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**Adapting trauma workflows for severely injured trauma patients during the COVID-19 pandemic: experience in a regional trauma centre in Singapore**

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Singapore is one of the most densely populated and globally connected countries in the world, making it susceptible to the highly contagious coronavirus disease 2019 (COVID-19). On 11 March 2020, the World Health Organization (WHO) declared the outbreak of COVID-19 a pandemic. The first imported and locally transmitted cases in Singapore were confirmed on 23 January and 4 February 2020, respectively. On 7 February, Singapore raised its Disease Outbreak Response System Condition (DORSCON) status from Yellow to Orange due to a spike in community spread of the COVID-19 infection.<sup>(1)</sup> As of 30 March 2020, there were 870 infected cases, of which 514 cases were imported, and three deaths.<sup>(1)</sup> Since DORSCON Orange, measures for social distancing and non-essential travel have escalated.<sup>(2)</sup> Hospitals isolated patients with pneumonia, tightened hygiene measures, and reduced inter-institutional transfers of patients and coverage by specialists.

In the midst of the COVID-19 outbreak, the provision of high-quality trauma care should be maintained while ensuring judicious use of critical resources.<sup>(3,4)</sup> Tan Tock Seng Hospital (TTSH) is an acute care hospital in Singapore with 1,600 beds. The Central Regional Trauma Service (CRTS) comprises of five restructured hospitals and one private hospital, serving a population of 2.8 million. TTSH is the designated anchor regional trauma centre for the central region of Singapore. It is co-located with the National Centre for Infectious Diseases (NCID), where the majority of confirmed or suspected COVID-19 cases are managed in Singapore. As the regional trauma centre, TTSH has adapted existing trauma workflows to ensure sustainable provision of trauma care during this outbreak, right-siting of trauma patients to designated centres, and safety of the healthcare workers (HCWs) involved in managing trauma patients. To date, there are no COVID-19 cases among the trauma providers in our centre. In this report, we describe the workflows for managing severely injured trauma patients (Tier 1 and 2 injuries) in our regional trauma centre during this evolving COVID-19 pandemic.

## **ADAPTATION OF TRAUMA WORKFLOWS WITHIN A REGIONAL TRAUMA SYSTEM**

### **Pre-hospital trauma management**

Prior to escalation of the DORSCON level from Yellow to Orange on 7 February 2020, trauma directors of all hospitals within the CRTS reached a consensus to further strengthen trauma diversion protocols to designated trauma centres. This was in anticipation of the restriction against cross-institutional coverage by medical personnel or secondary transfer of trauma patients during the DORSCON Orange period. As such, pre-hospital diversions of severely injured trauma patients or subgroup of trauma patients (eg. paediatric or pregnant) to centres with the relevant expertise were essential. This was achieved by actively engaging pre-hospital services such as the Singapore Civil Defence Force, Singapore Armed Forces and private ambulance services. Existing pre-hospital diversion protocols were reinforced and made readily available to all paramedics and ambulance crews. Right-siting of trauma patients based on diversion protocols was audited at a regular basis. These results were shared with pre-hospital stakeholders to improve the workflow. This was to ensure sustainability of trauma response during this outbreak.

### **Secondary transfer of trauma patients**

As there may have been a need for secondary transfer of trauma patients to higher-echelon designated trauma centres, adaptations to existing secondary transfer protocols were made. All acutely injured trauma patients who are unable to answer COVID-19 screening questions are managed as suspected COVID-19 cases. All medical personnel transporting the trauma patient are in full Tier 2 personal protective equipment (PPE) until the patient has been handed over to the receiving team. Full Tier 2 PPE includes an N95 mask, eye protection (face shield/visor mask/goggles), shower cap, disposable gown and two pairs of gloves. The patient is admitted

to an isolation ward in the trauma centre. The transporting ambulance should be cleaned, as per infectious disease protocol, at the destination hospital prior to returning to the parent unit. For non-urgent trauma transfers, the patient must be tested for COVID-19 infection prior to transfer. This requires two COVID-19 nasopharyngeal swab tests to be done 24 hours apart. After two negative swabs, the trauma patient can then be transported as per the usual protocol to a non-isolation ward in the designated trauma centre. If tested positive, the patient is transferred to NCID for further management by the trauma team.

