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Daniel J. Zinder, Captain, MC, USN

Paper Advisor (if Any): William J. Hartig

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14. ABSTRACT

Consolidating battlefield surgeons when conditions allow will provide more surgical care to more patients in less time with fewer resources. However, the emotional commitment of a commander to his wounded is extremely strong and leads to the inappropriate attachment to a local surgeon. The attachment creates a great deal of resistance to moving surgeons on the battlefield. This paper explores the reason for this resistance and shows that it is based on faulty logic and misunderstanding of counter intuitive principles. Data from the civilian trauma literature and examples from Operation Iraqi Freedom are provided to demonstrate the benefits of consolidation. When done to increase the capability of the trauma system it is an enhancement to care, not a degradation. The Commander must assure that everyone in his command understands this value, and has confidence that care is available, in order to maintain the fighting will of the force.

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COMBAT TRAUMA- PLACING SURGEONS TO SAVE THE MOST LIVES

by

Daniel J. Zinder

CAPT MC USN

A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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06 Nov 2007

Abstract

Combat Trauma- Placing Surgeons to Save the Most Lives

Consolidating battlefield surgeons when conditions allow will provide more surgical care to more patients in less time with fewer resources. However, the emotional commitment of a commander to his wounded is extremely strong and leads to the inappropriate attachment to a local surgeon. The attachment creates a great deal of resistance to moving surgeons on the battlefield. This paper explores the reason for this resistance and shows that it is based on faulty logic and misunderstanding of counter intuitive principles. Data from the civilian trauma literature and examples from Operation Iraqi Freedom are provided to demonstrate the benefits of consolidation. When done to increase the capability of the trauma system, it is an enhancement to care, not a degradation. The Commander must assure that everyone in his command understands this value, and has confidence that care is available, in order to maintain the fighting will of the force.

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INTRODUCTION

Small mobile surgical teams attached to maneuver units save lives in the initial stages of major combat operations.[1] Consolidating surgical capability in later phases of an operation will save more lives with fewer resources. Surgical care can be initiated sooner, the variety of specialists can be increased, and fewer complications are encountered. Tactical commanders, however, resist moving surgeons away from their areas of responsibility, even when it will provide timelier, more comprehensive care to their wounded. This problem of resistance and its complexity are well known.[2,3,4,5,6,7]

The purpose of this paper is to discuss the reasons for this resistance and further, to provide recommendations for overcoming it. The premise is that surgeons should be placed in the battlespace to save the most lives. When conditions permit in late Phase 3 or beyond, small surgical sites should be consolidated and incorporated into a theater trauma system that provides rapid evacuation, increased surgical capability, and surge capacity for mass casualty events. This can be shown empirically, but the resistance to moving surgeons on the battlefield is high. The resistance exists because it interferes with the emotional attachment of leaders to their wounded, is based on counter intuitive principles, and contradicts common beliefs passed down through generations of military personnel.

The approach is to first discuss the intense emotional component through excerpts of conversations with tactical commanders during Operation Iraqi Freedom (OIF). Then, explain three misunderstood concepts driving line officer opinions on surgical placement; the Golden Hour, the Capability-Proximity Paradox, and the Surgeon mentality. Data from civilian trauma literature and from OIF surgical experience is provided as supporting

evidence. Finally, recommendations for maintaining premier surgical care on a dynamic battlefield are provided.

Although the examples and discussion in this paper are based on experience in Iraq, the principles apply in any trauma environment, civilian or military. The optimal trauma system is a layered network with exponentially increasing capability from first responder through definitive surgical care. The uncertainties of early combat do not allow a trauma network to be established on initial deployment. Surgical capability is distributed across the battlefield in a time-space distribution to provide the best possible care under the circumstances. As areas of the battlefield progress in the operational phases, the opportunity to move toward a trauma system can be assessed. Some areas may need to remain decentralized, while others can increase in capability. Conditions need to be right to make the move, but as shown in this paper, trauma systems save more lives than distributed parallel assets.

Recent changes to Joint Doctrine describe a capabilities based approach to combat medical care.[8] This move away from traditional Levels of Care is congruent with the expedited development of trauma systems on the battlefield. Levels of Care facilitated restrictive thinking that attached units to specific capabilities instead of encouraging a systems approach to care. Professional military education (PME) based on this joint doctrine can provide an opportunity to discuss the benefits of moving to trauma system management as soon as feasible in the combat environment. Included in the PME should be discussion on the detriment of emotional attachment to distributed local surgical care and why the trauma system is an enhancement to care for the wounded warrior.

EMOTIONAL COMPONENT

The emotional tax of the wounded on a Commander cannot be underestimated. He feeds, houses, clothes, and provides safety for his men. He also sends them into combat. Agreeing to move a surgeon away from the area, removing his opportunity to witness and control care to his wounded, runs counter to his intense commitment to his men. The quotes below are from different US Marine Corps tactical commanders during OIF 05-07, when they were individually briefed on a plan for Phase 4 surgical consolidation.[9] This brief became known as the "[Expletive] Brief" because of the expletives it evoked on each presentation. "I see the numbers, I understand it, I know why this is better….. Do it to someone else!" "You know what? [Expletive] this! I want my surgeon. I'm taking care of my guys!" "Then at least put helicopters on our base so I can hear them spinning to pick up my men!" And finally, a few days after watching a surgeon slice open the chest of one of his men and shove his hand in through spewing blood to manually massage his heart, "But Doc… What they did to that kid (with tears welling)... you can't take that away from me!"

These statements portray the feelings of responsibility, guilt, helplessness, vulnerability, and the need to trust another unit for transport. The thought of waiting for a helicopter that cannot be seen or heard when one or more of your men is on the ground, bleeding and moaning, possibly screaming in pain, is untenable when you know you could put him in a vehicle and drive him yourself, even if the drive will take longer than the flight.[10] As pointed out by a Battalion Commander, "Fifteen minutes is an eternity in that situation."

The surgeons themselves are not immune to this sense of moral obligation. In discussion with the surgeon who opened the chest of the patient above, he noted the condition of the patient when he came in.[11] "He was cold. His pupils were fixed and dilated. He was dead."

When asked why he opened the chest, he said, “Because there were 10 guys standing at the door looking at me after driving him across IED laden roads, and their eyes said, ‘We did our part doc, now you do something’” Which begs the question, what does moving a surgeon miles away from a unit do to their will to fight. If surgical consolidation results in more loss due to decreased morale, then the effect of saving more of those who do come in is wasted.

The emotional attachment to the wounded is a major driver in the resistance to surgical consolidation. Some of the emotion, however, stems from misunderstanding the facts underlying care. The next section examines misconceptions and counter intuitive principles that underlie combat casualty care. Understanding these can help commanders see the value of consolidation and teach their men why it is an improvement in care as opposed to a degradation. This education is critical to maintain the fighting will of the force.

