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Brief Communication

Addressing evacuation delay: the critical role of the core region of combat trauma concept in future warfare

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Abstract: With the transition to large-scale combat operations (LSCOs) and distributed warfare in theatre, medical evacuation times could be a lot longer, which challenges the "golden hour". In response to this challenge, the paper presents the "Core Region of Combat Trauma (CRCT)" as a novel framework for directing care in the Prolonged Casualty Care (PCC) phase when evacuation is prolonged. The CRCT is the site of injuries which are among the leading causes of potentially preventable deaths following Tactical Combat Casualty Care (TCCC). The care of CRCT located in the transitional phase between TCCC and damage control surgery. The guiding principle of CRCT management is damage control and physiological maintenance. This methodology facilitates the transition of casualties from a state where evacuation is not feasible to one where evacuation is tolerable.

Keywords: Prolonged casualty care (PCC), core region of combat trauma (CRCT), damage control surgery, medical evacuation, large-scale combat operations (LSCO)

The basic framework for providing medical aid during war and in battle is echeloned care. As distributed warfare becomes a focus in LSCO, the enhanced air-defense and fire-suppression strategies place significant restrictions on medical evacuation [1, 2]. Given this, the so-called traditional "golden hour" for resuscitation is becoming difficult to be achieved in future conflicts, which poses a major challenge for frontline medical teams regarding prolonged casualty care (PCC) [3-6]. While the forward surgical teams (FSTs) sent to the front lines to increase surgical capabilities have met some successes [1]. Similar resource-limited forward battlefields, which are delayed to a point where evacuations are not possible and FSTs are unreachable, require a coherent theoretical framework to prioritize medical interventions during the ensuing bridging phase. To fill this gap, the paper introduces the "Core Region of Combat Trauma (CRCT)" concept, providing a theoretical foundation for PCC in future warfare scenarios.

The term CRCT refers to the anatomical structures which give direct and immediate support to essential central nervous system functions and circulatory physiology after combat injuries. The CRCT encompasses the following contiguous anatomical compartments, defined by their containment of life-sustaining organ systems and major named arteries where hemorrhage is often non-compressible and/or can rapidly lead to catastrophic physiological derangement: (1) Central nerve system: brain and spinal cord; (2) Thoracic compartment: trachea, lungs, heart, thoracic aorta, and great vessels (superior/inferior vena cava, pulmonary arteries/veins); (3) Abdomino-pelvic compartment: solid abdominal viscera (liver, spleen, kidneys, pancreas), major abdominal vasculature (abdominal aorta, celiac axis, superior/inferior mesenteric arteries, renal arteries, iliac arteries and veins), and the bony pelvis (as a potential source of major retroperitoneal or pelvic hemorrhage). The hollow viscera are considered secondary unless injury leads to catastrophic contamination or is associated with major vascular injury. Hemorrhage from extremities can be effectively controlled with tourniquets or direct pressure (**Figure 1**). Injuries in CRCT represent a primary focus for mitigating potentially pre-

