011:
65 patients who underwent resuscitative thoracotomy
• 14 survivors (21.5%)
Long-term outcomes following traumatic out-of-hospital cardiac arrest

B Beck,1 JE Bray,2 P Cameron,13 E Andrew,4 S Bernard,1,4 K Smith1,4,5

VACAR 2008-2014: 168 TCA transported to hospital; 124 with full data available

18/124 (15%) survived to hospital discharge
10/124 (8%) discharged home

Of 15 patients at 12 months:
2 had died
10 had moderate / good functional outcomes (10/124 = 8%)
8 were living at home without additional care

Conclusions
While survival rates in traumatic OHCA are low, patients can have good functional outcomes, demonstrating that the resuscitation of these patients is not futile.
Guidelines – questions...

BUT:

Traumatic cardiac arrest: Should advanced life support be initiated?

Carmen Camacho Leis, MD, Consuelo Canencia Hernández, MD, Ma José García-Ochoa Blanco, MD,
and Paloma Covadonga Rey Paterna, RN, Ramón de Elías Hernández, MD,
and Ervigo Corral Torres, MD, Madrid, Spain

Spanish registry 2006 – 2009:

49% ROSC
6.6% complete neurological recovery

TABLE 2. Comparison Between This Series and Others Already Published

<table>
<thead>
<tr>
<th>Study</th>
<th>ROSC Rate</th>
<th>Survival to Discharge</th>
<th>CNR Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMUR (167 patients)</td>
<td>49.1%</td>
<td></td>
<td>6.59%</td>
</tr>
<tr>
<td>Faucher et al.² (2009) (129 patients)</td>
<td>24.8%</td>
<td>0.77% (per year)</td>
<td>1.6%</td>
</tr>
<tr>
<td>RESUSCITATION (2010)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willis et al.³ (2006) (89 patients)</td>
<td></td>
<td>4.49%</td>
<td></td>
</tr>
<tr>
<td>Cera et al.⁴ (2003) (161 patients)</td>
<td></td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Shimazu and Shatney⁵ (1983) (267 patients)</td>
<td></td>
<td></td>
<td>1.5%</td>
</tr>
</tbody>
</table>

The exclusion criteria were patients who initially received ALS but, in less than 10 minutes, had the ALS terminated because specific criteria were met for withholding the ALS (lethal lesions).
Professor of Trauma Karim Brohi argues that in any traumatic cardiac arrest, secondary to blunt or penetrating trauma, cardiopulmonary resuscitation not beneficial. His rationale is that there is no role for chest compressions, and that they may cause harm, in haemorrhagic shock, tamponade or tension pneumothorax where preload is diminished, and that these patients benefit from fluids, bilateral thoracostomies and US to exclude tamponade, followed by ED thoracotomy if no cause is identified, with the presumption that opening the thorax will permit haemorrhage control from distal vessel (aortic) compression.

http://stemlynsblog.org/traumatic-cardiac-arrest/
TRAUMATIC cardiac arrest is DIFFERENT

Ernest E Moore · University of Colorado
I would not do external massage, but open chest / clamp descending thoracic aorta/ open pericardium while ET intubation is being done. Others would argue REBOA is warranted because of dismal prognosis.

Patricio Cortés Picazo · SAMU/EMS-Clinica Alemana(ER), Santiago, CHILE
Chest compressions in TCA theoretically no good if there are multiple rib fractures and / or "empty heart"

Jason E Smith · Plymouth Hospitals NHS Trust
Thank you all. The international perspective is interesting. There is a growing school of thought in the UK that we should de-emphasise chest compressions and focus on the reversible causes of traumatic cardiac arrest (hypoxia, hypovolaemia, tension pneumoTx, cardiac tamponade) as the priority. In particular, those patients with haemorrhage as the primary pathophysiology underlying their cardiac arrest may be potentially amenable to damage control (haemostatic) resuscitation.