UNDERLYING PRINCIPLES

The Golden Hour

The Golden Hour concept has developed into the commonly held belief that a wounded warrior will have the highest likelihood of survival if he is delivered to a surgeon within 60 minutes after wounding. This belief unfortunately, is not borne of fact. Death from combat trauma is a logarithmic function of time (Figure 1). It is different than the tri-modal pattern of death seen in civilian trauma (Figure 2). And neither shows a step in survival at the 60 minute point. The Golden Hour is best conceived as an imperative to get the patient to the *right* care in the *shortest* amount of time. For example, taking a patient with penetrating head trauma to a general surgeon at a forward surgical site in less than 60 minute would be detrimental compared to flying 90 minutes directly to a neurosurgeon.

The concept is poorly adapted from civilian trauma data and has taken on mythical power in the military. The myth is perpetuated by folklore,[12] by articles that define it without reference,[13,14] and by civilian hospitals that use it for advertising.[15] The level of a Commander's attachment to the Golden Hour is exemplified in OIF by the Corps Commander requiring each Division commander to report any CASEVAC flight that extended beyond 60 minutes in the daily battle update brief.[16]

The origin of the term "Golden Hour" is unclear, but many attribute it to Dr. R. Adams Cowley, a pioneer in US civilian trauma care.[17,18] Others refer to French World War I combat survival data that shows survival at 90% if shock is treated within the first hour after wounding (Figure 3). This is consistent with NATO doctrine which refers to the Golden Hour in relation to advanced resuscitation, not surgical care.[19] The Golden Hour is a useful concept for expediting care but over time it has developed into the belief of a 60 minute period of safety. Review of the medical literature reveals there is no clinical data to substantiate the Golden Hour as a 60 minute interval to initiate definitive care.[20]

Using time-space factors to distribute limited surgical capabilities in the battlespace in the initial phases of combat is prudent.[21] As the theater matures and Phase 4 stability operations are entered, a capabilities based trauma system will provide more care for more people in less time, even with evacuation times greater than 60 minutes.

The first step in emotionally accepting the benefits of surgical consolidation lies in releasing attachment to the Golden Hour as a 60 minute period. This folklore forces many commanders to adhere to an arbitrary timeline as opposed to what is best for the care of the wounded. Releasing it however, removes a psychologically important measure to confirm to a Commander that he is doing all possible for his troops.

The Proximity-Capability Paradox

The proximity-capability paradox is the counter intuitive, but well proven, concept that the surgeon a commander can see, touch, talk with, and watch operate will better serve the unit if moved several miles away with other surgeons. British WWII experience in Africa[22] and US experience in OIF[23] have shown that two surgical teams working together can do more surgery than two geographically separate teams.

Some of the gained efficiency is a practical matter of surgeon availability. If two teams are available to operate, cases are normally completed on a rotational basis. With one team in surgery, the other is available to evaluate and resuscitate patients waiting for surgery. As soon as the team operating finishes, the other can roll into the second room and begin a case. This frees the finishing team to take on triage/resuscitation, and the crew to clean the room for the next case. The rotation removes the significant period when a single team finishes a case, then has to reevaluate the patients to determine who will go next, while the room is being cleaned. In surge periods, two cases can be done simultaneously if needed.

A less quantifiable part of the synergy occurs when surgeons are able to compare ideas and validate procedures with each other. The surgeries go more smoothly and there is a higher level of confidence in precarious situations when the surgeon knows assistance is available if needed, especially for young, less experienced surgeons.

Consolidation also effects surgical specialty mix and caseload. When more than three teams are consolidated, the specialty mix can be expanded to include areas such as Head and Neck, Thoracic, or Vascular surgery. This increased capability provides a higher level of care with the same number of surgeons. When separated into small minimally capable surgical units, some units may be busy while others slow. In the less used surgical units,

skills may stagnate, and boredom is a problem. Then, when suddenly very busy, the surgery is less than optimal. The best care is provided when surgical teams are operating daily and the techniques and procedures for the worst trauma becomes routine.

The Surgeon Mentality

The surgeon mentality can be summed up by the cliché, "Have knife, will cut." Surgeons have a deeply rooted belief that the best surgeon for an injured patient is themselves. This is a matter of survival as opposed to arrogance. If a surgeon constantly believed that another surgeon could do better, he or she could never operate.[24] When a lone surgical team receives multiple patients, they will stack the patients and work through them one by one as opposed to sending some on to another surgeon.

Patient stacking is a multi-faceted problem. A surgeon's belief in his or her skills is one facet. Determining who to send to the next surgeon is another, and is not possible while the surgeon is tied up in the operating room (OR). The surgeon will perform a quick triage between cases and go to the OR with the most severe case as soon as the room is available. Who and when to send is a complex decision than cannot be made in a quick sweep between cases. Stacking is common and results in delayed care for many wounded. Even though a combat unit may transport their wounded to the surgical team within a mythical timeline, the actual time to treatment may be much longer if the OR is full and multiple patients need surgery. It is a simple problem of queuing.

Another aspect of the surgeon mentality is the surgeons' well honed practice building skills. Developing referral source relationships is inherent to their training. In combat, referral sources are unit commanders, and commanders develop a very close relationship

with “their” surgeon. This relationship adds to the separation anxiety of moving the surgeon away from the local area, even if it will increase care to the wounded.

CIVILIAN LITERATURE

Civilian trauma literature is rich with information related to surgical consolidation. Three specific areas that apply to combat trauma are the value of damage control surgery, the impact of case volume on surgical outcome, and the practice of bypassing nearby facilities to arrive at more capable centers further away.

Damage control surgery refers to only doing what is absolutely surgically necessary to save the person’s life. It is a technique used in the sickest of sick. Once immediate life threatening injuries are temporized, the patients are moved to an intensive care unit to normalize their physiology. Ultimately they go back to surgery for definitive procedures. Damage control surgery’s value and effectiveness are well documented.[25,26,27] Its use in combat is valuable in high tempo mass casualty scenarios even though each individual patient may not require it physiologically.[28]

The concept of what constitutes damage control has been stretched in combat. One surgeon in a small surgical site in Iraq defined damage control as anything he could complete in 30 minutes operating time or less.[29] The definition creep allowed the surgeon to take on cases in a remote location rather than only resuscitate and send to the next higher level of care. This example of, “Have knife, will cut,” results in cases being done where it is not optimal for their outcome.

The medical literature on the relationship of trauma volume and patient outcomes is controversial. A premise for battlefield surgical consolidation is that a team caring for trauma regularly will better serve the patients than one that sits idle for weeks between cases.

