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REVIEW ARTICLE

# Mobile anesthesia: Ready, set, pack, and go

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## ABSTRACT

**Introduction:**Although we get into the habit of thinking that anesthesia cannot be safely delivered without the availability of all equipments available in a state of the art Operating room, we find ourselves faced with situations where the availability and mobility of all this equipment is limited ; this results in the impetus to start a thought process of how we can perform mobile anesthesia with less technology. Disaster situations, such as earthquakes, floods, or armed conflicts, might happen in areas where access of a regular operating room might be hours away or not available at all. **Golden Hour:** Delivering mobile Anesthesia during the golden hour can be a totally different experience from customary anesthesia practices in a regular operating room.It requires setting up a field/forward surgical teams with its organization and structure. Total Intravenous anesthesia gained popularity in crisis and combat situations and has been documented as a safe method in crisis situations.Anesthesia configured medic bag: Is a modified medic bag that can be utilized to contain the most commonly used Anesthesia supply material in a portable way. **Conclusion:** In reviewing the knowledge of how to provide anesthesia in crisis and disaster situations we conclude that there is evidence that anesthesia can be safely and efficiently delivered in a remote areas with limited tools and technology.

**Key words:** Disaster anesthesia, field surgical team, mobile anesthesia, TIVA anesthesia

## INTRODUCTION

At present, advocating anesthesia in a state-of-the-art operating room (OR) is constantly changing. As standards of care rise and levels of expectations increase, the art of anesthesia requires the utilization of the latest technologies and monitoring devices to deliver optimal anesthetic experience without anesthesia recall and complications.

Almost in every OR, there is a need for an access to a difficult airway cart, video-assisted laryngoscopy, fiberoptic laryngoscopy, color monitors, complicated anesthesia machines with built-in mechanical ventilators, automated medication dispensing machines, and anesthesia supply carts [Figure 1].

Although we get into the habit of thinking that anesthesia cannot be safely delivered without the availability of all the above, we find ourselves faced with situations where the availability and mobility of all this equipment is limited; this results in the impetus to start a thought process of how we can perform mobile anesthesia with less technology. Disaster situations, such as earthquakes, floods, or armed conflicts, might happen in areas where access of a regular OR might be hours away or not available at all.

Utilizing the adaptation of more practical portable equipment to deliver anesthesia for life- or limb-saving situations during the golden hour can be a totally different experience from customary anesthesia practices in a regular OR.[1-4]

**Figure 1:** An example of a state of the art OR with all equipments

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## THE GOLDEN HOUR

In emergency medicine, the golden hour refers to a time period lasting from a few minutes to several hours following traumatic injury being sustained by a casualty, during which there is the highest likelihood that prompt medical treatment will prevent death.[4] It is well established that the victim's chances of survival are greatest if they receive care within a short period of time after a severe injury, When comparing data from World War II, the Korean War, and the Vietnam War, approximately 90% of fatally wounded combat casualties died on the battlefield; only 10% died after entering a military treatment facility. In the Army Medical Department, the lowest level of medical care is the Battalion Aid Station. Thus, in these three conflicts, 90% of soldiers were dying before they reached the lowest level of medical care.[1] Presently, with the level of small arms and fragment protection that is issued to combat arms service members, the survival rate for combat trauma is approximately 98%; however, there has been an increase in the number of extremity, groin, and facial wounds, as these are areas that are not as well shielded by individual combat armor. The increased survival rate for combat trauma is further accentuated by the advanced training that enlisted medical personnel are receiving, the least of which is a new paradigm in which the traditional "ABCs" are being replaced by "stop the bleeding" first, followed by airway concerns. It is for this reason that some unit leaders are advocating that their Soldiers carry their own tourniquet and needle decompression device, in a pocket, as part of the daily uniform.

## FIELD/FORWARD SURGICAL TEAMS

Since those situations are common in a combat zone, military medicine was a pioneer in establishing surgical teams to deal with those situations. One of them is the Forward Surgical Team. US Army Forward Surgical Teams (FSTs) are small, mobile surgical units fielded since the 1990s. FSTs are utilized in a variety of ways. FSTs provide surgical care for those patients unable to survive (medical evacuation) to Level 3 (combat support hospital) care. Surgeons can perform hemorrhage control on combat casualties within the "Golden Hour" of injury. Casualties can then be packaged for medical evacuation to a higher level of care. The FST typically includes 20 staff members: 4 Surgeons (general surgeon × 3, orthopedic surgeon × 1), 3 RN's [emergency room (ER) Nurse, OR Nurse, intensive care unit (ICU) Nurse], 2 Certified Registered Nurse Anesthetists (CRNAs), 1 Administrative Officer (Medical Service Corps [MSC] Officer), 1 Detachment Sergeant, 3 Licensed Practical Nurses (LPNs), 3 Surgical Techs, and 3 Medics (or EMTs). By doctrine, the team is capable of continuous operations with a divisional or nondivisional medical company for up to 72 h with a planned caseload of 30 critical patients.[1] The FST can sustain surgery for 24 total operating table hours and has the ability to separate into two teams that function independently. A functional OR can be established within 1 h of being on scene and break down to move to a new location within 2 h of ceasing operations. Additionally, an FST can be split into two echelons, both providing surgical support in two different locations.[6]

### Field surgical team organization

Personnel in an Army FST are loosely organized into 4 main sections: Headquarters, ATLS or preoperative, OR, and Recovery/ICU or postoperative [Figure 2]. The headquarters section is composed of two personnel, the Executive Officer and the Detachment Sergeant. The role of these two Soldiers is to oversee operations of the unit when casualties are being treated. Two major responsibilities during combat casualty care are calling for helicopter evacuation of casualties (MEDEVAC) and submission of resupply needs to the supporting command. During noncasualty care operations, the FST Chief (by doctrine, a general surgeon; realistically, a nurse or nurse anesthetist) will also have a role in the headquarters section;[1] however, during care of casualties, these personnel will be directly involved in patient care and will be unable to engage in global unit operations.