Notably ... ATLS / EMST does not teach CPR
**ERC Guidelines**

European Resuscitation Council Guidelines for Resuscitation 2015  
Section 4. Cardiac arrest in special circumstances  
Anastasios Tzibakis, Charles E. Douketis, Jean-Beat Stover, Gamal El-Hin Alkhadder,  
Antonio Alleza, John J.M. Begier, Gert R. Reubres, Hermann Brugger,  
Jord Durevall, Shigeyuki Ando, Anis, Randolph W. Koster, David J. Luecke,  
Corina Litt, Peter Paul, Gavin D. Perkins, (Guilherme Samuels, Karl-Christian Tiers,  
David A. Johnston, Jeremy J. Nolan**, on behalf of the Cardiac arrest in special  
circumstances section Collaborators

**Effectiveness of chest compressions.** Chest compressions are still the standard of care in patients with cardiac arrest, irrespective of aetiology. In cardiac arrest caused by hypovolaemia, cardiac tamponade or tension pneumothorax, chest compressions are unlikely to be as effective as in normovolaemic cardiac arrest. Because of this fact, chest compressions take a lower priority than the immediate treatment of reversible causes, e.g., thoracotomy, controlling haemorrhage, etc., in an out-of-hospital setting.

Conventional CPR accorded same priority
One Response to *New Traumatic Cardiac Arrest Guideline*

Carl Gwinnutt says:

December 9, 2015 at 20:27

I was interested in your comments on the new ERC TCA algorithm. Whilst welcoming the written guidelines, I feel the algorithm is dangerously flawed. Algorithms are designed to lead an individual or team through a sequential series of actions, without omission, before proceeding. The ALS algorithm possibly being the most well known in medical practice; each step is completed in turn and it would be foolish to omit a step e.g. defibrillation. In the TCA algorithm, taking this approach could lead to inexperienced practitioners ‘controlling the airway’ and (even worse) performing bilateral chest decompression unnecessarily, as these actions are embedded with the algorithm.

For these and other reasons, the Resuscitation Council (UK) will not be using this algorithm and have produced one which we feel is in keeping with standard algorithm construction to ensure safe practice. This can be found on the RC (UK) website (www.resus.org.uk).
UK Guidelines

Prioritises conventional CPR

Early thoracotomy before more simple measures in penetrating trauma
In theory ...

- **Haemorrhage control** should be the first priority
- **Fluid resuscitation** MUST become beneficial at some point (but what is that point???)
- **Decompressing the chest** in cardiac arrest: “what’s the worst that can happen?”
- **Cardiac compressions** in an exsanguinated patient are **useless**
- **Airway patency** is important ... but doesn’t always require an endotracheal tube
- **A resuscitative thoracotomy** can relieve tamponade, control intrathoracic haemorrhage, facilitate cardiac compressions and defibrillation, & allow cross-clamping of the descending aorta.
In adult patients with cardiac arrest due to blunt or penetrating trauma (P), does any intervention (I) as opposed to no intervention (C) affect survival (O)?

Interventions examined: CPR, chest tube/drain, open thoracotomy, IV fluids, adrenaline, first aid, intravenous access and intraosseous access.
ARC Systematic review

Studies identified searching reference lists
N=2

Titles and abstracts identified and screened
N=2,540

Excluded
N=2,356

Full copies retrieved and assessed for eligibility
N=184

Excluded
N=155
- Non-traumatic (n=)
- Comment or opinion (n=)
- Review article (n=)
- Guideline (n=)
- Full article not available (n=)
- Single case report (n=)