Studies examining case volume versus outcomes are inconsistent. Nathens found significantly better outcomes in higher volume centers when patients presented in shock, but no difference if shock was not present.[30] Glance found no survival difference based on hospital volume for the severely injured.[31] London found hospital volume to be a poor proxy for patient outcome.[32] In fact, he found a trend for worse survival in the most severely injured at the busiest facilities. Demetriades found no difference in outcome due to volume but did find more capable facilities (Level I Trauma Centers) had better outcomes than lesser capable facilities (Level II Trauma Centers).[33]

The four studies described above all made comparisons at the facility level. They were limited by not looking at individual surgeon volume. The Institute of Medicine makes clear statements on this topic.[34] "There can be little doubt that for a wide variety of surgical procedures and medical conditions higher volume is associated with better health outcomes."[35] Many studies exist showing positive volume outcome relationships for individual surgeons in specific procedures but little exists in this regard for trauma. Recently, however, Haut found patients treated by part time trauma surgeons suffered 50% greater mortality than those treated by full time trauma surgeons.[36]

Much of the variability in facility based studies may be in the standard procedures in place and the relative familiarity of the operating teams working together. Remote battlefield surgical teams with low volume do not have the opportunity to smooth their procedures before major trauma arrives. And young surgeons 'alone and unafraid' are left to fend for themselves in markedly complex situations. Surgical consolidation allows for increased volume at central locations, with increased volume for each surgeon. This equates to making each a "full time" trauma surgeon. Consolidation also allows for pairing inexperienced

trauma surgeons with experienced, as well as with super-specialists. The volume and synergy facilitate good outcomes and develop future generations of combat surgeons.

Another counter intuitive concept of surgical consolidation is sacrificing time by bypassing a local medical facility to go to a more capable facility. Many combatants think of medical as a "black box." However, a nearby Battalion Aid Station (BAS) is not an equal choice to the surgical center several miles away for the litter borne wounded. During OIF II, many units would drive their wounded to the BAS where the General Medical Officer with limited supplies and skills could only begin minimal resuscitation and call a helicopter to transfer to the appropriate surgical site.[37] This resulted in delayed treatment, even though the unit dropped the patient off at "medical" within a specified time period.

Trauma care regionalization has been extensively studied in the civilian community. Surgical regionalization with centralized trauma centers gives the best opportunity for good outcome when compared to distributed, less capable facilities. Young found shorter hospital stays and lower mortality in the direct arrivals.[38] Sampalis found reduced morbidity and mortality in those brought directly to the trauma center.[39] And in a subsequent larger study he concluded that integration of trauma care services into a regionalized system reduces mortality.[40] Continued reevaluation of trauma systems supports the concept. MacKenzie recently found that the risk of death is significantly lower when care is provided in a more capable trauma center than in a non-trauma center.[41]

OPERATION IRAQI FREEDOM EXAMPLES

Two mass casualty events in Iraq are provided to demonstrate several of the principles described and the resource savings possible with surgical consolidation. These events also demonstrate the increased care possible through consolidation.

Figure 4 displays the surgical timeline for a mass casualty event. The top half is the actual event timeline, and the bottom is what would have happened if surgeons were consolidated regionally. Three main points to note: 1) Volume Capability- In the consolidated scenario (bottom half), all cases are completed more than 8 hours earlier than the non-consolidated (top half). 2) Surge Capacity- Patient stacking of urgent cases creates a backlog for surgery in the actual scenario. The two urgent cases (#3 and #8) at facility B, a single operating table facility, are completed sequentially. The same cases in the consolidated scenario, although starting 20-30 minutes later due to transport time, would have been completed approximately 2 hours earlier than when stacked sequentially. And a third room is still open to take immediately life threatening injured patients. 3) Triage availability- Case #1 on the top was initially triaged as Priority. Patient #1 began to decompensate while the surgeons were in the OR with cases #3 and #8. They brought him to surgery and found a normal abdomen despite his low blood pressure. Ultimately he was shipped to the more capable Combat Support Hospital where a CT scan of his head found an intracranial process and he underwent a second surgery, identified as Case #1-2 in the top half of the diagram. It is speculated that serial examinations made possible by roaming available surgeons would have caught this malady earlier and the patient sent to the neurosurgeon sooner, resulting in one anesthetic, vice 2. It still would have been appropriate to open the belly of this patient in either scenario to assure hemostatic conditions, but this would have been done during the same anesthesia, resulting in less anesthetic risk to the patient, earlier treatment, and release of the remote surgeons for other patient care.

The question arises of the impact of starting the cases 20-30 minutes later than the actual scenario. This is only the case for Case# 3. Case #8 would actually have been started ~1.5

hours earlier. There would have been no impact to the case outcome. The immediate actions of the Corpsmen and Medics in lifesaving measures such as stopping hemorrhage and stabilizing airways buys two to three hours of time in all but the terminally wounded.

In terms of resources, the consolidated surgical scenario in this example saves one general surgeon because of the mix of surgeons available at the consolidated site. The result is more surgery for more patients in a shorter amount of time with fewer surgeons. Although number of surgeons on the battlefield is not the driving factor for consolidation, this stewardship of personnel cannot be underestimated.

Figure 5 demonstrates the air asset savings in a consolidated surgical plan. This actual event involved a mass casualty scenario with 19 patients. The flight savings are based on location of helicopters with respect to surgical facilities. If the consolidated surgical facilities are on the larger bases where the helicopters are staged, then the savings can be significant. With the non-consolidated lay down, the helos go from launch to point of injury, then from point of injury to the remote surgical facility, and then they fly empty to their home base. When it's time to fly from the remote facility to the higher level of care, they fly empty from home to the remote facility and then to the higher level facility. This is two empty legs per trip, and each often has an escort helo associated. If all the surgery is done on the same base as the helo staging, this scenario saves 14 flight legs with 15.63 total hours of flying time and associated maintenance. In the high op-tempo flight ops of combat, this is a major savings.

OTHER ARGUMENTS

"Put two surgical teams at every remote site." This knee jerk response has several negative implications. Tactically, the surgical units become less mobile and unable to fit onto expeditionary platforms. More idle surgeons are a waste of precious resource, but also

with their mentality they find cases to do. In Iraq this often meant taking on routine civilian cases from the community. This had a secondary effect of showing the people their government could not care for them and was not nested with the goals of higher command.

"You're just doing this to save surgeons." Although the deployment strain on the surgical community is high, it cannot be a driving force for placement of surgeons on the battlefield. The medical requirement must be set and then the surgeons found to staff it. If there is a decrease in the total number of surgeons required with consolidation, then that is a fortunate byproduct. Unfortunately, previous efforts to argue for consolidation used the strain on surgical manpower as a driving argument and this decreased legitimacy of the medical department. This paper is written from a data driven approach to remove all emotion and lay out the 'facts on the ground' so an informed decision can be made. The data clearly shows that surgical consolidation, when possible, is beneficial.

"Next you will want to take away my Battalion Surgeon" On the contrary, the Battalion surgeon serves a vital roll in force health protection. Disease and non-battle injury remain the primary reasons for medical loss of personnel. Prevention, wellness, training, sick call, and advising the Commander are vital to successful military campaigns and are accomplished by the Battalion Surgeon. Their role in a trauma system however, is minimal. With respect to combat casualties, only the walking wounded should be brought to the Battalion Surgeon when more capable facilities are available.

RECOMMENDATIONS

1) Decision- The decision to consolidate should be made at the Division level or higher. Tactical commanders below Division are too emotionally attached to make a rational decision.

