

There Is No Role for Damage Control Orthopedics Within the Golden Hour

MAJ John C. Dunn, MD*,†; CAPT Eric A. Elster, MD‡,§; MAJ James A. Blair, MD†;
COL(R) Kyle N. Remick, MD‡,§; COL Benjamin K. Potter, MD‡,§;
COL Leon J. Nesti, MD, PhD*,§

ABSTRACT

Introduction:

Trauma systems within the United States have adapted the “golden hour” principle to guide prehospital planning with the goal to deliver the injured to the trauma facility in under 60 minutes. In an effort to reduce preventable prehospital death, in 2009, Secretary of Defense Robert M. Gates mandated that prehospital transport of injured combat casualties must be less than 60 minutes. The U.S. Military has implemented a 60-minute timeline for the transport of battlefield casualties to medical teams to include Forward Surgical Teams and Forward Resuscitative Surgical Teams. The inclusion of orthopedic surgeons on Forward Surgical Teams has been extrapolated from the concept of damage control orthopedics (DCO). However, it is not clear if orthopedic surgeons have yielded a demonstrable benefit in morbidity or mortality reduction. The purpose of this article is to investigate the function of orthopedic surgeons during the military “golden hour.”

Materials and Methods:

The English literature was reviewed for evidence supporting the use of orthopedic surgeons within the golden hour. Literature was reviewed in light of the 2009 golden hour mandate by Secretary Gates as well as those papers which highlighted the utility of DCO within the golden hour.

Results:

Evidence for orthopedic surgery within the “golden hour” or in the current conflicts when the United States enjoys air superiority was not identified.

Conclusions:

Within the military context, DCO, specifically pertaining to fracture fixation, should not be considered an element of golden hour planning and thus orthopedic surgeons are best utilized at more centralized Role 3 facility locations. The focus within the first hour after injury on the battlefield should be maintained on rapid and effective prehospital care combined with timely evacuation, as these are the most critical factors to reducing mortality.

INTRODUCTION

Trauma systems within the United States have adapted the “golden hour” principle to guide prehospital planning with the goal to deliver the injured to the trauma facility in under 60 minutes. The U.S. Military has implemented a 60-minute timeline for the transport of battlefield casualties to medical

teams to include Forward Surgical Teams (FSTs) and the recently implemented Forward Resuscitative Surgical Teams (FRST). Forward Surgical Teams are composed of anesthesiologists, general surgeons, and orthopedic surgeons in order to reduce casualty transport time to surgical care on the battlefield. Forward Resuscitative Surgical Teams are smaller units of FSTs, designed to push medical capabilities even further forward, ensuring that surgical capabilities are available within 60 minutes of every military tactical objective has become a cornerstone of military planning.¹ The inclusion of orthopedic surgeons on FSTs has been extrapolated from the concept of damage control orthopedics (DCO). However, it is not clear if orthopedic surgeons have yielded a demonstrable benefit in morbidity or mortality reduction. The purpose of this article is to investigate the function of orthopedic surgeons during the military “golden hour.”

A World War II veteran, Dr. R. Adams Cowley, acting on lessons learned as a young surgeon in France, stated that, “the first hour after injury will largely determine a critically injured person’s chances for survival.”² Although this declaration was made without specific evidence, it supported the development

*Clinical and Experimental Orthopaedics, Uniformed Services University, Bethesda, MD 79922, USA

†William Beaumont Army Medical Center, Fort Bliss, TX 79922, USA

‡Clinical and Experimental Orthopaedics, Uniformed Services University, Bethesda, MD, USA

§Clinical and Experimental Orthopaedics, Walter Reed National Military Medical Center, Bethesda, MD, USA

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of a trauma hospital system for the state of Maryland and ultimately precipitated the “golden hour” philosophy.³ Certainly the focus on effective prehospital care of time critical diagnoses (TCDs), including hemorrhagic shock, traumatic brain injury, sepsis, stroke, and cardiac arrest, along with rapid transport to the appropriate hospital (less than 5 minutes)^{4,5} has led to tremendous improvements in outcomes of TCDs.⁶ State assemblies have recognized this and passed legislation to ensure rapid prehospital care of TCDs.⁷ However, the benefits of widely applying the “golden hour” to all trauma casualties has been challenged by other reports that have not found a significant survival advantage for trauma patients with shorter prehospital times.^{8–14} In a recent review of 3,656 trauma patients taken to level I and II trauma centers in North America, there was no association between mortality and Emergency Medical Service activation, response, on-scene time, or transport.¹⁵ This finding led a cohort of emergency medicine physicians to conclude that the current out of hospital emergency care system time is less critical than previously believed.¹⁶

