

Activating Code Crimson in the emergency department: Expediting definitive care for trauma patients with severe haemorrhage in Singapore

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ABSTRACT

“Trauma activation” is a process adopted across all emergency departments of public healthcare institutions in Singapore, with the aim of rapidly mobilising personnel and resources to care for patients with major trauma. A subset of trauma patients with exsanguinating haemorrhage has a particularly high mortality rate, and they require an additional response beyond the usual trauma activation for definitive haemorrhage control. To address this need, Code Crimson has been developed at Auckland City Hospital in New Zealand and other jurisdictions as a step-up response. This is aimed at early activation of the massive transfusion protocol for haemostatic resuscitation, involvement of additional multidisciplinary teams for rapid decision-making, and expediting definitive haemorrhage control. At present, there is no protocol for activation of Code Crimson in Singapore. Code Crimson may be effective in Singapore, as it has been in other jurisdictions, to reduce morbidity and mortality in major trauma patients with severe haemorrhage.

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Public healthcare institutions (PHIs) in Singapore have a range of policies and guidelines for the management of patients presenting to the emergency department (ED) with blunt or penetrating major trauma. “Trauma team activation” is initiated by the ED specialist through the hospital call-centre, and is a process that mobilises key personnel (ED specialist, doctor and nurses; as well as surgical registrar, orthopaedics registrar, diagnostic radiology doctor and radiographer) who are initially required for assessment and management of these patients. This activation is based on predefined criteria that include an initial assessment of the mechanism of injury, anatomical injuries and/or physiological criteria (Table 1). The activation either occurs directly after prehospital notification of arrival of a trauma patient by the Singapore Civil Defence

Force (SCDF) paramedics, or upon the patient’s arrival in ED and assessment by the ED specialist.

In patients with major trauma, severe or exsanguinating haemorrhage is a leading cause of potentially preventable death. These patients only form a small subset of the total trauma activations. Along with advancements in resuscitation strategies for bleeding control (direct pressure, tourniquets, pelvic binders, tranexamic acid, permissive hypotension, haemostatic resuscitation and prevention of the lethal triad of coagulopathy, acidosis and hypothermia), these patients also require a timely decision on the best method of haemorrhage control, and prompt transfer to the site where that can be effected.

To address this need, Code Crimson has been developed as an additional form of trauma activation in ED. It has been integrated into a number of hospitals

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in Australia and New Zealand.¹⁻³ PHIs in Singapore have yet to initiate this form of step-up trauma activation. Code Crimson activation mobilises additional personnel and resources who are specifically required for decision-making, above those that are required for most major trauma activations. This step-up response is aimed at early activation of the massive transfusion protocol and expediting definitive haemorrhage control by transferring the patient to the operating theatre (OT) or interventional radiology (IR) suite. A retrospective study to evaluate the impact of Code Crimson activation in patients with exsanguinating truncal trauma reported high blood transfusion rate and that they were very likely to undergo operative or angiographic intervention. Moreover, Code Crimson at Westmead Hospital in Sydney, Australia significantly reduced the median time from ED to OT to 23 minutes versus 59 minutes in patients with major haemorrhage in whom the code was not activated.¹ In 2018, Critical Haemorrhage to Operation Room Patient (CHOP) protocol was implemented by the Department of General Surgery at Khoo Teck Puat Hospital in Singapore, with a goal of bringing a severely injured patient rapidly to definitive care within 90 minutes. Analysis of the first 10 cases of CHOP protocol activation reported an average time of 73 minutes from the time of patient's arrival at ED to transfer to OT or IR suite.⁴