2) Education- The entire chain of command, from the Commander to the most junior enlisted, must understand the general concepts of consolidation and that it is an increase in capability, not a degradation. It should be explained as a move to a more capable trauma system from the less capable distributed trauma care.

3) Timing- Surgical consolidation should be considered when areas on the battlefield are beginning to change operational phases.

4) Conditions- Air superiority and secure lines of communication must be in place. Climate/weather must be favorable with associated distances and modes of travel.

5) Flexibility- The ability for a quick reaction force surgical team must be maintained. Equipment and staffing must be identified and training maintained for rapid deployment to named operations or contingencies.

CONCLUSION

Surgical consolidation incorporated into a combat casualty trauma system will provide more care to more wounded with fewer resources. However, the emotional commitment of a commander to his wounded is extremely strong and leads to the inappropriate attachment to a local surgeon. This attachment creates a high degree of resistance to moving surgeons on the battlefield. The resistance is rooted in faulty logic and misunderstanding of counter intuitive principles. Educating the combatants, from the Commander to the most junior enlisted, is a critical requirement to overcome this resistance. The logic and counter intuitive thoughts must be fully explained to make the optimal care palatable and understandable. The unit must have confidence that care is available and that the system in place gives them the best chance for survival in order to maintain the fighting will of the force.

APPENDIX A

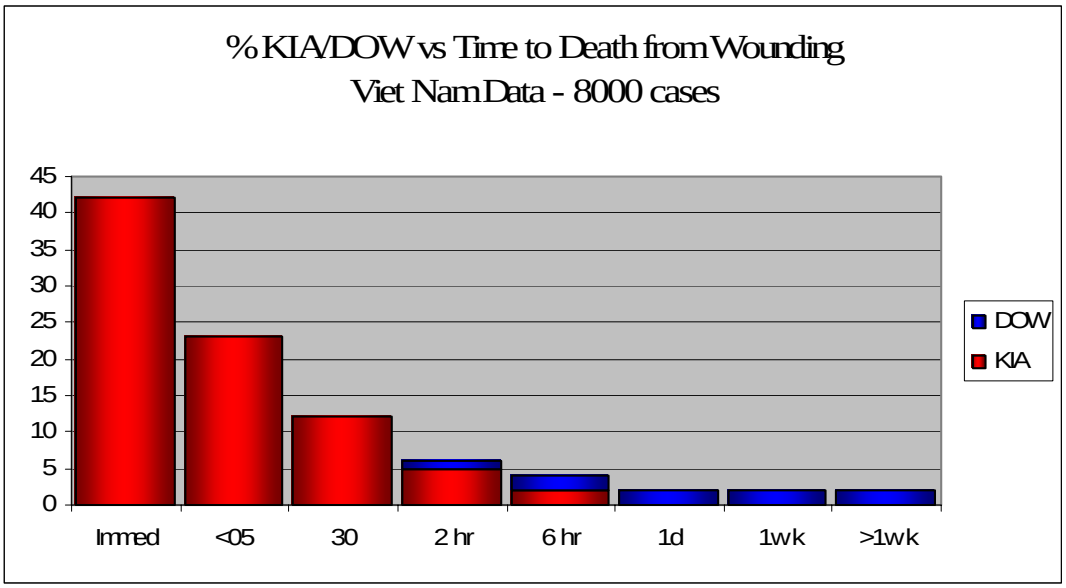

Figure 1. Mortality data from time of wound to death- Viet Nam

Adapted from Bellamy.[42] Based on 8000 records collected by the Wounds Data and Munitions Effectiveness Team (WDMET) during the Viet Nam War. The chart shows the percentage of Killed in Action (KIA) or Died of Wounds (DOW) as a function of time from injury. As Bellamy notes, the distribution is different than Trunkey's civilian trauma data shown in Figure 2. Specifically, there is no tri-modal distribution, which suggests combat trauma is different than civilian trauma. It is also important to note that nearly 80% of KIA are well within 60 minutes, with approximately 65% in the first 5 minutes. "The implication for combat casualty care, based on the observed distribution of deaths in the WDMET data, is obvious: if there is a 'golden' period, it is a golden 5 minutes."

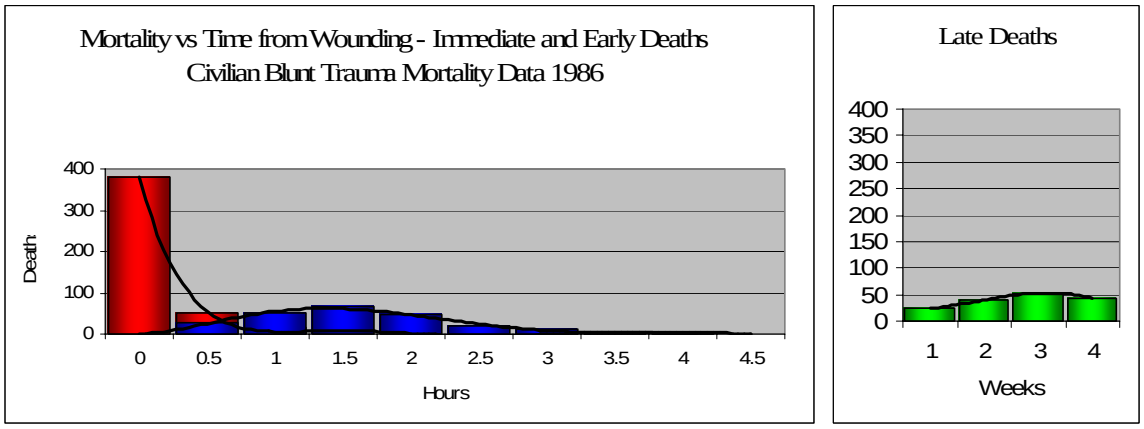

Figure 2. Mortality data from time of wound to death- Civilian

Adapted from Trunkey.[43] These graphs depict 862 trauma deaths in San Francisco. They show a tri-modal distribution with 'Immediate Deaths' in red, 'Early Deaths' in blue, and 'Late Deaths' in green. Immediate deaths were typically the result of laceration of the brainstem, brain, upper spinal cord, heart, or major vessel. Trunkey notes that only a fraction of these could be saved even in the best of circumstances. The 'Early' group is the one where time to treatment is critical to outcome. These deaths were typically due to major internal hemorrhage of the head, respiratory system, or abdominal organs, or multiple smaller wounds causing severe blood loss. The "Late Deaths" are a result of infection or multiple organ failure. Many attribute this data to the Golden Hour concept because starting treatment (not specifically surgery) roughly within the first hour will enhance the chances of survival for these patients. More importantly, however, it is a different distribution than the chart of combat deaths vs time in Figure 1.

