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Editorial

In a stable battlefield, avoid using austere surgical units to meet the golden hour of trauma time to care goal

Introduction

The North Atlantic Treaty Organization (NATO) categorizes combat casualty care facilities according to their capabilities. Role 1 (R1) is the most basic and delivers primary care and basic resuscitation. A Role 2 (R2) facility has basic resuscitative *and* emergency surgical capability. Role 3 (R3) is generally the most comprehensive theatre medical asset with the most robust resources. In the United States, both the Army and the Marine Corps have R2s; the Army has the Forward Surgical Team (FST) while the Marine Corps has the Forward Resuscitative Surgical System (FRSS).

R2s are ideal on a dynamic battlefield. They can be set up and taken down within an hour, and are highly mobile on the modern maneuver battlefield covering up to 50 to 100 kilometers in a day [1]. They provide timely surgical capability where there otherwise would be none. Many R2 assets were embedded with combat units during the attack phase of Operation Iraqi Freedom (OIF). They are also useful when the risk of casualties is low, number of troops small, or presence transient, as to make establishing an R3 resource prohibitive.

Once the battlefield stabilizes R3s are established. However R2s often stay in place, surrounding R3s to ensure compliance with the American operational planning principle of the "Golden Hour of Trauma" (GHT). This GHT concept holds that if a severely injured patient can receive resuscitative surgery within an hour, his or her chances of survival are improved. US ground forces now operate within an hour of surgical capability if possible.

By using forward R2s, time to treatment—as defined by early access to surgery—is decreased. However, this practice emphasizes early access to surgery over treatment at a well-resourced, high-volume center – such as an R3.

Using R2s to satisfy the Golden Hour of Trauma time to treatment goal, after R3s and en route care assets have been established, is misguided. Care at R3s should be emphasized as the weight of the published evidence shows that treatment at a well-resourced, high-volume center is likely more important than time to treatment. Furthermore, time to treatment goals can be achieved with robust casualty evacuation resources, and important acute treatments can be done en route to R3 facilities with new, advanced evacuation platforms. While R2s play a critical role in certain operational settings, when the battlefield matures care at an R3 should be prioritized.

Care at R3s likely superior to care at R2s

While R2s provide superb care, a review of the existing literature reveals that care at R3s is likely to be superior to care at R2s. There have been two studies directly comparing mortality between R2s and R3s. The first study found no difference in mortality between patients initially seen at R2s compared to patients initially seen at R3s [2]. In contrast, the second study, which was five times as large, found the mortality rate was 6.6% lower for critically injured casualties initially treated at an R3 [3].

R3s are likely to provide better care because of their robust resources and the high volume of care they provide. The benefit of robust resources was established with the introduction of civilian trauma systems. Trauma systems coordinate pre-hospital, acute care, and rehabilitation assets to ensure timely access to appropriate care. In these systems, seriously injured trauma patients are directed to trauma centers where resources, interventions, and specialized staff are concentrated. Studies have found that the introduction of trauma systems is associated with decreased mortality [4–7].

Militarily, R3s have more resources than R2s. R2s usually have two to four general and orthopedic surgeons, anesthesiologists, nursing support and basic blood bank support. In addition to these resources, R3s have specialists, CAT scans, intensive care units, and robust blood transfusion, pharmaceutical and operating room assets. These assets are important in the operational setting, as the modern care of IED injured patients often involves 5–8 surgeons and 3 anesthesiologists working simultaneously [8].

In addition to having robust resources, data from civilian trauma centers reveal a benefit from seeing a high-volume of critically injured trauma patients. That is, with repetition, hospitals improve. This relationship—improved quality of care with increased patient volume—is well established in health care and trauma care specifically [9–14]. Because severely injured patients have better outcomes at high-volume centers, the American College of Surgeons requires advanced trauma centers to admit at least 1200 trauma patients yearly, 240 of which must be severely injured [15].

In a medically mature battlefield, R2s do not see many patients. Our data from USMC units in Afghanistan reveal that our R2s performed one surgical case every two months; compare that to 158 surgical cases per month at R3s (Table 1) [8,16–20]. Some R2s saw only one injured patient every two weeks.

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Table 1
Comparison of volumes at Role 2 versus Role 3 in OIF/OEF in stable battlefields with established R3s and robust CASEVAC.

Setting	Months of Data	Median Trauma Patients/Mo[d]	Median Trauma Operative Cases/Mo[c]
Role 2 Unpublished[a]	65	2.6	
Role 2 Unpublished[a]	53		0.6
Role 2 Published [16–19]	52.5	54.4	23.4
Role 3 Published [20]	15	173.3	
Role 3 Published[b] [8,20]	48		157.9

[a] C Alvarado, G Demers, A Elliot, J Liang J. Moore, P Woodson. Personnel Communication 2013–2014 all from US Navy units serving in Helmand Province Afghanistan 2010–2014. We were able to obtain 65 months of data for trauma cases, and 53 months for operative cases, from two Role 2 units.
[b] Role 3 operative cases included specialty fields including neurosurgery, OMFS, and ophthalmology.
[c] Operative cases may, especially at role 3 facilities, include multiple operative procedures.
[d] Trauma patient definition varied according to publication; some met Joint Theater Trauma Registry inclusion criteria, others were defined loosely as trauma resuscitations tracked in individual databases. In general, all patients regardless of acuity were included.