Publications included in review
N=29

Publications included in review
N=29
<table>
<thead>
<tr>
<th>No.</th>
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<th>Study design</th>
<th>Intervention</th>
<th>Description</th>
<th>Evidence rating*</th>
<th>Study Outcome</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alanezi et al. 2004</td>
<td>Retrospective, case series N=50</td>
<td>CPR</td>
<td>Adult (&gt;16yo) trauma patients who required CPR pre-hospital or &lt;24hrs after admission due to cardiac arrest</td>
<td>IV/D</td>
<td>0% survival</td>
<td>All patients requiring pre-hospital CPR died, overall mortality 48/50 (96%), 58% male, 92% blunt trauma, mean age 45yo, mean ISS 38 (+/- 18)</td>
</tr>
<tr>
<td>2</td>
<td>Battistella et al. 1999</td>
<td>Retrospective, case series N=604</td>
<td>CPR</td>
<td>Pre-hospital CPR on (n=300) penetrating or (n=304) blunt trauma. Mean CPR time was 22 +/- 11 minutes. 50% also underwent ED thoracotomy (does not separate groups)</td>
<td>IV/D</td>
<td>2.6% survival</td>
<td>4% for penetrating trauma (3% with good neuro outcomes), 1.3% for blunt trauma (0% with good neuro outcomes)</td>
</tr>
<tr>
<td>3</td>
<td>Mattox KL and Feliciano DV 1982</td>
<td>Retrospective, case series N=100</td>
<td>CPR</td>
<td>External cardiac compressions on cases of arrest secondary to blunt or penetrating truncal trauma (CPR&gt;3mins pre-hospital)</td>
<td>IV/D</td>
<td>0% survival</td>
<td>Major cardiovascular damage on autopsy including air embolus in coronary arteries from forced ventilation (on autopsy). ECC was developed for non-TCAs and is not of value in truncal trauma</td>
</tr>
<tr>
<td>4</td>
<td>Mollberg et al. 2011</td>
<td>Retrospective, case series N=294</td>
<td>CPR</td>
<td>Review of cases which breached ASCOT guidelines to terminate resuscitation. All had CPR, 25% had ED Thoracotomy (no breakdown of survival by thoracotomy).</td>
<td>IV/D</td>
<td>0.3% survival (0% full neurological recovery)</td>
<td>Thoracotomy in 25.2%</td>
</tr>
<tr>
<td>5</td>
<td>Rosemurgy et al. 1993</td>
<td>Retrospective, case series N=138</td>
<td>CPR</td>
<td>Pre-hospital TCA patients receiving CPR prior to admission. Describes cost:benefit of resuscitation</td>
<td>IV/D</td>
<td>0% survival</td>
<td>70% blunt, 30% penetrating, states resuscitation in this patient cohort is futile and costly</td>
</tr>
<tr>
<td>6</td>
<td>Willis et al. 2006</td>
<td>Retrospective, case series N=89</td>
<td>CPR</td>
<td>Pre-hospital CPR by paramedics in TCA, blunt (80%) or penetrating (20%)</td>
<td>IV/D</td>
<td>4.5% survival</td>
<td>97% mortality rate for blunt trauma, 89% mortality rate for penetrating trauma</td>
</tr>
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**ARC Systematic review**

**CPR is essentially ineffective**
## Prehospital tube / finger thoracostomy is effective

**ARC Systematic review**

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<tbody>
<tr>
<td>22</td>
<td>Huber-Wagner et al. 2007</td>
<td>Retrospective case series N=176</td>
<td>Chest decompression</td>
<td>Pre-hospital chest tube insertion following pre-hospital TCA. 5.7% of patients had tension pneumothorax, 23.2% had chest drain inserted</td>
<td>OR 0.3 (95%CI 0.13-0.8)</td>
<td>ROSC</td>
<td>Placement of bilateral chest tubes if any suspicion of thoracic trauma increases survival OR 0.3 (95%CI 0.13-0.8) p=0.013 in logistic regression.</td>
</tr>
<tr>
<td>28</td>
<td>Mistry et al. 2009</td>
<td>Retrospective case series N=18</td>
<td>Chest decompression</td>
<td>Pre-hospital thoracostomy (1 case of needle decompression), on clinical suspicion (all cases confirmed pathology e.g. pneumothorax or haemothorax), HEMS</td>
<td>22% ROSC</td>
<td>3/17 thoracostomies achieved ROSC, 1/1 needle decompression achieved ROSC, doctor on-board made no difference to outcome, but was more likely to perform intervention. If clinical signs then positive predictive value (PPV) of performing decompression is 1, if no signs present and performed due to mechanism of injury PPV=0</td>
<td></td>
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</table>
Thoracotomy (incl. prehospital) is effective in selected patients