The activation of Code Crimson at Auckland City Hospital is currently based on the Assessment of Blood Consumption (ABC) Score, which is validated to predict the need for a massive transfusion protocol (MTP) in patients with major haemorrhage.⁵ The patient should meet 2 out of 4 criteria of ABC score for activation, namely, (1) heart rate >120 beats per minute, (2) systolic blood pressure <90mmHg, (3) penetrating injuries to head, neck, chest, abdomen and/or proximal extremities, and (4) positive focused abdominal sonography in trauma (FAST) imaging indicating haemoperitoneum or haemopericardium. There were a total of 3,002 trauma activations at Auckland City Hospital from August 2015 to February 2021, out of which 148 patients (4.93%) met the criteria for Code Crimson activation. The clinical data of Code Crimson during this period are described in Table 2. The majority of patients (73%) suffered from blunt trauma. The average Injury Severity Score for these patients was 25, indicating its utility for patients with major trauma. Code Crimson managed to significantly reduce the average time from arrival in ED to transfer to OT or IR for definitive intervention to a mean of 54 minutes. The mean length of stay of these patients in the intensive care unit was 6 days, and the mortality rate was 19.6%.

In Singapore, blunt trauma is the predominant mechanism of injury in about 98% of trauma patients, either secondary to road traffic crashes, fall from height, interpersonal violence or industrial incidents.⁶ High-energy blunt injuries such as pelvic disruption, massive haemothorax, uncontrolled maxillo-facial haemorrhage or amputation of limbs lead to massive haemorrhage and haemodynamic instability. The high mortality rate in this group of patients is usually contributed by coagulopathy. Thus, rapid initiation of a massive transfusion protocol is relevant.^{7,8} By activating Code Crimson, the patients with high-risk blunt trauma would benefit from early access to MTP and definitive intervention to control haemorrhage.⁷

Activation of Code Crimson in the ED requires consideration of both penetrating as well as high-energy blunt trauma injuries, and should meet 2 out of the 4 criteria aforementioned.

A proposed workflow for Code Crimson activation from the ED is described in Fig. 1. Code Crimson can be activated by the ED specialist or the trauma team leader (trauma surgeon or general surgeon). This second-tier activation through the hospital call centre, in addition to the usual trauma activation, should automatically lead to activation of MTP from the blood bank and delivery to the ED resuscitation room, commencement of E-blood (emergency O-negative blood) stored in the ED and priming of a rapid infuser or fluid warmer in ED. It should also lead to activation of the following additional on-call specialists: trauma or general surgery consultant, anaesthesiologist, intensive care specialist, interventional radiology (IR) specialist, OT in-charge nurse to designate the emergency OT, and stand-by OT staff and IR suite in-charge nurse. Thus, critical communication across the key decision makers is made more efficient by incorporating a single activation code, eliminating the need for multiple calls to the individual personnel, which often leads to delay. Activation of Code Crimson identifies the patient who requires evaluation by the relevant specialists for quick decision-making and plans for definitive control of major haemorrhage and subsequent care. The trauma or surgery consultant, anaesthesiologist, intensivist and IR consultant should arrive in the ED rapidly upon activation. After discussion among all these relevant specialists, the trauma team leader, who is the overall team leader for the case, should make a decision for rapid transport of the patient to the OT or IR suite for definitive haemorrhage control, ideally within 30 minutes from the time of activation of Code Crimson.