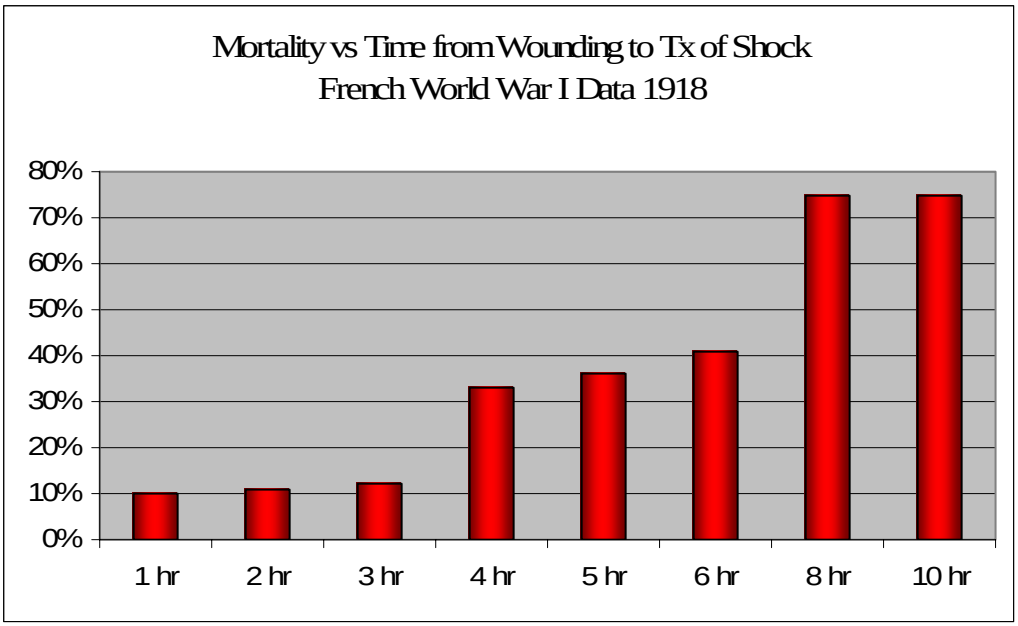

Figure 3. Mortality data from time of wound to treatment of shock- 1918

Adapted from Trauma.Org.[44] French Data. "In World War I, there was a real appreciation of the time factor between wounding and adequate shock treatment. If the patient was treated within one hour, the mortality was 10 percent. This increased markedly with time. After eight hours, the mortality rate was 75 percent." Some consider this the first data to support the concept of the "Golden Hour," but note that the time on the x-axis is time to treatment of shock, not specifically to surgery. This is consistent with NATO doctrine of advanced resuscitation within 1 hour of injury when needed. Also note that the change in mortality at 2 and three hours is minimal even without treatment of shock in these patients. This may be related to the type of wounds received.

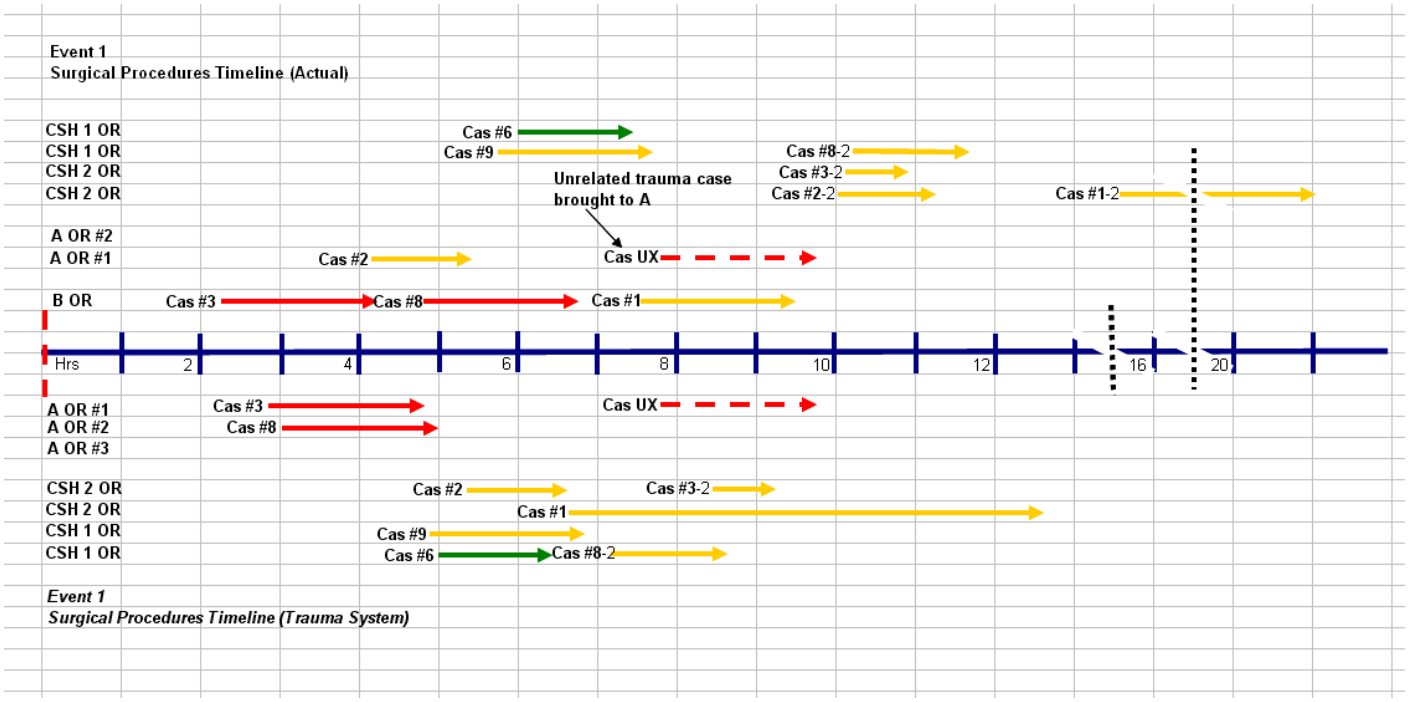

Figure 4. Mass casualty surgical data- Iraq OIF 05-07

Surgical timeline for mass casualty event in Iraq during OIF 05-07. Top half is actual event timeline, bottom is what would have happened if surgeons were consolidated regionally at Facility A, instead of distributed at facilities A and B. CSH 1 and 2 are Combat Support Hospitals, which are a higher level of care approximately 90-120 minutes away by air. Each arrow represents one surgery. Color indicates triage category: Red = Urgent, needs surgery as soon as possible, Yellow = Priority, needs surgery within 4 hours, Green = Delayed, needs surgery within 12-24 hours. The dotted red line is a case not related to the mass casualty event that was brought into the same treatment facility. Cases #6 and #9 required specialty care not available at the remote site- ophthalmology and neurosurgery. Cases #3 and #8 underwent damage control procedures and were sent on to the higher level of care for definitive care. Case #1 decompensated while in the OR with Case #8 and was taken to the OR to explore the abdomen. This was negative and the patient was sent on to the higher level of care where he was found to have an intracranial process. Cases #4, #5, and #7 did not require surgery. In the proposed consolidation shown in the bottom half of the diagram, all cases finish more than 8 hrs earlier, with the urgent cases #3 and #8 finishing more than 2 hours earlier than the actual.

