



Case Report

Two cases of penetrating left ventricular cardiac trauma: Pre-hospital ultrasound and direct to theatre[☆]

Paul Hanley^{a,b,*}, Joshua Holden^a, Tamara Johnson^c, Alan Garner^a, Andrew Weatherall^a

^a CareFlight Rapid Response Helicopter (CRRH), CareFlight, Locked Bag 2002, Wentworthville, NSW 2145, Australia

^b Royal Australian Army Medical Corps (RAAMC), Randwick Barracks, NSW 2032, Australia

^c Western Sydney University School of Medicine, Locked Bag 1797, Penrith, NSW 2751, Australia

ARTICLE INFO

Keywords:

Left ventricle
Penetrating trauma
Trauma
Pre-hospital
Ultrasound

ABSTRACT

Left ventricular (LV) Cardiac penetrating trauma is a rare and grave injury.

In cases of penetrating cardiac trauma, pre-hospital Ultrasound by flight doctors can assist identify specific pathology. This pre-hospital triage has now been linked to a change in both pre-hospital and in-hospital management.

There are minimal cases reported where Pre-Hospital ultrasound provided definitive diagnosis and, while providing Pre-Hospital blood transfusion, informed a direct to theatre approach. In 2017 in New South Wales, Australia, a new protocol “Code Crimson” has been introduced to formalise a system wide process where Pre-Hospital medical teams can expedite a straight to Theatre approach.

Case presentations

Case 1

A 28-year-old otherwise healthy male sustained two stab wounds to the right chest. The Care Flight Rapid Response Helicopter (CRRH) staffed by a retrieval physician and advanced care paramedic was airborne 3 min after notification. The Team was at the patient 21 min later. At initial assessment the patient was pale and diaphoretic. A systolic blood pressure (BP) of 70 mmHg, heart rate (HR) 136, respiratory rate (RR) of 30, SpO₂ of 100% on room air and Glasgow coma scale (GCS) of 14.

Intravenous (IV) access obtained. The physician performed an extended focused assessment with sonography for trauma (EFAST). A large pericardial effusion was observed with features of tamponade including right ventricular systolic collapse, right atrial diastolic collapse and a distended inferior vena cava (IVC). A decision was made to transport immediately by air (see also Fig. 1).

The team departed with patient 17 min after arrival. 1 unit of red cell concentrate (RCC) and 500 mL of crystalloid were administered. The receiving Major Trauma Centre was advised of the EFAST findings. The receiving Cardiothoracic Service and Operating Theatre (OT) were prepared for patient arrival. The local Massive Transfusion Protocol (MTP) was activated. During flight a further 120 mL RCC was transfused and the patient received 1 g of IV Tranexamic Acid (TXA).

After a 20 min flight the patient was met on the helipad by the Trauma Team Leader and transported directly to the OT. He

[☆] This work has not been presented wholly or in part at any meeting.

* Corresponding author at: CareFlight, Locked Bag 2002, Wentworthville, NSW 2145, Australia.

E-mail addresses: paul.hanley@careflight.org (P. Hanley), joshua.holden@careflight.org (J. Holden), alan.garner@careflight.org (A. Garner), andrew.weatherall@careflight.org (A. Weatherall).

<https://doi.org/10.1016/j.tcr.2019.100189>

Accepted 7 April 2019

Available online 13 April 2019

2352-6440/ © 2019 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).



Fig. 1. Careflight Rapid Response Helicopter (CRRH) Service Helicopters over Sydney Harbour, Sydney, Australia. The second Helicopter in the image was flown on both missions.
A Model BK 117 Helicopter, Call sign VH-IME
Photography credits Mr. Paul Sadler c/o CRRH.

arrived in theatre 37 min after patient contact with Retrieval team from a distance of 84 km by direct flight. Emergency Sternotomy and mini thoracotomy revealed a left lower chest wound penetrating the chest wall with entry into the LV myocardium and a five-millimetre wound lateral and distal to the Left Anterior Descending Coronary Artery with active bleeding. There was also a 500 mL haemothorax in the left thoracic cavity. These injuries were surgically repaired. The patient was extubated immediately post operatively, discharged from intensive care the following day, and made a full recovery.