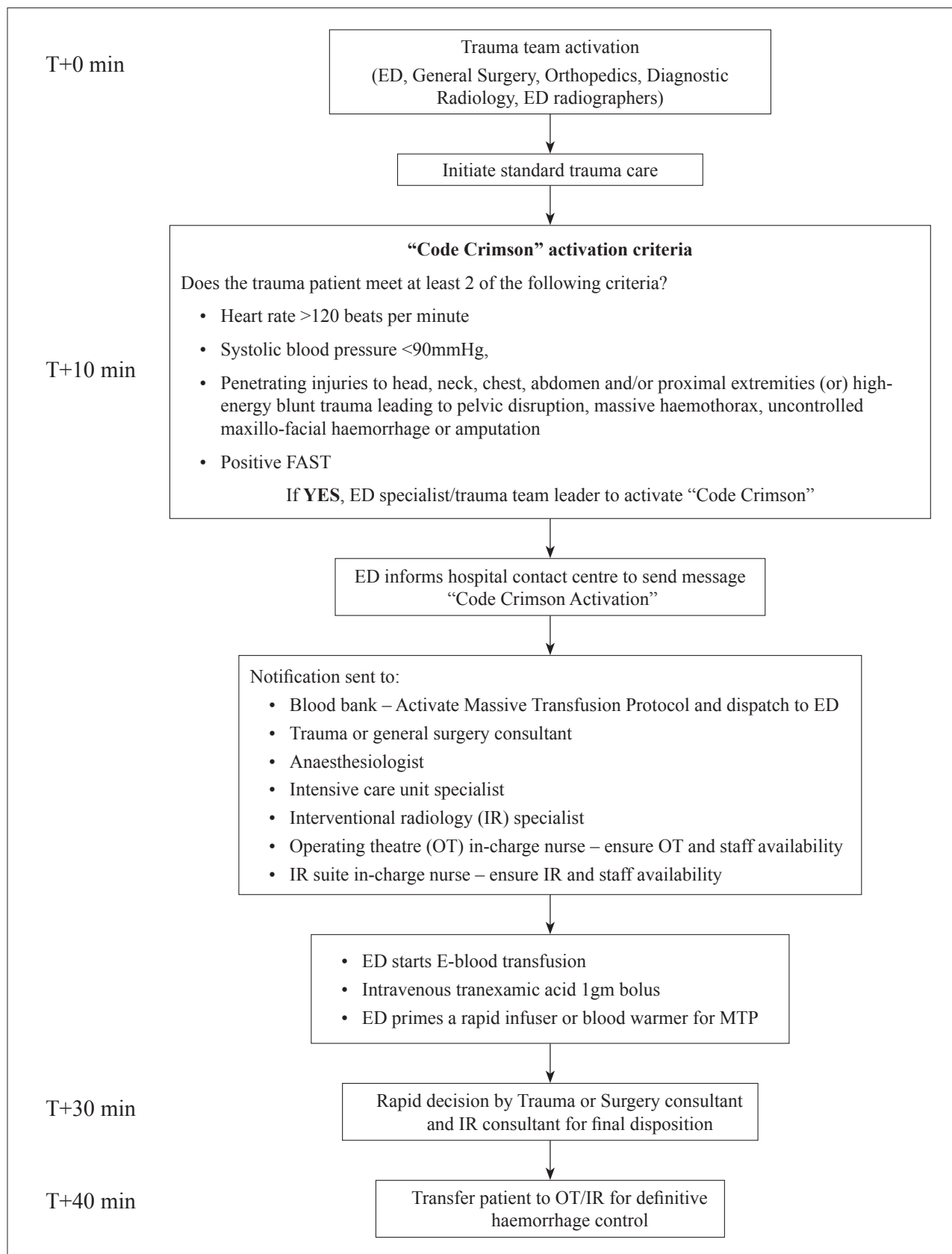


Fig. 1. Workflow of Code Crimson activation in the emergency department.

ED: emergency department; FAST: focused abdominal sonography in trauma; IR: interventional radiology; MTP: massive transfusion protocol; OT: operating theatre

In Auckland, prehospital Emergency Medical Services (EMS), ambulance EMS and helicopter EMS can activate Code Crimson if the patient meets the activation criteria. It would also be possible for prehospital activation of Code Crimson by SCDF paramedics in Singapore. Currently, the SCDF paramedics do not use portable ultrasound for FAST in the prehospital setting. The EMS will be able to activate Code Crimson if the patient met any 2 of the 3 criteria suggested (criteria 1, 2 and 3). In the future, when the SCDF paramedics are trained to perform FAST in the prehospital setting, they would be able to activate if the patient meets any 2 of the 4 criteria, similar to the activation of Code Crimson from the ED.

The following key performance indicators (KPIs) are recommended to be part of the ongoing evaluation

of Code Crimson activation by the trauma service of a hospital:

- Code Crimson activation within 10 minutes of initial assessment of the patient with ongoing haemorrhage in ED;
- Transferring the patient to the OT or IR suite within 30 minutes of Code Crimson activation (total 40 minutes from the time of trauma activation).