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Athanasiou et al. 2004</td>
<td>Retrospective, case series N=53</td>
<td>Thoracotomy</td>
<td>Prehospital (31) and ED (7) thoracotomies by HEMS, remaining 15 were performed in OR, all traumatic arrests</td>
<td>N/D</td>
<td>18.8% survival</td>
<td>Improved survival in those performed in hospital as opposed to pre-hospital. Significant association between mortality and ISS, but no association between mortality and time variables (time on-scene, stay on scene time), no difference between specialist or grade.</td>
</tr>
<tr>
<td>8</td>
<td>Baker et al. 1980</td>
<td>Retrospective, case series N=168</td>
<td>Thoracotomy</td>
<td>ED Thoracotomy in trauma (111 cases no vitals or agonal)</td>
<td>N/D</td>
<td>19.6% survival</td>
<td>Cost : benefit (5:12), initially n=175, 7 excluded (non-traumatic arrest)</td>
</tr>
<tr>
<td>9</td>
<td>Brenney et al. 1998</td>
<td>Retrospective, case series N= 708</td>
<td>Thoracotomy</td>
<td>ED Thoracotomy for TCA (624 prehospital and 84 in ED). Study also includes another 160 patients with vital signs (EDT done for shocked trauma patient)</td>
<td>N/D</td>
<td>2% survival</td>
<td>14 survivors (2%) from group without vital signs prehospital or lost in ED (798). Overall 868 patients with 4.4% survival (3.9% neurologically intact). Compares survivor with non-survivors.</td>
</tr>
<tr>
<td>10</td>
<td>Brown SE et al. 1996</td>
<td>Retrospective, case series N=160</td>
<td>Thoracotomy</td>
<td>ED Thoracotomy for penetrating trauma, Class I-II patients (no vitals or agonal) vs Class III-IV (shocked)</td>
<td>N/D</td>
<td>0% survival</td>
<td>89% of patients were Class I-II (arrests) - 0% of this group survived</td>
</tr>
<tr>
<td>11</td>
<td>Coats et al. 2001</td>
<td>Retrospective, case series N=39</td>
<td>Thoracotomy</td>
<td>Prehospital Thoracotomy by HEMS</td>
<td>N/D</td>
<td>10% survival -75% full neurological recovery</td>
<td>If &gt;10mins from ER survival is unlikely</td>
</tr>
<tr>
<td>12</td>
<td>Danne et al. 1984</td>
<td>Retrospective, case series N=89</td>
<td>Thoracotomy</td>
<td>ED Thoracotomy for arrest, profound shock, tamponade or cardiac massage (85% of patients pulseless)</td>
<td>N/D</td>
<td>17% ROSC -11% survival -90% full neurological recovery</td>
<td>17% of patients were women but contributed to 30% of survivors. Note an increasing trend of survival over time (1980 - 3%, 1981 - 8%, 1982 - 14% survival)</td>
</tr>
<tr>
<td>13</td>
<td>Davies et al. 2011</td>
<td>Retrospective, case series N=71</td>
<td>Thoracotomy</td>
<td>Prehospital thoracotomy for penetrating trauma, in physician led service (HEMS)</td>
<td>N/D</td>
<td>18% survival -80% full neurological recovery</td>
<td>All survivors were in non-shockable rhythms. Witnessed arrests had better outcomes, as did those attended in &lt;5mins</td>
</tr>
<tr>
<td>14</td>
<td>Demetriades et al. 1987</td>
<td>Retrospective, case series N=73</td>
<td>Thoracotomy</td>
<td>ED Thoracotomy, for cardiac arrest secondary to stab wounds to chest and neck. Absence of cardiac function or cardiac arrest in-hospital. Prehospital arrests excluded</td>
<td>N/D</td>
<td>16.4% ROSC 6.8% survival</td>
<td>Recommend that those with no vital signs (no cardiac electrical activity, no respiratory effort or fixed pupils) should not undergo thoracotomy</td>
</tr>
<tr>
<td>15</td>
<td>Durham et al. 1992</td>
<td>Retrospective, case series N=387</td>
<td>Thoracotomy</td>
<td>ED Thoracotomy for presumed haemorrhage in stab and gunshot victims. 53% of patients with prehospital CPR (this group also made up 53% of survivors)</td>
<td>N/D</td>
<td>8.3% survival</td>
<td>15.2% survival for stab wounds, 7.3% for gunshot wounds. Mean 5.1mins of prehospital CPR (ETT prolonged successful ischaemisation of CPR from 4.2 to 9.4min in survivor group)</td>
</tr>
<tr>
<td>16</td>
<td>Falika et al. 2004</td>
<td>Retrospective, case series N=38</td>
<td>Thoracotomy</td>
<td>ED Thoracotomy for chest or abdominal injury, strict inclusion/exclusion criteria</td>
<td>N/D</td>
<td>10.6% survival</td>
<td>Recommends use of thoracotomy in blunt trunk trauma and haemorrhagic shock (with similar outcome to penetrating trauma) if within 20mins of initiation of external CPR</td>
</tr>
<tr>
<td>17</td>
<td>Flynn et al. 1982</td>
<td>Retrospective, case series N=33</td>
<td>Thoracotomy</td>
<td>ED Thoracotomy for arrest secondary to blunt or penetrating trauma</td>
<td>N/D</td>
<td>12.1% survival</td>
<td>No survivors of trauma below diaphragm (blunt or penetrating)</td>
</tr>
<tr>
<td>18</td>
<td>Gomez et al. 2010</td>
<td>Retrospective, case series N=102</td>
<td>Thoracotomy</td>
<td>ED Thoracotomy for the resuscitation of major trauma, data from 2000-2008 extracted from notes and added to previous data 1995-2000 from same centre.</td>
<td>N/D</td>
<td>7.8% survival (2000-2008)</td>
<td>2.5% survival (1995-2000). Increasing survival over time. 27% had no injuries identified by thoracotomy. Classified by physiological status (Class I-IV, I absent signs of life, II PEA or agonal rhythm, III profound shock, IV mild shock). Increased survival with increasing class. 86 subjects class I/II (arrests) with 2 survivors (2.3%).</td>
</tr>
</tbody>
</table>
Blunt trauma is less amenable to emergency thoracotomy, but survival is still possible
In the minority (7.5%) of patients with shockable rhythms, prehospital AED use did not improve survival.
Aggressive prehospital fluid resuscitation is associated with improved survival