Case 2

A 52-year-old otherwise healthy male received two stab wounds to the chest and a laceration to his left wrist. The CRRH was airborne three minutes after tasking and arrived at the patient 29 min later. A road EMS crew had already obtained IV access, performed needle decompression of the left hemi thorax and administered oxygen after finding the patient was agitated with SpO₂ of 80%. Upon arrival of the CRRH team, the patient had SpO₂ of 99% on 15 l via non-rebreather mask, a systolic BP of 82 mmHg, HR of 115, RR of 15, and GCS of 10.

The physician performed an EFAST, identifying a large pericardial effusion with features of tamponade and a large left haemopneumothorax. 1 unit RCC and 500 mL of compound sodium lactate were infused, followed by rapid sequence intubation (RSI), left thoracostomy and pleural drain insertion.

After 30 min on scene, the retrieval team transferred the patient, administering TXA 1 g in flight, three units of RCC and a further 1000 mL of compound sodium lactate to maintain systolic BP between 70 and 80 mmHg. Flight time was 16 min to travel 75 km. The hospital was notified of EFAST findings and patient condition during flight and Cardiothoracic Surgery team and the OT were activated. The retrieval team was met on the helipad by the Trauma Team with a further 2 units RCC. The patient proceeded directly to the OT and arrived there 66 min following initial patient contact. See Fig. 2.

At left thoracotomy a profusely bleeding left internal mammary artery was revealed. The patient had a laceration to the left lower lobe of the lung that went through pericardium and penetrated the left ventricle. The patient remained intubated post operatively and underwent surgery the following day for removal of thoracic packs and definitive closure of his chest. He was extubated 2 days after injury, discharged from ICU a day later, and made a full recovery. See Table 1.

Discussion

The state of New South Wales (NSW) in Australia has an area of 800,000 km². This is approximately three times larger than the entire United Kingdom and twice as large as Germany. It is often challenging to minimise time to transport trauma patients to definitive medical interventions. The ability of Pre-Hospital Medical teams to obtain diagnoses, exercise high level clinical decision-making and notify Hospital services before arrival at Hospital can provide these patients with time critical care (See Fig. 3).



Fig. 2. Intraoperative photograph of case 2 patient on the operating table.
Photography credits Dr. Joshua Holden (CRRH).

We present two cases with isolated penetrating stab injuries to the chest that penetrated the Left Ventricle. Both injuries occurred remote from the nearest trauma centre and both resulted in cardiac tamponade. Both with prolonged time to definitive care and a poor prognosis [1].

Diagnosis of pathology using pre-hospital ultrasound is now being supported by the literature [2,3]. These patients received an in-flight red cell concentrate transfusion. Early Pre-Hospital blood transfusion is associated with improved survival [4]. There was Pre-Hospital activation of the Hospital massive transfusion protocol and activation of the Cardiothoracic Surgery team and an Operating Theatre. Each patient was then transferred directly from the helipad to the OT.

In these two cases, a direct transfer from the helicopter to the OT shortened this process even more.

Previously trauma centers in Australia had different approaches for receiving patients like these.

A recently introduced statewide protocol aims to formalise and expedite the process from retrieval, through the emergency

Table 1
Patient treatments in Flight.