In order to quickly adapt to the evolving nature of the outbreak, a common messaging platform was used to facilitate open communication between all trauma directors of the CRTS. This allowed for load balancing and right-siting of patients during secondary transfer.

## **MANAGEMENT PROTOCOL WITHIN A DESIGNATED REGIONAL TRAUMA CENTRE**

### **Acutely injured trauma patients**

The presentation of an acutely injured trauma patient is highly variable and unpredictable. It is challenging, and at times near impossible, to obtain an accurate COVID-19 history. This is further complicated by the potential need for acute airway management and possible contact with blood or bodily fluids. In light of these uncertainties, we adapted our trauma protocols with the assumption that all acutely injured trauma patients are suspected COVID-19 cases (Fig. 1). All HCWs, including health attendants and radiographers, must be in full Tier 2 PPE during the initial assessment and management of the acutely injured patient. Full Tier 2 PPE is worn during all management of the patient, including transport, until the patient has been handed over to the ward or operating theatre staff. The PPE is doffed according to the institutional infection control guidelines.

**Haemodynamically stable trauma patients**

Unique to our regional trauma centre, TTSH is co-located with NCID. In order to decrease the potential exposure of TTSH HCWs to COVID-19, haemodynamically stable patients who require computed tomography (CT) imaging are transported to the CT scan room in NCID for the required imaging. A designated transport route is planned to minimise contact with other patients or HCWs. Patients receiving conservative treatment are transported back to an isolation ward in TTSH, while patients requiring surgical or radiological intervention are transported to negative pressure (NEP) operating theatres (OTs) in TTSH.

**Haemodynamically unstable trauma patients**

Should a haemodynamically unstable trauma patient respond to initial resuscitative attempts, further CT imaging or other imaging modalities will be performed in TTSH instead of NCID. The TTSH CT room is comparatively nearer as it is adjacent to the emergency department, as compared to the NCID CT room, which is in an adjacent building. Security staff assists in minimising social and environmental contact along the transport route. After imaging, the scan room and machine are thoroughly disinfected as per infection control protocol. Meanwhile, the standby CT scanner and radiographer are activated while the scanner used is being disinfected.

Haemodynamically unstable trauma patients who are non-responders to initial resuscitative attempts are transferred to the NEP OT in TTSH for resuscitative efforts, angio-embolisation or surgery. The anaesthesia team receiving the patient must be in full Tier 2 PPE and powered air-purifying respirators prior to the arrival of the patient in the OT. All HCWs involved in the resuscitative procedures will don full Tier 2 PPE for the entire duration. Post procedure, rather than nursing in the recovery ward, these patients are nursed in the NEP OT until they are fit for transfer to isolation beds in the intensive care unit (ICU) or high dependency unit (HDU) in TTSH.

The first COVID-19 swab, if not already done at the time of presentation, will then be performed in the ward, HDU or ICU. The second swab is sent 24 hours after the first. The trauma patient is eligible for deisolation if both swabs are negative and clinical suspicion of COVID-19 infection is low.

### **Trauma patients with confirmed COVID-19 infection**

All known COVID-19 positive trauma patients are managed in NCID. All required imaging and procedures are also performed in NCID. Surgical interventions and emergency angio-embolisation are performed in its NEP OTs. Training sessions are scheduled to improve the trauma team's familiarity with the settings in NCID.

### **Prioritisation of critical care resources**

As the majority of polytrauma patients require close monitoring in the HDU or ICU, there is a need to balance the number of acute care beds in tandem with the requirements of an evolving disease outbreak situation. The surgical division has prioritised for elective surgeries conditions that are life-threatening, malignancies that could progress or active symptoms requiring urgent attention. This is to ensure appropriate use of the HDU and ICU in response to the disease outbreak and critical care needs.