<table>
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<tr>
<td>29</td>
<td>Leis et al, 2013</td>
<td>Retrospective cohort N=167</td>
<td>Multiple, including type of ambulance, ambulance delay, and fluid replacement,</td>
<td>The quantity of fluid replacement prehospital was greater in patients who achieved ROSC than in those who did not (p&lt;0.05)</td>
<td>IV/D</td>
<td>49.1% ROSC; 6.6% complete neuro recovery</td>
<td>Potentially confounded by indication bias</td>
</tr>
</tbody>
</table>
### Adrenaline

**Adrenaline may be beneficial**

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<tbody>
<tr>
<td>1.</td>
<td>Chiang et al., 2015</td>
<td>Retrospective cohort</td>
<td>Adrenaline vs. no adrenaline</td>
<td>Among adult patients with TCA in a metropolitan area, administration of prehospital adrenaline was associated with increased short-term survival (in the 8.4% of cases who received it), especially for those with a longer prehospital time.</td>
<td>IV/D</td>
<td>Adrenaline associated with higher survival to discharge (14.0 % vs. 3.0 %, p &lt; 0.01).</td>
<td>Likely to be biased by the requirement to survive long enough to receive adrenaline</td>
</tr>
</tbody>
</table>
KEEP CALM
AND
DO SOMETHING DIFFERENT
KeepCalmAndPosters.com
Most deaths due to trauma occur in the first five minutes following the traumatic event, and most of