Despite the evidence on the contrary, the aggressive shift toward rapid transport has further condensed the “golden hour” into the “platinum 10.” The “platinum 10” refers the critical first 10 minutes following injury in which specific interventions may reduce prehospital death. These include tourniquet application for hemorrhage control and blood transfusion in the case of hemorrhagic shock.¹⁷ In a review of the casualty evacuation data of the 160th Special Operations Aviation Regiment during the Afghanistan war (2008–2015), the average time from the scene of injury to the hospital was less than 20 minutes for the 227 patients included. The survival rate was 85%. Nearly all (84%) of those that did not survive expired before reaching surgical care.¹⁸ This is consistent with previously published analyses of the current military conflicts which reported that 91% of preventable prehospital deaths were related to hemorrhage, and the preponderance of these required torso hemorrhage control.¹⁹ Moreover, the vast majority (97%) of all deaths occur in those most severely injured (New Injury Severity Score of 25–75), and half of those who are critically injured will not survive. Mortality in the most severely injured was reduced with early prehospital blood transfusion, irrespective of transport time.²⁰ Thus the mortality of those in hemorrhagic shock can be mitigated with early prehospital tourniquet application and blood transfusion.

In an effort to reduce preventable prehospital death, in 2009, Secretary of Defense Robert M. Gates mandated that prehospital transport of injured combat casualties must be less than 60 minutes.²¹ A subsequent retrospective analysis of over 21,000 casualties before and after the mandate found that after the mandate there was a reduction in killed in action (KIA) and case fatality rate. However, many other factors may have influenced the reduction in mortality other than limiting prehospital transport to 60 minutes. First, it is worth noting that a majority of patients in the series had missing

prehospital flight and treatment information.²¹ Second, after the mandate, extremity injuries increased by 10%, which are often nonlethal, potentially representing one factor leading to the reduction in KIA.^{21,22} Third, the incidence of blast mechanism of injury increased after Secretary Gates’ 2009 mandate as compared to before. Fourth, blood products were not carried on military helicopters until 2010. Fifth, the practice of damage control resuscitation, to include tourniquet use in the prehospital setting, was not fully implemented and documented during the early stages of the Global War on Terror.²² Improved prehospital interventions, such as liberal use of blood transfusion, reduced battlefield mortality by 83%.²² Taken together, it is likely that the reduction in KIA in 2009 may have been multifactorial and only partly related to the “golden hour” mandate.

Regardless of the cause of decreased mortality after the “golden hour” mandate, providing DCO within 60 minutes was not one of the factors noted to have contributed to the decreased mortality.²¹ Thus, it is reasonable to surmise that orthopedic surgeons play no role in the implementation of this standard of care. Three factors that have the greatest impact on survival are rapid medical evacuation,²³ tourniquet application,^{24,25} and early administration of blood products.²⁶ None of these are influenced by the presence of an orthopedic surgeon. Despite this evidence, DCO has been included in military medical planning as similarly essential within the “golden hour.” Damage control orthopedics is a philosophy that emphasizes early temporizing stabilization, usually by external fixation of long bones of the appendicular skeleton, sparing the individual with multiple complex injuries the physiologic insult caused by long surgical times yet while providing physiologic benefit of temporary long bone stabilization.²⁷ In contrast to DCO, Early Total Care (ETC) refers to the opposite philosophy of immediate and definitive skeletal fixation. Initial external fixation and stabilization (DCO), as opposed to definitive internal fixation (ETC), has been shown to reduce the incidence of postoperative systemic inflammatory response syndrome, multiorgan dysfunction,²⁸ total operative complications, acute respiratory distress syndrome,²⁹ operative blood loss, and operative time.³⁰

While in forward deployed setting, there is no role for internal stabilization of long bone fractures. Thus, the question is not if the patient should undergo intramedullary fixation or external fixation within 1 hour. Rather, the question is if the patient benefits from external fixation within the “golden hour.” The studies that evaluate DCO are primarily critical of ETC and additionally do not advocate for external fixation within 1 hour.^{27,31–33} In fact, very early orthopedic “golden hour” fixation of any kind can be detrimental.³¹ Battlefield medical evacuation is now so efficient in the current conflicts in Iraq, Syria and Afghanistan that immediate surgical intervention in less than suitable conditions may delay patient transport.