Time to care in trauma patients should not be overemphasized

Many would agree that care at R3s might be better, but argue that decreased time to treatment makes up for this difference. The existing literature is all observational, so definitive conclusions cannot be made; however, what exists reveals only a weak association between transport time and mortality in trauma patients.

The effect of prehospital time on mortality in trauma patients has been examined in both the civilian and military sector. Harmsen recently published a systematic review examining the influence of prehospital time on outcome in civilian trauma patients [21]. Sixteen studies of total prehospital time (TPT) met their inclusion criteria. In six studies examining total prehospital time in undifferentiated trauma patients, only one showed a clinically significant association between TPT and mortality. Only one of three studies of penetrating trauma showed an increase in mortality with increased TPT. None of the three blunt-trauma patient studies showed a benefit to short prehospital time. Only one of three studies looking at traumatic brain injury (TBI) showed a statistically significant decrease in mortality with early transport.

The one study in TBI patients that is cited as showing decreased mortality with shortened prehospital time had mixed results and is emblematic of the studies on the subject [22]. While a statistically significant association with mortality with each incremental minute of patient arrival was found, it is unlikely to be clinically significant. The hazard ratio (HR) was 1.002, 95% CI 1.001–1.004, $p = 0.001$. A HR of 1 would represent no association. There was no survival benefit observed for patients arriving within 60 min of injury time (HR 0.77, 95% CI 0.50–1.18, $p = 0.22$) but an apparent benefit for those presenting within 2 h of injury time (HR 0.31, 95% CI 0.15–0.66, $p = 0.002$). There is therefore a hint of effect, but certainly nothing convincing.

When using observational literature to determine causation, consistency is required; it is absent on this subject. Most of the studies on the subject are negative. It is important to remember that in observational literature, a study that finds no association is more likely true than a study that does find an association [23]. If there were a strong association between TPT and mortality, then in all the negative studies there would have to be a confounder that exactly counteracted the benefit of a shortened prehospital time.

In 2009 Secretary of Defense Robert M. Gates mandated prehospital helicopter transport of critically injured combat casualties in 60 min or less. In 2015 Kotwal published an important study examining the effect of this golden hour policy on combat casualty mortality [3].

The investigators found that after the mandate, transport time decreased and mortality rate improved even in the setting of more severely injured casualties. While this is an encouraging finding, it does not necessarily follow that the decreased transport time caused the decreased mortality. Combat casualty care has continually improved over the course of the last 15 years. Increased tourniquet use [24], the introduction of hemostatic dressings [25], decreased hypothermia in the prehospital setting [26], advances in prehospital care capabilities [27], implementation of damage control resuscitation [28], the introduction of an organized military trauma system [29], more robust combat trauma research [30], improved training [31], the use of tranexamic acid [32], and improved diagnostic capabilities [33]: these are just some of the advances in combat casualty care made in the last conflict. These improvements, as well as unseen factors, confound our ability to make causal inferences from Kotwal's observational data.

The available evidence is consistent with the conclusion that short transport time probably decreases mortality in a small portion of patients. While the evidence to support an association between pre-hospital time and mortality is weak, we are not arguing against a short transport time *per se*. Rather, we are against using forward surgical assets to accomplish transport time goals because it minimizes the greater importance of being seen at a well-resourced, high-volume center, and because there are better ways to shorten pre-hospital time.

Robust casualty evacuation resources: the best way to shorten time to treatment

The best way to decrease time to treatment is by increasing evacuation assets, not by placing forward R2 surgical assets. In 2009, after Secretary Gates mandated the GHT policy, air assets were increased to meet this mandate [34]. The result was decreased time to treatment, with a simultaneous decrease in the percent of patients seen at R2s. The percent of casualties initially seen at R3s increased from 42.4% to 48% with a corresponding decrease in the percent of patients initially seen first at R2s [3].

The use of the MV22 Osprey is also an intriguing option to decrease time to treatment. With a max speed of 316 mph, the casualty could be over 100 miles away from an R3 and still be delivered within an hour [35]. Using MV22 as an evacuation platform has been explored and we are curious to see more data [36,37].

The recent conflicts in Iraq and Afghanistan saw advances in pre-hospital care that can mitigate longer transport time. One example of improved patient evacuation was the British Medical Emergency Response Team (MERT). In the MERT system, a team consisting of a physician, nurse, and two paramedics operating within a large CH-47 Chinook helicopter were able to administer advanced care typically not available in conventional en route care. Some of these important interventions that can be completed en route to higher care include compressible hemorrhage treatment, airway control, chest decompression, blood product administration, and hypothermia control [26,27]. There is evidence that, in

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