There are, however, three common causes of preventable early death in trauma:

- Airway obstruction
- Tension pneumothorax
- Haemorrhage

Unless there are injuries obviously incompatible with life, attempted resuscitation of patients with cardiac arrest due to trauma is not futile and should be attempted.
Pre-Arrest: Stop the Bleeding

Trauma patients who are able to maintain their circulation may have injuries or wounds that will lead to cardiac arrest if not adequately treated. The first priority in such patients is to **stop the bleeding** using one of the techniques in ANZCOR Guideline 9.1.1 or (in hospital) more advanced interventions such as surgical exploration or interventional radiology. Only after such interventions are commenced should attention be directed to the airway or breathing (Class A, LOE IV), unless there are sufficient people to perform interventions simultaneously.
2 Airway

A patient in cardiac arrest due to trauma should have the airway opened as quickly as possible while not delaying blood volume expansion and relief of possible tension pneumothorax. Chin lift / jaw thrust are preferred techniques but head tilt and / or positioning in the recovery position (likely to be associated with more cervical spine movement) may be required. (Class B, LOE IV).

Direct trauma to the airway may contraindicate usual supraglottic approaches. Therefore, insertion of an endotracheal, tracheostomy or purpose-designed cricothyroidotomy tube through the cricothyroid membrane or trachea may be required. Whether these procedures should take priority over restoration of the circulating blood volume will depend on the likely principal cause of the cardiac arrest or impending arrest.
3 Restoration of Circulating Blood Volume

Intravenous or intraosseous access should be established as rapidly as possible. If peripheral intravenous cannulation can be accomplished prior to cardiac arrest, ideally two cannulae of at least 18G should be inserted (Class A, LOE IV).

Peripheral venous cannulation is likely to be impossible in cardiac arrest due to exsanguination, regardless of whether or not cardiac compressions are being performed. In adults, central venous cannulation may be possible and should be attempted using a Seldinger technique and a short, large-bore catheter (such as a catheter-introducer for a pulmonary artery catheter or a dialysis catheter).

IO access may be more rapidly and reliably achieved than venous access, especially by clinicians inexperienced with central venous catheter insertion, and especially in children.
3 Restoration of Circulating Blood Volume

3.2 Fluid therapy
If hypovolaemia is a possible cause or contributor to traumatic cardiac arrest, an initial (ideally warmed) fluid bolus of 20mL/kg (approximately 1.4L in a 70kg patient) should be given as rapidly as possible (Class B; LOE IV). In exsanguinating haemorrhage, this should be a 1:1 or 1:2 mixture of thawed (Class B; LOE III) thawed fresh-frozen plasma : packed red blood cells.\(^9\)\(^{10}\) Us

If blood products are not available, a crystalloid solution should be used. Blood products should be substituted for crystalloid as soon as possible.

In adults, once spontaneous cardiac output is restored, prior to surgical haemorrhage control and at least for the first hour, further fluid should be titrated either to a systolic blood pressure of 90mmHg (permissive hypotension) or to consciousness. (Class B; LOE IV).\(^1\)
4 Chest Decompression

All patients in cardiac arrest with suspected chest trauma who are not responding to airway opening and restoration of circulating blood volume should have their chest decompressed as described below. (Class B; LOE IV). Resuscitative thoracotomy may be indicated in limited situations.

Finger thoracostomy (initially on the most affected side of the chest) is the preferred method of chest decompression.

An alternative to finger thoracostomy that may allow more rapid chest decompression in some circumstances is insertion of a long, large bore (ideally 8cm, 12- or 14-gauge) cannula into the pleural cavity.
5 Pericardiocentesis

The commonest cause of pericardial tamponade due to trauma is a penetrating injury or wound to the myocardium, which will require surgical intervention via thoracotomy. Urgent bedside echocardiography should be used to identify or exclude pericardial tamponade due to trauma (Class B; LOE IV).