Upon arrival in the resuscitation room, ED nurses should immediately assess vital signs of the trauma patient and commence continuous physiologic monitoring. Simultaneously, ED doctors should conduct a rapid primary survey for identification of life-threatening injuries and severe haemorrhage, including FAST for identifying haemoperitoneum

Table 1. Trauma team activation criteria

Physiological criteria	• Cardiorespiratory arrest • Unstable vital signs (heart rate <50 or >100 beats/min, respiratory rate <8 or >20 breaths/min, systolic blood pressure <90mmHg, SpO₂ <90%) • Compromised neurological status (Glasgow Coma Scale <13) or lateralising neurological signs • Airway obstruction or anticipation of difficult airway • Pregnancy
Anatomical criteria	• Penetrating wound to the head, neck, chest, abdomen, pelvis or groin, extremity above knee or elbow • Injuries involving 2 or more body regions • Major blunt chest or abdominal trauma • Flail chest, major chest wall injury or pulmonary contusion • Suspicion of vascular or cardiac injury • Severe maxillo-facial injury • Near or complete amputation proximal to wrist or ankle • 2 or more proximal long bone fractures • Pelvic fracture • Open or depressed skull fracture • Evidence of spinal cord injury with or without paralysis • Burns >15% body surface area
Mechanism of injury	• Fall >10 feet • Fall from 2nd floor or higher • Motor vehicle collision with: - High speed crash - Rollover of vehicle - Intrusion of vehicle >12-inch occupant side or 18-inch any side - Entrapment or prolonged extrication >20 minutes - Death of an occupant - Ejection (partial or complete from vehicle) - Auto versus pedestrian/bicyclist thrown, run over, or with significant impact >30kph - Motorcycle crash >50kph • Explosion • High voltage injury

Table 2. Clinical data of Code Crimson at Auckland City Hospital from August 2015 to February 2021

Parameters	Median (range) N=148
Patient demographics	
Age, years	35 (15–83)
Sex, no. (%)	
Male	110 (74.3)
Female	38 (25.7)
Presentation during office hours (0800–2159 hours), no. (%)	102 (68.9)
Mechanism of injury, no. (%)	
Blunt trauma	108 (73.0)
Penetrating trauma	40 (27.0)
Injury Severity Score	25 (1–59)
Management, no. (%)	
E-blood/MTP usage at ED	148 (100)
Intervention	92 (62.2)
- Operating theatre	88 (95.6)
- Interventional radiology	3 (3.3)
- Combined	1 (1.1)
Time to intervention, minutes	54 (26–189)
Mortality, no. (%)	
Alive	119 (80.4)
Death	29 (19.6)
Length of hospital stay, days	
Intensive care unit	6 (1–56)
Total	16.5 (1–120)

E-blood: emergency O-negative blood; ED: emergency department; MTP: massive transfusion protocol

or haemopericardium. The current trauma activation response in PHIs should enable adherence of the proposed 10-minute KPI for activation of Code Crimson in patients identified to have severe external or internal haemorrhage. All cases where Code Crimson was activated should be subsequently evaluated, and the review should include the appropriateness of patient inclusion, interventions performed in ED/OT/IR, and whether the set KPIs were met.⁹ This ensures appropriate utilisation of additional resources for trauma patients with severe haemorrhage to achieve improved outcomes.

Trauma patients with uncontrolled haemorrhage benefit from a second-tier of response in addition to the standard trauma team activation. Activation of Code Crimson in the ED for these patients helps put processes in place, with the aim of expediting the time for rapid diagnosis of major haemorrhage, initiation of haemostatic resuscitation using the MTP, as well as rapid operative or radiological intervention for definitive haemorrhage control. Introduction of Code Crimson in the trauma system of all EDs may be effective in Singapore, as it has been in other jurisdictions, as an effective step-up strategy to reduce morbidity and mortality in major trauma patients with severe haemorrhage.

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