Patient Movement Summary of Mass Casualty Case Study (Escort aircraft not included)

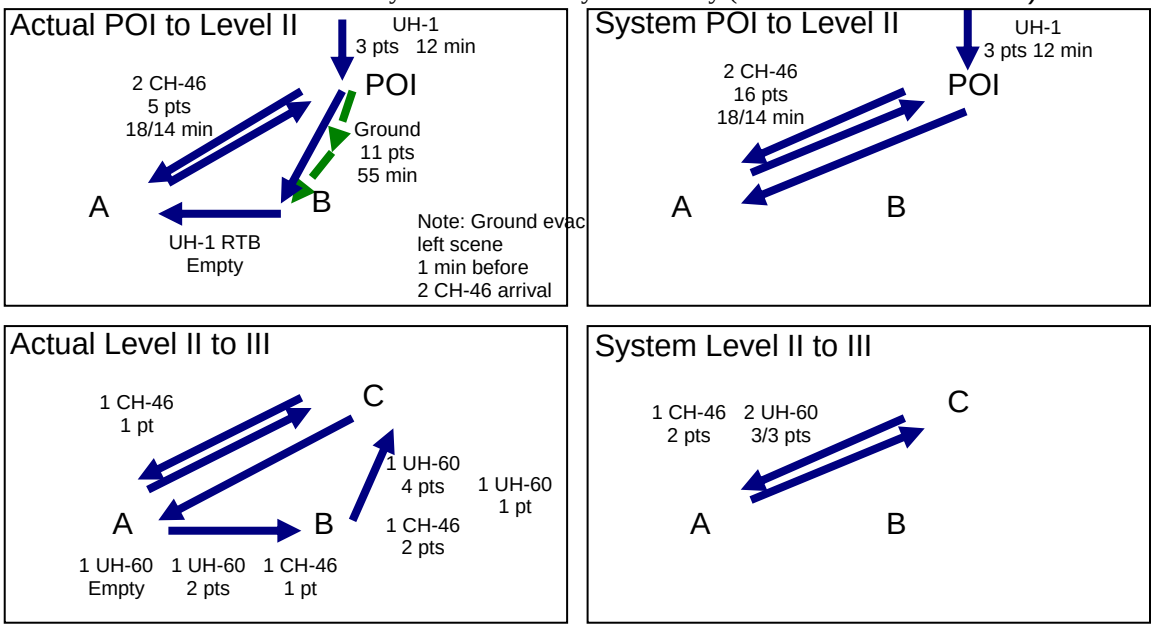

Figure 5. Mass casualty flight data- Iraq OIF 05-07

Example of saved flights from surgical consolidation. Actual mass casualty scenario in Iraq. In this episode, the consolidated surgical set up would have saved 14 flight legs, 15.63 hours of flying time and associated maintenance hours, and cases would have been completed 12 hours earlier for 19 Patients (2 Urgent, 4 Priority, 4 Delayed, 7 Minor, and 2 Evac)

Another event, not diagrammed had the following potential savings:
15 Patients (4 Urgent, 7 Priority, 2 Delayed, 2 Minor, + 4 Evac) Cases complete 10 hours earlier, 16 Fewer flight legs, 19.62 Saved flight hours

END NOTES

[1] Harold R. Bohman and Bruce L.Gillingham, "Saving Lives Up Front: Forward Resuscitative surgery," *United States Naval Institute Proceedings* 132, no. 4 (April 2006): 28-32.
"Of the 895 trauma patients showing signs of a pulse who were treated by the surgical platoon between March 2004 and 2005, 97% survived." "The surgical shock trauma platoon model offers a highly effective combination of proximity and capability for patients who cannot be evacuated rapidly to a combat surgical hospital. Determining the ideal relationship between proximity to surgical care and the capability of the surgical unit, however, remains a challenge."

[2] Joseph F. Rappold, "Navy Medicine in Critical Condition," *United States Naval Institute Proceeding* 131, no 12 (December 2005): 25-27.
"In the now mature combat theater of Iraq, Navy medical assets continue to be poorly staffed and used. Despite advanced levels of care rapidly available from Air Force and Army facilities, top Marine Corps line officers are unwilling to divest themselves of the rapidly mobile but less capable Navy units used during the attack phase."

[3] Joseph F.Rappold, "FRSS Teams in Iraq: A good idea whose time has come," *United States Naval Institute Proceedings* 133, no. 2 (February 2007): 22-23.
"The forward surgical teams made sense during the maneuver phase of the war. Not anymore…. It does not make sense to perform complex surgical procedures in a Base-X tent or comparable hardened structure with minimal support and supply when – with careful planning, reasonable communication, and triservice cooperation- a more capable facility can be found less than 45 minutes away by helicopter, and, if needed, ground transportation."

[4] Harold R. Bohman and Bruce L.Gillingham, "Saving Lives Up Front: Forward Resuscitative surgery," *United States Naval Institute Proceedings* 132, no. 4 (April 2006): 28-32.
"The resources required to provide life-and-limb salvaging care to severely injured casualties is considerable- not only in terms of medications and supplies, but in man hours and stress on the team. Just a few combat casualties, occurring either simultaneously or over a relatively short time period (24 to 48 hours), can completely overwhelm this limited capability. The logistic support, communications, security, and ability to move recently stabilized post-operative patients are as essential to the success of these units as is their forward location. Careful consideration of the tactical situation must be given to balancing the benefits of enhanced proximity afforded by small, mobile forward surgical units against the disadvantages of dispersing resources, and experience, throughout the battle space."

[5] Arthur M. Smith and Harold R. Bohman. "Medical Command and Control In Sea-Based Operations." *Naval War College Review* 59, no. 3 (Summer 2006): 53-71.
"During redeployment of Navy medical assets in IRAQI FREEDOM II,* the location of surgical assets was again often determined by ground combat commanders, who based their decisions upon evacuation times, attempting to ensure that every Marine was within one hour of an operating table, if needed. This once resulted in placement of a Navy FRSS team within twelve minutes' evacuation time of an established advanced Army combat support hospital, thereby creating redundancy and wasting limited valuable resources that were needed elsewhere, such as during the initial operations in Fallujah."

[6] William H. Ogilvie, *Forward Surgery in Modern War* (London, Butterworth, 1944), quoted in Harold R. Bohman Bruce L.Gillingham, "Saving Lives Up Front: Forward Resuscitative surgery," *United States Naval Institute Proceedings* 132, no. 4 (April 2006): 28-32.Discussing British use of forward surgical teams in Africa 1944, " This point must be insisted on, because there is constant temptation on the part of keen medical administrative officers to push forward their surgeons beyond the point where they can do useful work, and for surgeons there to undertake more than life saving surgery with the splendid folly that prompted the Charge of the Light Brigade"

[7] St. J.D. Buxton, "Surgical Experience in the Middle East," *British Journal of Surgery* 31, no. 122(1943):111 – 127.

