

# Trauma Resuscitation and Monitoring

## Military Lessons Learned



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### KEYWORDS

- Monitoring/physiologic • Combat casualty care • Military medicine • Wounds • Injuries

### KEY POINTS

- Systolic blood pressure (SBP) and heart rate (HR) are not sensitive indicators of hypoperfusion.
- Hypoperfusion may begin with an SBP of 100 to 110 mm Hg.
- Shock index is a more sensitive and specific indicator of hypoperfusion than SBP or HR alone.
- New dynamic, noninvasive monitors may provide earlier and more sensitive indications of deterioration or occult hypoperfusion.

The management of a patient with a severe injury requires careful resuscitation and astute monitoring. The principles of trauma management have evolved over the past several years, partly due to the military experiences in the care of casualties in Iraq and Afghanistan.<sup>1</sup> The United States and coalition partners have demonstrated an unprecedented reduction in combat-related deaths, despite an increase in injury severity. Within the context of a 7000-mile-long continuum of care from the point of injury to the United States and the new practices associated with damage-control resuscitation, this article draws on military research regarding the limitations of current vital sign monitoring and introduces innovative monitoring technologies that may be beneficial in severely injured patients.

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The authors have nothing to disclose.

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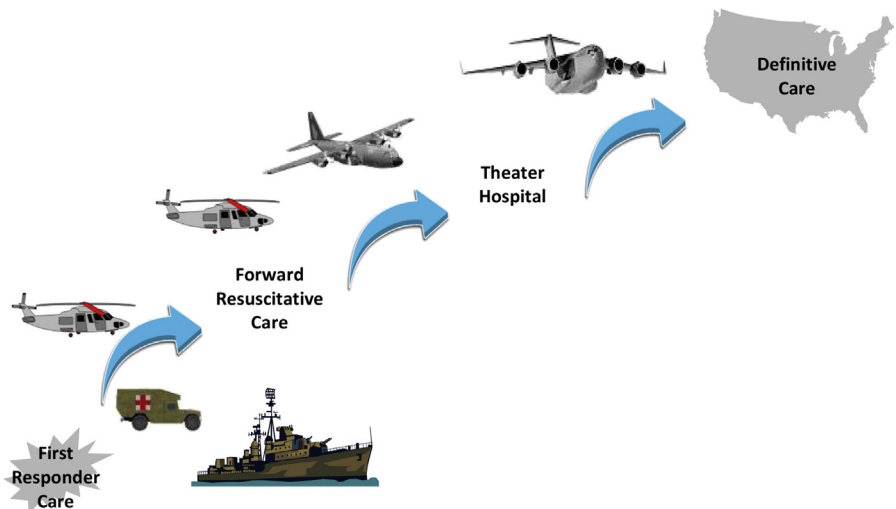
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## MILITARY TRAUMA CARE ACROSS THE CONTINUUM

The Joint Theater Trauma System (JTTS) was developed with the vision that every soldier, marine, sailor, and airman injured on the battlefield will have the optimal chance for survival and maximum potential for functional recovery. The military trauma care continuum begins at the point of injury and extends to definitive care in the United States (Fig. 1).<sup>2</sup> In this system, medical capabilities are as close to the battlefield as possible,<sup>3</sup> resulting in the need to provide critical care, including damage-control resuscitation, during transport for the patients.<sup>4,5</sup> Global en route care and the Air Force Critical Care Air Transport Teams (CCATTs) have revolutionized combat critical care. The CCATTs, with a critical care physician, nurse, and respiratory therapist, transport patients in a cargo aircraft on missions that range from 1 to 18 hours, with most flights 6 to 8 hours long.<sup>6</sup> During the Vietnam War, patients were evacuated from theater to a remote hospital in 21 days; with the CCATTs, the average time to transport after an injury is 28 hours, and often as little as 12 hours.<sup>3</sup> Rapid movement of critically injured casualties (average Injury Severity Score 23.7) within hours of wounding is safe, with a minimal mortality during movement (0.02%). These patients have a 30-day mortality (2.1%) that is independent of the time from injury to arrival at definitive care.<sup>7</sup> Among 1491 patients transported by CCATT, 69% suffered polytrauma, primarily due to explosions. The injuries are complex, including soft tissue trauma (64%), orthopedic (45%), thoracic (35%), skull fracture (27%), and brain injuries (25%).<sup>8</sup> These patients, who may be stabilizing but not stable, require ongoing interventions and monitoring during the en route phase of care, which is challenging given the austere and dynamic conditions onboard an aircraft. The integration of new research and practice on the battlefield and during transport, and a system to support care across the 7000-mile continuum from the battlefield to the United States, has been instrumental in the unprecedented survival rate for combat casualties.<sup>9-12</sup>



**Fig. 1.** Military en route care continuum. The US military en route care system begins at the point of injury and extends to definitive care in the United States. Along the continuum, care is provided at military trauma hospitals and by highly specialized transport teams onboard military ground, sea, and air transports. (Adapted from Chairman Joint Chiefs of Staff (CJCS). Health service support (Joint Publication 4-02). 2012. Available at: [http://www.dtic.mil/doctrine/new\\_pubs/jp4\\_02.pdf](http://www.dtic.mil/doctrine/new_pubs/jp4_02.pdf). Accessed November 15, 2014.)

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