In addition to a potential delay of a rapid medical evacuation, early definitive fixation of long bones may not benefit

the injured service member. In a review of 61 femoral shaft fractures which underwent fixation (open reduction internal fixation, intramedullary nail, or external fixation), those who had surgery within 2 hours were 8 times more likely to become hemodynamically unstable during surgery as compared to those who had surgery after a 24-hour surgical delay. The authors advised waiting 24 hours to reduce the incidence of hypoxia, hypotension, and low cerebral perfusion pressure.³² A second retrospective review analyzed 33 patients who sustained blunt trauma causing both closed head injury as well as fractures—including femur (15), tibia (14), and multiple other fractures. Those that had orthopedic surgical intervention before 24 hours required more fluid resuscitation, had a higher rate of intraoperative hypotension and hypoxia, and a lower GCS (Gun Shot Wound) upon discharge as compared to those who had surgery after 24 hours. The mechanism of injury, admission GCS, Abbreviated Injury Scale, and Injury Severity Score were equivalent upon admission. The authors underscored that the greater resuscitation required in the early surgical group likely potentiates the sequelae following head injuries.³³

Aside from operative stabilization, even the dogma of emergent debridement of open fractures has been called into question. The Lower Extremity Assessment Project retrospectively reviewed 315 severe high energy lower extremity injuries at 8 level I trauma centers for timing of debridement, antibiotic administration, fracture stabilization, and soft tissue coverage. They found that although 27% of patients developed an infection within 3 months on the injury, there was no association with timing to debridement or soft tissue coverage. Only time from injury to admission at a trauma center was an independent predictor of infection.³⁴ The presence of an open fracture alone is not an emergency and certainly does not require orthopedic operative intervention within the “golden hour.”

The erroneous assumption that DCO should be accomplished within the golden hour has precipitated an inappropriately high utilization of key U.S. Military medical resources. The downstream effect of this overutilization has resulted in low military retention rates of surgeons, poor graduate medical education continuity, and reduced case volume in military surgical training programs which is not sufficient to maintain critical wartime combat casualty care skill sets.³⁵ To address maintenance of a military surgeon’s perishable skills and procedural ability in the setting of recurrent deployments with low volume and abnormal frequency of surgical cases, Knowledge, Skills, and Abilities (KSAs) were developed. Knowledge, Skills, and Abilities were created by clinicians based on clinical practice guidelines, case registries, and relevant literature for multiple specialties including orthopedic surgery.³⁶ In fact, the principles of external fixation are taught to general surgeons and certain Physician Assistants in the military’s War Extremity Course and Combat Extremity Surgery Course, are a component of general surgery KSAs, and have been applied with biomechanical

satisfaction to lower extremity long bone fractures by general surgery residents.³⁷ General surgeons have also effectively applied external fixators for extremity trauma at Role 2 facilities during Operation Inherent Resolve.

Non-orthopedic surgeons can apply binders to pelvis fractures, apply splints to extremity fractures, give antibiotics, and irrigate wounds—despite the fact that the timing of operative debridement of high-energy fractures is not as critical as we once thought. It may be worthwhile to have an orthopedic surgeon at a Role 3 facility to stabilize fractures when indicated and serve as the point of contact via a telemedicine consultation service for the theater. This strategy would maximize resource utilization and enable the orthopedic surgeon to perform their duties at a more medically appropriate time. Knowledge, Skills, and Abilities and the military’s Joint Trauma System Clinical Practice Guidelines may be improved by implementing specific recommended changes to include (1) Timeline for skeletal stabilization; (2) Indications for external fixation; and (3) Type of external fixation constructs (Table I).