Needle pericardiocentesis is almost never the optimal means of decompressing the pericardium in trauma, as it does not address the commonest cause (myocardial laceration) and because pericardial blood is often clotted, preventing aspiration. However, when no surgeon or other clinician with the required skills and experience is present to surgically manage the patient, needle pericardiocentesis (ideally under ultrasound guidance) can be attempted in a patient who is peri-arrest or in cardiac arrest with a high suspicion of cardiac tamponade (Class B; LOE IV).
6 Resuscitative Thoracotomy

In one case series, resuscitative thoracotomy was successfully performed by adequately trained and experienced prehospital clinicians. However, in general in the Australian and New Zealand civilian context this will remain a hospital intervention performed by a surgeon or a specifically trained and experienced emergency or critical care physician. Whether a clam-shell or anterolateral approach is best will be determined by the pattern of injury or wounding and the available surgical expertise. The decision on proceeding with resuscitative thoracotomy will rest on the mechanism of injury or wounding, whether there is likely to be a surgically-correctable problem given the expertise and resources available, and the duration since the traumatic event and the onset of cardiac arrest. Ideally, hospitals should develop local guidelines relevant to their institution.

As a general guide, cardiac arrest due to penetrating trauma is more likely to respond to emergency thoracotomy than cardiac arrest due to blunt trauma. A favourable outcome is rarely possible (even in penetrating trauma) if resuscitative thoracotomy is initiated more than 10 minutes after the onset of cardiac arrest. (Class A; LOE IV).
7 Special Circumstances

7.1 Crush syndrome
7.2 Direct cardiac trauma resulting in commotio cordis
7.3 Isolated major head injury
8 Conventional Basic and Advanced Life Support

“Burning of the Templars” (for heresy), 1314
8 Conventional Basic and Advanced Life Support

In cardiac arrest due to trauma, all of the interventions aimed at addressing underlying causes take priority over chest compressions, defibrillation and adrenaline. However, if there are sufficient resources available and there is no interference with essential procedures, conventional CPR can occur simultaneously. The effectiveness of conventional CPR will depend on correcting the causes of the cardiac arrest.
8.1 External Chest Compressions

An exsanguinated patient theoretically derives little benefit from external cardiac compressions until blood volume is restored to a minimally sufficient quantity. External chest compressions may exacerbate haemorrhage and cardiac tamponade, and positive pressure ventilation may further reduce critically low venous return or cause air embolism. Several case series demonstrate that external chest compressions are virtually never effective for patients in traumatic cardiac arrest unless the underlying cause of the arrest is simultaneously and rapidly addressed. Conversely, there is no clinical evidence that chest compressions worsen outcome in trauma. Therefore, external chest

In the absence of the requisite equipment or expertise to address the underlying aetiology of cardiac arrest in trauma, first aiders should summon skilled assistance then proceed directly to BLS.
8.2 Adrenaline

ANZCOR does not recommend adrenaline for patients in traumatic cardiac arrest until haemorrhage control, opening the airway, commencement of restoration of circulating blood volume and (if appropriate) decompression of tension pneumothorax have been addressed. (Class A; LOE IV).

Once spontaneous cardiac output is restored, hypotension is usually the result of hypovolaemia and should be treated initially with ongoing volume replacement. (Class B; LOE IV). In the later phases of post-arrest care, vasodilation or myocardial depression may require adrenaline or other vasoactive infusions.
8.3 Defibrillation

Only 7.5% of patients in traumatic cardiac arrest are initially found in VF or VT. Therefore defibrillation is not the priority for the majority of trauma patients in cardiac arrest. ANZCOR suggests not using defibrillation prior to opening the airway, commencement of restoration of circulating blood volume, and (if appropriate) decompression of the chest (Class B; LOE IV). In the
10 Terminating Attempted Resuscitation