Buxton describes the far forward mobile surgical teams. In one section he notes the attachment of the forces to the Surgeons, especially when things are slow and they can do other cases. "…and it was thought the troops appreciated this surgical team so far forward during a time of ebb and flow of the fighting." Later he describes, the thoughts of the surgeons. "Undoubtedly early operation is ideal (Note- early in this context is 1.5 to 6 hours from time of wounding) but at this time the surgeons operating in the forward areas were definite in their opinion that operations should be limited to those who are *severely* wounded. The practice [sic] of operating on all wounded in field hospitals during an 'ebb and flow' battle, without discrimination, is bad policy."

[8] Chairman, U.S. Joint Chiefs of Staff, *Health Service Support,* Joint Publication (JP) 4-02, (Washington DC: CJCS, 06 October 2006), iii.
"Replaces the traditional five phases of casualty care management with the seven health service support capabilities of policy and resource acquisition capability, prevention and protection capability, first responder capability, forward resuscitative capability, theater hospitalization capability, definitive capability, and en route capability.

[9] Conversations with unit commanders after briefing them on a plan for surgical consolidation during OIF 05-07, Al Anbar Iraq, June 2006. (unattributed)

[10] Conversation with Lynn Welling CAPT MC USN, 1st Marine Logistics Group Surgeon, Al Taqaadum Iraq April 2006. The civilian equivalent of this behavior is a husband or wife putting their spouse in the car, while they are having a heart attack, to drive then to the nearest medical clinic or community hospital. Often times these facilities do not have what is needed to care for the patient and transfers to the proper location, ultimately delaying care. If the spouse would have called 911 the patient would have received care en-route and been taken to the facility of choice as opposed to the nearest less capable facility.

[11] Conversation with General Surgeon at an FRSS in Al Anbar Iraq, June 2006. (unattributed)

[12] Lt Gen Peter Chiarelli, V Corps Commander OIF 05-07. During video teleconference discussed discussion he had with the Corps Surgeon, "You mean to tell me that the Golden Hour that I grew up with my entire career is wrong? I'm not buying it. I called the Army Surgeon General and asked him to show me the data." September 2006.

[13]Guy S. Strawder, "The 'Golden Hour' Standard, Transforming Combat Health Support," *Joint Forces Quarterly* 41, (2nd Quarter 2006): 60-67.
"At the heart of that conviction is the standard to which the entire brotherhood of military medicine must hold itself personally accountable: the *golden hour*, broadly the first 60 minutes following trauma or the onset of acute illness. The chances of survival are greatest if surgery or advanced trauma life support can be provided within that hour."

[14] Murray Hammick, "The cutting edge: Battlefield casualty management." *International Defense Review* 25, no. 3 (1993):243-51 "The concept of the "Golden Hour" following wounding is well established."

[15] University Hospital, University of Medicine and Dentistry of New Jersey, "The Golden Hour," http://www.theuniversityhospital.com/trauma/gold.htm (accessed 08 September 2007).
"The Golden Hour is defined as the tine period of one hour in which the lives of a majority of critically injured trauma patients can be saved if definitive surgical intervention is provided"

[16] Conversation with Thomas Abel, COL USMC, G3 Fires responsible for reporting CASEVAC flight data to the CG for daily Battle Update Assessment brief in compliance with MNC-I FRAGO. June 2006.

[17] University of Maryland Shock Trauma Center, "R Adams Cowley Shock Trauma Center Tribute to R Adams Cowley, M.D." http://www.umm.edu/shocktrauma/history.htm (accessed 02 October 2007).
Dr Cowley discussed the concept in an interview: "There is a golden hour between life and death. If you are critically injured you have less than 60 minutes to survive. You might not die right then; it may be three days or two weeks later -- but something has happened in your body that is irreparable."

[18] Bruce Lambert, "Dr. R. Adams Cowley, 74, Dies; Reshaped Emergency Medicine ," New York Times, November 1, 1991 (Online archives accessed 09 October 07.) http://query.nytimes.com/gst/fullpage.html?res=9D0CEFDC1538F932A35752C1A967958260
"Dr. Cowley coined the term "the golden hour" for his concept of quickly treating injuries before potentially fatal damage from shock affects body organs."

[19] North Atlantic Treaty Organization Allied Joint Medical Support Doctrine (AJP) 4.10, February 2002, 025, 22.
"In order to reduce the mortality rate of casualties, resuscitation and stabilisation should be initiated on the field, primarily within the first hour of trauma management, sometimes called "the golden hour." A proportion of casualties resuscitated will deteriorate or remain unstable. These casualties will require emergency surgery as soon as possible. Where emergency surgery can be provided forward the number of casualties saved can be increased, and the degree of disability can be minimized [sic]."

[20] E. Brooke Lerner and Ronald M. Moscati, "The golden hour: scientific fact or medical "urban legend"?" *Academic Emergency Medicine* 8, no. 7(July 2001):758-60.
"The term 'golden hour' is commonly used to characterize the urgent need for the care of trauma patients. This term implies that morbidity and mortality are affected if care is not instituted within the first hour after injury. This concept justifies much of our current trauma system. However, definitive references are generally not provided when this concept is discussed. It remains unclear whether objective data exists. This article discusses a detailed literature and historical record search for support of the 'golden hour' concept. None is identified."

[21] For OIF I, the Marine Division Commander in Al Anbar placed his surgical assets in the center of one hour helicopter circles drawn to cover the battlespace. This was appropriate and reasonable for the situation. The nearest location to provide definitive surgery was in Kuwait, the lines of communication were not clear, and units were maneuvering for combat throughout the battlespace. By OIF 05-07 however, Phase 4 ops were well underway, the Army and Air Force had established definitive care Combat Surgical Hospitals less than 90 minutes away from anywhere in Al Anbar. Maintaining distributed surgical ops at this point was detrimental to care.

[22] US Military Intelligence Service, "Medical Notes on Mobile Surgical Units in the Middle East," in *Tactical and Technical Trends*, (Washington DC, 23 September 1943): 31-33.
"Personnel of Surgical Teams: There is room for two types of teams in the forward combat zone; the extremely mobile team running one table, and the rather less mobile team running two tables, but more than twice the capacity and very economical in personnel and equipment" "Conclusions: If an ideal unit were to be designed, it is thought that the expandible trucks, one as an operating room , the other as a sterilizing room, and the two table system with two surgeons would be best. And if that were not obtainable the single team operating truck for the most advanced sooradic work and the two-table pent-house arrangement for the heavier work a little further to the rear would be most desirable."

[23] Harold R. Bohman, CAPT MC USN, OIF II Data showing improved survival in multi-table surgical sites. Review of 14 cases at one table sites and 79 cases at two table sites shows 35.7% mortality at one table sites and 12.7% mortality at two table sites. Comparatively, 337 cases at a Los Angeles County Medical Trauma Center had mortality rate of 12.8%. Although this data is not statistically significant, it shows a compelling trend that requires further study.