## **DISCUSSION**

The COVID-19 pandemic has introduced specific challenges in both regional trauma systems and trauma centres. As the lead regional trauma centre, the needs of our trauma patients dovetailed with specific infectious disease considerations arising from COVID-19. The early involvement of stakeholders in pre-hospital trauma management and intra-hospital trauma processes is the cornerstone to ensuring a sustained response to a protracted infectious disease

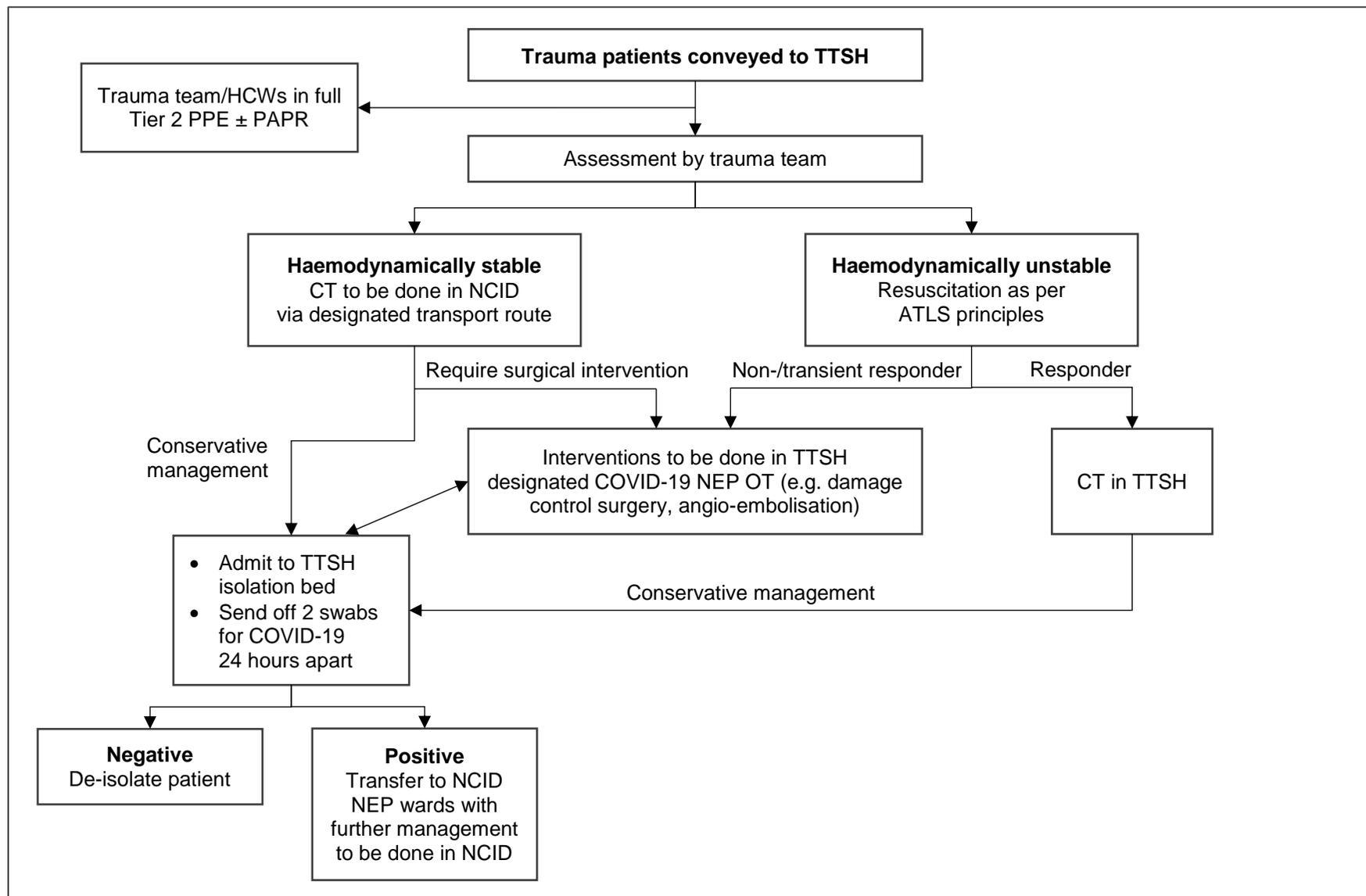
outbreak such as COVID-19. It is imperative that trauma centres develop protocols to heighten vigilance and compliance to infection control to avoid unnecessary transmission in critical settings.

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**Fig. 1** Flowchart shows the workflow for managing suspected COVID-19 trauma patients. ATLS: advanced trauma life support; COVID-19: coronavirus disease 2019; CT: computed tomography; NCID: National Centre for Infectious Diseases; NEP: negative pressure; OT: operating theatre; PAPR: powered air-purifying respirator; PPE: personal protective equipment; TTSH: Tan Tock Seng Hospital