Implementation of the golden hour mandate contributed to decreased battlefield mortality,²⁰ but providing DCO within 1 hour does not provide a survival or functional recovery benefit. In fact, data argue that DCO provided too early may be unnecessarily harmful to polytrauma patients. Within the military context, DCO should not be considered an element of golden hour planning and thus orthopedic surgeons are best utilized at more centralized Role 3 facility locations. The focus within the first hour after injury on the battlefield should be maintained on rapid and effective prehospital care combined with timely evacuation, as these are the most critical factors to reducing mortality. Appropriate resource allocation is necessary especially in light of the prospect of nonlinear war versus near-peer competitors like Russia and China.³⁸ These types of conflicts would be an inextricable strain on already taxed, finite military medical resources. Furthermore, Prolonged Field Care, care for a patient for up to 72 hours, may increase in frequency in a conflict in which the United States does not have air superiority for rapid medical evacuation. A near-peer conflict would therefore require a tremendous increase of medical resources which are already strained. The authors recommend keeping the orthopedic surgeon within the FRST structure so that the units are ready for near-peer conflicts. However, we advocate allowing “waivers” for Iraq, Afghanistan, and Syria, to be adjudicated by the consultant to the surgeon general and not the FRST commander, based on operational frequency and the volume and types of injuries sustained within operational spheres. Two potential negative consequences of this initiative are as follows: first, orthopedic surgeons may become less valued and fewer may be trained and recruited in the future, and second, orthopedic surgeons may not develop small team skills within an austere environment. However, in order to maintain a superior, effective, and durable military force, appropriate attention must be placed on manpower allocation. In this

TABLE I. Recommendations for Treatment of Combat Sustained Extremity Injuries

Timeline for skeletal stabilization
<ul style="list-style-type: none"> - The authors recommend no external fixation is necessary in Role 1 (unit-level field care) and Role 2 (mobile field surgical care) facilities. - All extremity injuries should initially be splinted with preparations made for evacuation to higher levels of care. - The only relative indication for external fixation in a Role 2 facility would be if air transport to a Role 3 (a fixed medical treatment facility with expanded surgical capability) would be greater than 24 hours, as in the case in which the United States and its allies do not maintain air superiority.³⁰ - If a surgeon feels that radiography is required, transport to a Role 3 facility should be considered. - Role 3 facilities should have large and small power to permit expedient external fixation of the appendicular skeleton; radiography is not typically required. - Role 3 facilities should coordinate with the Role 4 (base hospital in United States or allied nation) facility regarding timeline for transfer and should stabilize fractures with external fixation within 24 hours of the injury.
Indications for external fixation in an austere environment (Role 3 facility)
<ol style="list-style-type: none"> 1. Fractures of the femoral shaft 2. Comminuted fractures of the tibial shaft with significant soft tissue injury. Most tibia fractures can be splinted. 3. Any long bone fracture in which the surgeon does not feel may be adequately stabilized during transport to a Role 4 facility 4. Concomitant vascular repair, soft tissue injury, or those who are hemodynamically unstable 5. Hemodynamically unstable pelvic ring fractures not adequately treated in a pelvic binder, pelvic ring injuries requiring surgical access to the lower abdomen or pelvis, and pelvic ring injuries requiring stabilization but with anticipated prolonged evacuation time
Type of external fixation constructs:
<ol style="list-style-type: none"> 1. Ankle spanning external fixation—which can span most of the tibia—“delta frame” 2. Knee-spanning external fixation 3. Femoral shaft external fixation 4. Pelvic external fixation utilizing iliac crest pins
Additional pearls
<ul style="list-style-type: none"> - We recommend against any external fixation in the upper extremity in theater unless associated with a vascular repair or large concomitant soft tissue injury. - The vast majority of upper extremity injuries can be immobilized in a splint. In addition, upper extremity anatomy is complex and damage to a neurovascular structure may introduce unnecessary morbidity. - These recommendations can be extrapolated to civilian trauma in rural settings. - In a polytrauma scenario in a small rural medical facility, we recommend established communication and action plan in conjunction with a larger facility with expanded resources, rapid facilitation of transportation, and skeletal stabilization with splints.

context, the most effective and optimal placement of orthopedic surgeons should be centralized at Role 3 Combat Support Hospitals.

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