Treatment given	Patient 1	Patient 2
O2	Non rebreather mask	Non rebreather mask
IntraVenous access,	15 L	15 L
Intravenous fluids	Yes,	Yes,
Cardiac tamponade on extended focused assessment with sonography in trauma (EFAST)	500 mL Hartmanns	500 mL Hartmanns
Blood transfusion	Yes	Yes
with packed red blood cells (PRBC) unit (1 unit = 300 mL)	Yes 1 unit PRBC + further 120 mL PRBCS.	Yes 1 unit PRBC
Chest decompression	Yes	Yes road crew
	intercostal catheter	left needle decompression, thoracostomy, then left intercostal catheter
Pre hospital intubation	NO	YES
Tranexamic acid	YES 1 GRAM intravenous	YES 1 GRAM intravenous
Prehospital thoracotomy	No	No

department to intervention for patients with non-compressible, life-threatening haemorrhage (Fig. 3). Following a Pre-hospital activation, the protocol standardises Emergency room responses (Fig. 4), Facilitating streamlined surgical decision-making at the receiving hospital.

The importance of time to definitive treatment in trauma patients is documented [5]. This is particularly relevant for hypotensive patients with non-compressible penetrating thoracic injuries, as longer transport times are associated with higher mortality. Minimizing time from injury to OT is a challenge in Australia, where long transport times are common. Pre-hospital ultrasound, pre-hospital transfusions, and a rapid transfer to the Trauma Centre are only of benefit to the patient if this hard won precious time is respected and matched by the processes within the receiving Hospital itself.

Both patients survived neurologically intact this often-fatal injury.

List of abbreviations

NSW ITIM NSW Institute of Trauma and Injury Management

LV	Left Ventricular
OT	Operating Theatre
MTC	Major Trauma Centre
MERT	Medical Emergency Response Team
BP	Blood Pressure
HR	Heart Rate
RR	Respiratory Rate
GCS	Glasgow Coma Scale
EFAST	Extended Focused Assessment with Sonography for Trauma
IVC	Inferior Vena Cava
CRRH	CareFlight Rapid Response Helicopter
MTP	Massive Transfusion Protocol
TXA	Tranexamic acid
IV	Intravenous
RSI	Rapid sequence intubation

Author's contributions

PH and JH collated the patient case information. PH and TJ performed the literature review. PH, TJ and wrote the manuscript and prepared it for publication. AG and AW revised the manuscript prior to submission. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Written informed consent was obtained from the patients for publication of this case report and accompanying images. A copy of