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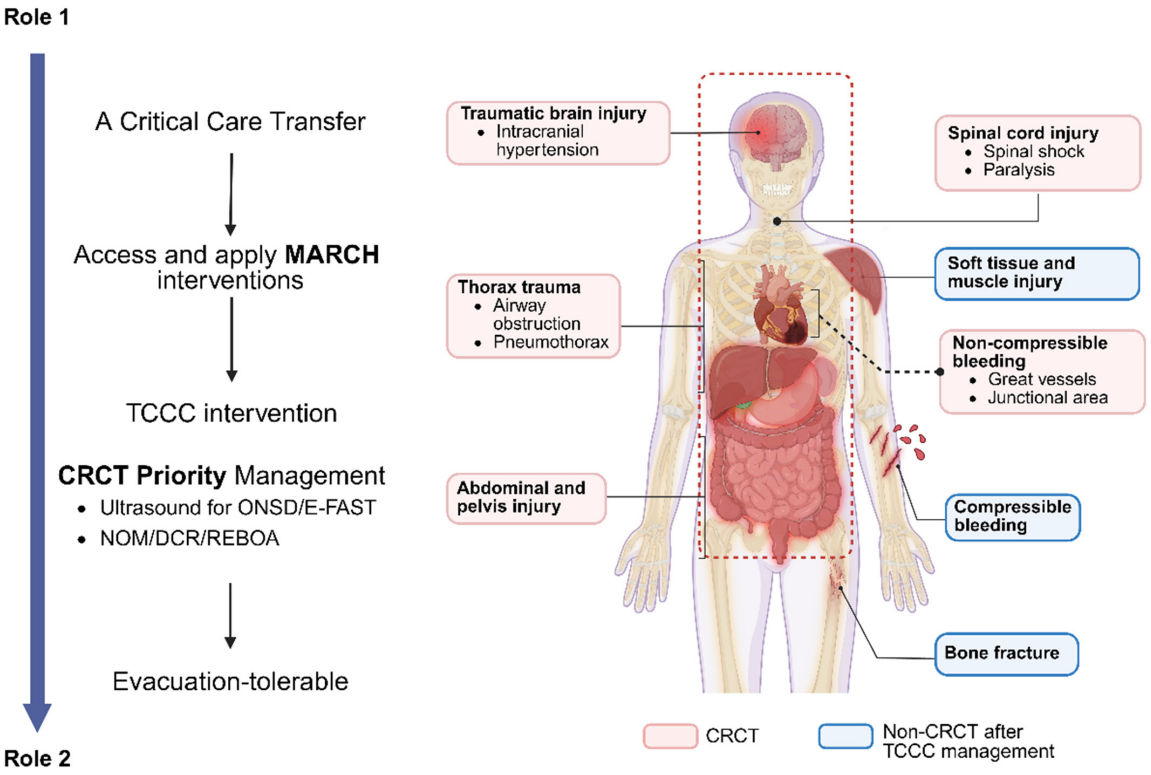

Figure 1. Flowchart for the management of CRCT injury. This schematic delineates the vital structures constituting the CRCT. Injuries to these areas can rapidly become fatal if not identified and managed promptly, thus mandating prioritized assessment and intervention after TCCC (MARCH: Massive hemorrhage, Airway, Respirations, Circulation, Head injury/Hypothermia; ONSD: Optic Nerve Sheath Diameter; E-FAST: extended Focused Assessment with Sonography for Trauma; NOM: Non-Operative Management; DCR: Damage Control Resuscitation; REBOA: Resuscitative Endovascular Balloon Occlusion of the Aorta).

ventable death, a concept historically supported by data from earlier conflicts after tactical combat casualty care (TCCC) [7, 8] and reinforced by the ongoing challenges identified in modern casualty analyses [1, 9-11].

This concept is proposed as a specific clinical prioritization strategy to be applied within PCC. This period can extend from several hours to potentially more than 72 hours post-initial TCCC. The CRCT framework provides the necessary clinical focus for this prolonged interval, guiding medical personnel to prioritize surveillance and limited interventions on the CRCT to bridge the casualty from a non-evacuable status toward a state stable enough to tolerate evacuation to Role 2 for damage control surgery/resuscitation. In this stage, the primary focus of treatment is to maintain life, reduce damage, and continue with aftercare. The main goals of treatment for CRCT injuries emphasize damage control and physiological support. During this resource-constrained phase, clinical surveillance and limited interventions should be prioritized toward identifying the threats to the CRCT and averting them. The aim is to stop deadly pathological processes as quickly as possible in resource-limited situations but with more advanced technical methods than those used in TCCC (**Figure 2**).

Furthermore, the CRCT framework directly informs dedicated training and equipment requirements. Training modules should focus on CRCT injury recognition and temporizing intervention through high-fidelity simulation conducted in theatre, using realistic casualty care situations. Such as managing tension pneumothorax in a traumatic brain injured patient or monitoring for intra-abdominal hemorrhage. Corresponding key equipment items mapped to CRCT regions include: (1) focused assessment of the thorax and abdomen with extended focused assessment with sonography in trauma (e-FAST), (2) advanced airway management tools and capability for resuscitative