There is no consensus on how long resuscitation attempts should continue after cardiac arrest due to trauma. Most case series of traumatic cardiac arrests do not report informative time data. Restoration of a circulating blood volume sufficient to sustain spontaneous circulation may take several minutes, depending on the equipment and venous access available. In the absence of data, ANZCOR recommends continuation of BLS or ALS (including external cardiac compressions) for up to 10 minutes after these potentially reversible causes have been addressed, following which resuscitation attempts should be stopped if there is no ROSC. (Class A; LOE IV).
Life-threatening trauma

Obvious non-reversable cause. E.g. total body disruption, decapitation

Stop bleeding
Open airway
Decompress chest & assist breathing if necessary
IV or IO access; fluid resuscitation to goal SBP=90mmHg or consciousness
Early damage control surgery

Traumatic cardiac arrest

Summon assistance if required. Consider ‘medical’ causes (e.g. myocardial infarction precipitating minor trauma) & if likely, manage according to conventional guidelines with consideration of the points below.

- Open airway and protect cervical spine.
  Consider airway devices e.g. endotracheal intubation; supraglottic airway
  
  Yes
  
  No

  ROSC?

  IV or IO access
  20mL/kg IV plasma/colloid replacement
  Further 5-10mL/kg fluid boluses if indicated

  Yes
  
  No

  ROSC?

  Control likely sites of haemorrhage (direct pressure, tamponade)

- Decompress chest: finger or needle thoracotomy
  followed by insertion of intercostal catheter

  Yes
  
  No

  ROSC?

- Ultrasound (if available) to assess pericardial tamponade. Resuscitative thoracotomy if tamponade identified (or if ultrasound unavailable, likely given the known mechanism). Consider needle pericardiocentesis only if surgical intervention is not possible.

  Yes
  
  No

  ROSC?

- Consider resuscitative thoracotomy to clamp descending aorta, control thoracic haemorrhage, relieve cardiac tamponade, and facilitate internal cardiac compressions and internal defibrillation

  Yes
  
  No

  ROSC?

- Conventional BLS, ALS or internal cardiac compressions for 1 minute after all reversible causes have been addressed. BLS / ALS can occur simultaneously with the above interventions if this does not interfere with their application and there are sufficient people available.

  Yes
  
  No

- ROSC

- No ROSC

Cessate resuscitation

* These interventions are prioritised according to the likely aetiology of the cardiac arrest, and if indicated are ideally addressed simultaneously by a multi-disciplinary team.
• Attempted resuscitation is not futile
• Pre-arrest: first priority is to stop bleeding
• Open the airway using a simple manoeuvre
• Restore the circulating blood volume (CVC, peripheral IV or IO) with 20ml/kg fluid (blood components or, if necessary, initially crystalloid)
• Once ROSC is attained, target SBP 90mmHg for the first hour until surgical haemorrhage control
• Finger thoracostomy better than needle decompression
• Surgical relief of pericardial tamponade NOT needle pericardiocentesis (if at all possible)
• Consider resuscitative thoracotomy if within 10mins of cardiac arrest (esp. in penetrating trauma)
• Deprioritise conventional CPR (chest compressions, defibrillation and adrenaline)
• >10 minutes CPR after addressing bleeding / blood volume / airway / tension PTx (to the degree possible) is almost universally fatal
The future?

- Better non-blood resuscitation fluids
- Absence of benefit / potential for harm in chest compressions in an empty heart
- Emergency echocardiography to determine when the heart is sufficiently full, and to exclude tamponade
- De-emphasising open chest compressions

Open chest cardiac massage offers no benefit over closed chest compressions in patients with traumatic cardiac arrest

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- REBOA as an alternative to emergency thoracotomy in some circumstances

no significant improvement in ET\textsubscript{CO}_2 or ROSC with OCCM.
Conclusion
The Defence Chair of Military Medicine and Surgery:
a collaboration between the Australian Defence Force and The University of Queensland

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