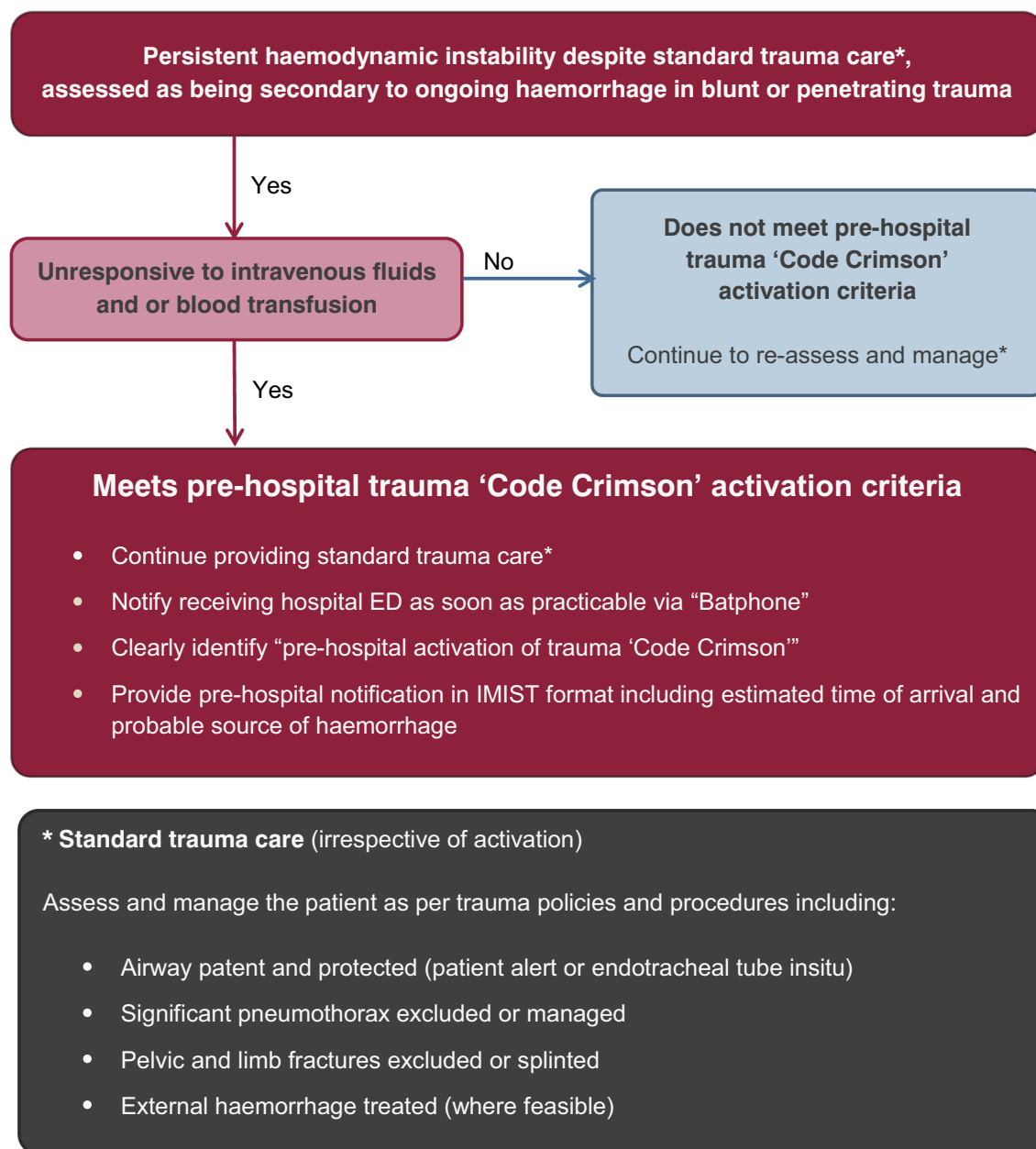


Fig. 3. Activation of code crimson by pre-hospital medical service.

Flow chart of NSW Government policy. Courtesy of ITIM – NSW Institute of Trauma and Injury Management.

the written consent is available for review by the Editor-in-Chief of this Journal.

Availability of data and material

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

Competing interests

The authors declare that they have no competing interests.