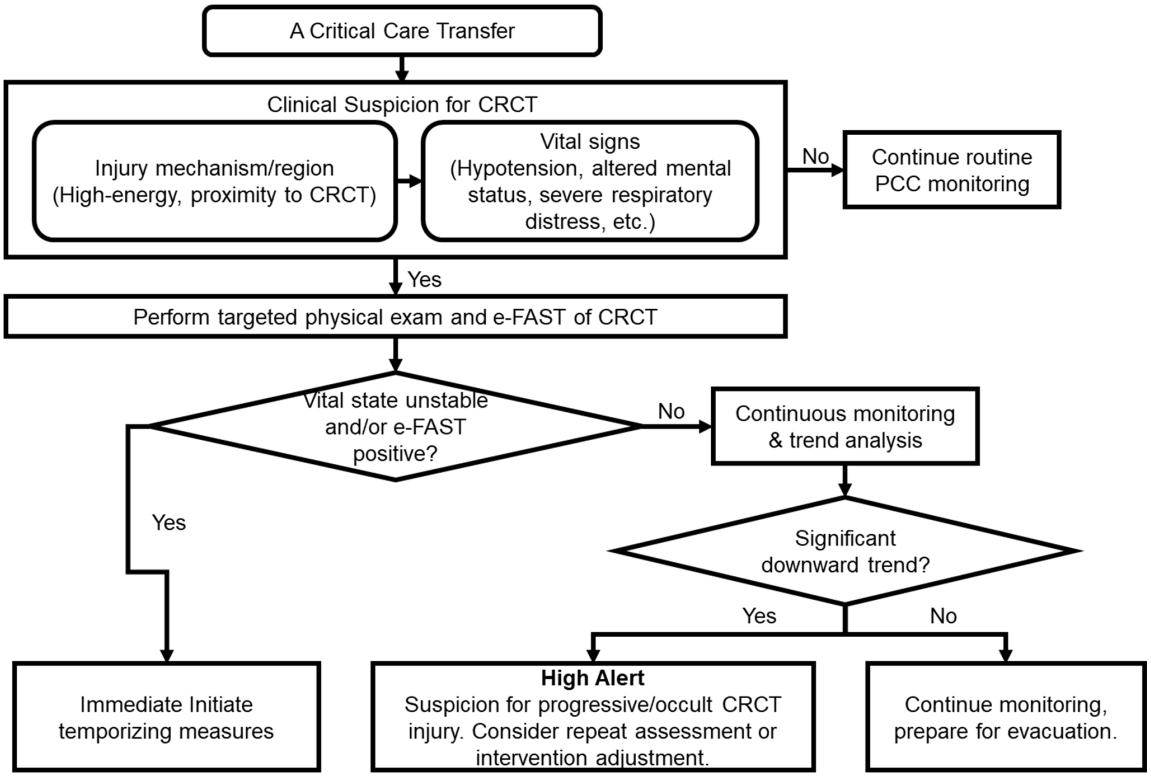

Figure 2. Proposed CRCT-focused assessment approach for the resource-limited PCC phase. This stepwise approach prioritizes the rapid identification and temporizing management of life-threatening injuries to the CRCT when evacuation is delayed.

endovascular balloon occlusion of the aorta (REBOA) training for truncal hemorrhage control, and (3) ultrasonic assessment of Optic Nerve Sheath Diameter (ONSD) and multimodal neurological monitors. Equipment should be integrated to an one-stop platforms, which refers to an integrated, portable system capable of continuous vital sign monitoring, targeted diagnostics, and delivering essential supportive therapies (e.g., ventilation, infusion) to sustain a CRCT-injured casualty.

However, we must admit that this conceptual framework has several limitations. CRCT is still a theoretical model that requires rigorous validation. First, ethical and logistical barriers inherent to combat medical research make it extremely difficult to obtain robust prospective clinical outcome data, and the proposed interventions have an inherent resource dependency, which limits their utility in highly austere or dynamic low-resource environments. Second, the available data from contemporary LSCO is insufficient. Hence, this concept requires validation through future operational research and clinical studies, accompanied by scenario-based testing and systematic doctrine development to make the CRCT-first prioritization strategy ready in mass-casualty cases.

Disclosure of conflict of interest

None.

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