[24] This concept is an extension of the well researched phenomenon of dealing with uncertainty in medicine. Physicians in general function at a level they know is adequate and sufficient. Practice patterns are deeply rooted in their sense of self.

[25] Michael B. Shapiro, Donald H. Jenkins, C. William Schwab, and Michael F. Rotondo, "Damage control: collective review," *Journal of Trauma* 49, no. 5 (November 2000):969-78.

[26] John B. Holcomb, et.al.. "Damage control resuscitation: directly addressing the early coagulopathy of trauma," *Journal of Trauma* 62, no. 2 (February. 2007): 307-10.

[27] D.M.G. Bowley, P. Barker, and K.D. Boffard KD, "Damage Control Surgery – Concepts and Practice" *Journal of the Royal Army Med Corps* 146, no. 3 (October 2000):176-82.

[28] Harold R. Bohman and Bruce L.Gillingham, "Saving Lives Up Front: Forward Resuscitative surgery," *United States Naval Institute Proceedings* 132, no. 4 (April 2006): 28-32.
"Fundamental to the low death rates of patients treated at the forward units was the successful application and continued refinement of tactical surgical intervention, i.e., the selective use of damage control or definitive trauma surgery for combatant casualties consistent with the physiological status of the patient, the number and conditions of other concurrently received casualties, the stats of the unit's resources, and the overall tactical situation"

[29] Conversation with General Surgeon at an FRSS in.Al Anbar Iraq, discussing the use of damage control surgery and which patients to send to more capable centers vs operating on at the remote site, June 2006. (unattributed).

[30] Avery B. Nathens, Gregory J. Jurkovich, Ronald V. Maier, David C. Grossman, Ellen J. MacKenzie, Maria Moore, and Frederick P. Rivara, "Relationship between trauma center volume and outcomes." *Journal of the American Medical Association* 285, no. 9 (March 7, 2001):1164-71.
Reviewed 478 penetrating abdominal cases (penetrating trauma more closely approximates combat trauma) in 31 University trauma centers.

[31] Laurent G.Glance, Turner M.Osler, Andrew Dick, and Dana Mukamel, "The relation between trauma center outcome and volume in the National Trauma Databank." *Journal of Trauma* 56, no. 3 (March 2004):682-90.
Reviewed 1,097 penetrating and 6,274 blunt trauma records across 67 hospitals in 29 states.

[32] James A.London, and Felix D. Battistella, "Is there a relationship between trauma center volume and mortality?" *Journal of Trauma* 54, no. 1 (January 2003):16-24.
Reviewed 98,245 trauma cases across 38 trauma centers in California.

[33] Demetrios Demetriades, Matthew Martin, Ali Salim, Peter Rhee, Carlos Brown, and Linda Chan, "The effect of trauma center designation and trauma volume on outcome in specific severe injuries." *Annals of Surgery* 242, no. 4 (October 2005):512-7.
Evaluated records from 12,254 severely injured patients across 248 hospitals.

[34] Maria Hewitt, *Interpreting the Volume-Outcome Relationship in the Context of Health Care Quality*, Institute of Medicine; 2000
"A higher-volume, better-outcome association was observed in three-quarters of the studies reviewed. Volume is, however, an imprecise indicator of quality. Some low-volume providers have excellent outcomes, and conversely, some high-volume providers have poor outcomes. Volume per se does not lead to good outcomes in health care; it is instead a proxy measure for other factors that affect care."

[35] Ethan A. Halm, Clara Lee, and Mark R. Chassin, "How Is Volume Related to Quality in Health Care? A Systematic Review of the Research Literature," Appendix C in *Interpreting the Volume-Outcome Relationship in the Context of Health Care Quality*, Institute of Medicine; 2000

[36] Elliott R. Haut, David C. Chang, David T. Efron, and Edward E. Cornwell, "Injured patients have lower mortality when treated by "Full-Time" trauma surgeons vs. surgeons who cover trauma "Part-Time," *Journal of Trauma* 61, no. 2 (August 2006):272-279.
Reviewed 14,171 patients in an urban Level I Trauma Center comparing trauma patient mortality between patients who were operated on by full time trauma surgeons to those operated on by part time trauma surgeons.

[37] Conversation with Harold R. Bohman May 2006. Discussion on early trauma care during OIF. Dr Bohman was the Director for Clinical Care for 1st FSSG in Al Anbar province during OIF II. Work with units and trauma surgeons led to the 'rule of thumb' which said, if the patient is walking, take him to the BAS, if on a stretcher, get him to the surgical site. In OIF 05-07, the problem became which surgical site. Those who flew were guided to the appropriate location. Those driven in were often taken to the nearest but often less capable site, resulting in patient stacking and delays to care.

[38] Jeffrey S.Young, Deeni Bassam, Gerald A. Cephas, William J. Brady, Kathy Butler, and Michelle Pomphrey, "Interhospital versus direct scene transfer of major trauma patients in a rural trauma system." *American Surgeon* 64, no. 1 (January 1998):88-91
Compared 151 patients transferred to the University of Virginia trauma center to 165 patients brought directly to the center.

[39] John S. Sampalis, Ronald Denis, Pierre Frechette, Rea Brown, David Fleiszer, and David Mulder., "Direct transport to tertiary trauma centers versus transfer from lower level facilities: Impact on mortality and morbidity among patients with major trauma," *Journal of Trauma* 43, no. 2 (August 1997): 288-96.
Compared 2,756 patients transferred to Quebec trauma centers to 1,608 patients brought directly to the trauma centers.

[40] John S. Sampalis, et.al., "Trauma care regionalization: A process-outcome evaluation," *Journal of Trauma* 46, no. 2 (April 1999): 565-581.
Prospectively followed 12,208 patients in Quebec.

[41] Ellen J. MacKenzie, Frederick P. Rivara, Gregory J. Jurkovich, Avery B. Nathens, Katherine P. Frey, Brian L. Egleston, David S. Salkever, and Daniel O. Scharfstein, "A national evaluation of the effect of trauma-center care on mortality," *New England Journal of Medicine* 354, no. 4 (January 26, 2006):366-78.
Reviewed 5191 trauma patients across 69 hospitals.

[42] Ronald F. Bellamy, "Combat trauma overview." In: *Textbook of Military Medicine, Vol 4: Anesthesia and Perioperative Care of Combat Casualty*, ed. R. Zajtchuck , C.M. Grande. (Washington, DC: TMM Publication, 1995), 1-42.

[43] Donald D. Trunkey, "Trauma," *Scientific American* 249, no. 2 (1983): 28-35.

[44] Trauma.org, "History of Trauma Resuscitation," http://www.trauma.org/archive/history/resuscitation.html (accessed 10 September 2007)
From: Santy, P. Marquis Moulinier, Da Shock Tramatique dans les blessures de Guerre, Analysis d'observations. *Bul.Med Soc.Chir.* 44 (1918):205

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