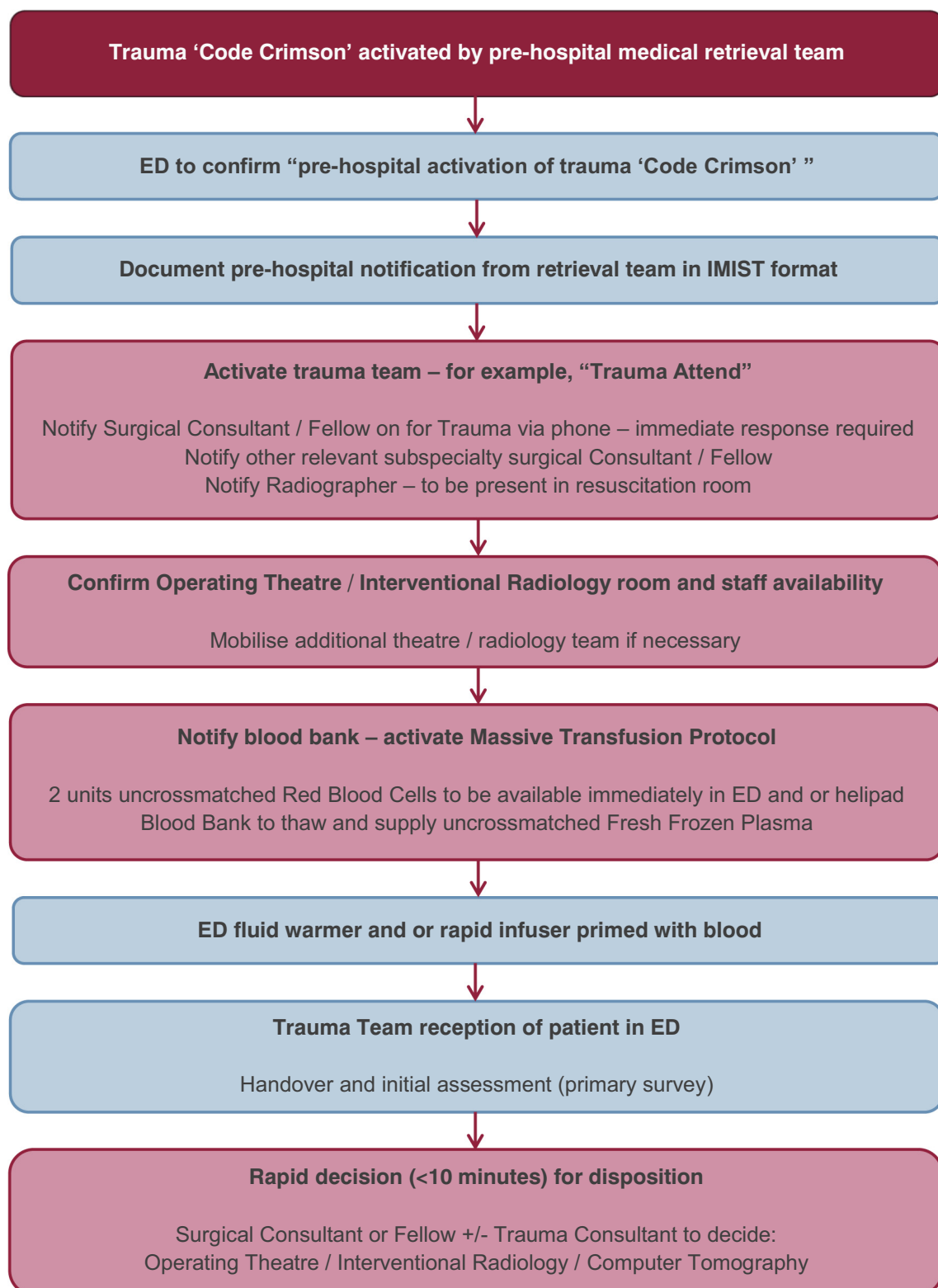


Fig. 4. Code crimson actioned by receiving trauma centre.

Flow chart of NSW Government Policy. Courtesy of ITIM – NSW Institute of Trauma and Injury Management.

Funding

There was no funding for this paper.

Acknowledgements

Not applicable.

References

- [1] M. Bamous, A. Abdessamad, J. Tadili, A. Kettani, M. Faroudy, Evaluation of penetrating cardiac stab wounds, *Scand. J. Trauma Resusc. Emerg. Med.* 24 (2016).
- [2] D. O'Dochartaigh, M. Douma, Prehospital ultrasound of the abdomen and thorax changes trauma patient management: a systematic review, *Injury* 46 (2015) 2093–2102.
- [3] V.S. Tayal, M.A. Beatty, J.A. Marx, C.A. Tomaszewski, M.H. Thomason, FAST (focused assessment with sonography in trauma) accurate for cardiac and intraperitoneal injury in penetrating anterior chest trauma, *J. Ultrasound Med.* 23 (2004) 467–472.
- [4] Kotwal R, Scott L, Janak J, Tarpey B, Howard J, Mazuchowski L, Butler F, Shackelford S, Gurney J, Stockinger Z.: The effect of prehospital transport time, injury severity, and blood transfusion on survival of US military casualties in Iraq. *J. Trauma Acute Care Surg.*: July 2018 – Volume 85 – Issue 1S – pS112-S121.
- [5] M. Swaroop, D.C. Straus, O. Agubuzu, T.J. Esposito, C.R. Schermer, M.L. Crandall, Pre-hospital transport times and survival for hypotensive patients with penetrating thoracic trauma, *J. Emerg. Trauma Shock* 6 (2013) 16–20.