The ATLS section will be composed of three enlisted medics and one ER nurse, who is a commissioned officer. These personnel are directly responsible for triage and preparation of patients for surgery, or for transport if wounds do not require surgery.

The OR section is composed of four surgeons (three general surgeons and one orthopedic surgeon), two nurse anesthetists,

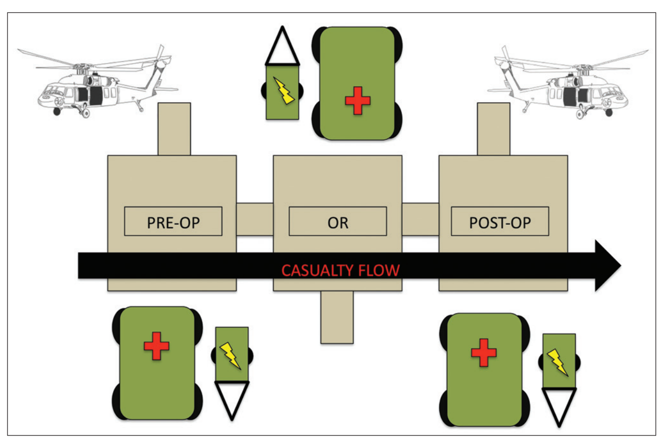


**Figure 2:** The diagram of an example of field surgical team made from three tents attached to each others

three surgical techs, and one OR nurse. The FST's medical equipment set includes two OR beds, which can be placed "head-to-head" if continuous surgical operations necessitate that one anesthetist conduct two anesthetics.

The recovery/ICU section contains eight beds for postoperative care, two of which are reserved for casualties awaiting evacuation to a higher level of care. Personnel in this section are one ICU nurse, also a commissioned officer and three enlisted licensed practical nurses.

Examples of surgeries that an FST can conduct include airway management, wound debridement, hemorrhage control, and fracture stabilization. At any given time, thoracic, abdominal, and orthopedic surgery will simultaneously be occurring on the same patient. On rare occasion, a general or orthopedic surgeon will also have to be comfortable performing burr hole craniotomies.

Medical equipment necessary for FST operations includes, but is not limited to, two defibrillators, two vital signs monitors possessing capnography monitoring, six vital signs monitors that do not measure capnography, two ventilators, two field OR tables, a refrigerator, two field sinks, and a 5 kW generator (although current fielding provides for greater electrical current).

Because the number of personnel in an army FST is so small, it sometime becomes necessary for personnel to cross-train in areas outside of their specialties. Thus, it would be customary to expect that a medic also learn how to assist as a surgical tech and vice versa, for example. Additionally, if the FST is, by doctrine, located within the range of direct fire; thus, if the FST itself sustains casualties, the surgical mission quickly ends, due to lack of personnel to receive casualties.

During sustained combat operations, the FST will require laboratory, X-ray, and dental services. This is made possible with the co-location of the FST with "Charlie-Med" (Charlie Company, part of the brigade support element).

### Medical facilities in the combat theater

Army FSTs provide surgical services that are required to allow combat casualties to survive long enough to make it to the next higher level of surgical care. These levels of care are organized into Levels, of which there are three that exist within the combat theater, and two are away, altogether a total of five levels.

The Battalion Aid Station provides the entry of the combat casualty into the medical evacuation system. Level 1 care is provided at this stage. Level 2 care will be provided by the treatment platoon of Charlie Company, also known as "Charlie-Med" (A company is a military medical Unit that is part of a support battalion). Charlie Company provides the aforementioned services, as well as a limited patient holding capacity, security, and logistic support. The FST is usually located adjacent to a Charlie Med and is part of Level 2 care. The final level within the combat theater is composed of the combat support hospitals, which provide Level 3 care—personnel at this level will be dedicated to further (but not necessarily definitive) surgical care, radiography, laboratory, computed tomography scanning, pharmacy, and staffed wards.

## TOTAL INTRAVENOUS ANESTHESIA

Providing inhalational anesthesia will require anesthesia machine and ventilator, additionally, proper end-tidal monitoring and scavenging system has to be in place in order to deliver accurate concentrations and keep the operation environment free of anesthetics contamination. Also, one of the desired end points in disaster anesthesia is to maintain spontaneous breathing whenever possible. For those reasons total intravenous anesthesia (TIVA) gained popularity in crisis and combat situations.[5] TIVA has been documented as a safe method to deliver anesthesia for a wide variety of scenarios (acute trauma, wound irrigation and debridement, elective surgical cases, ICU care, procedural sedation, and craniotomy). Some of the benefits of TIVA, especially in this setting, are at a much lower risk of postoperative nausea and vomiting, lower postoperative pain, and low risk of psychomimetic effects. Additionally, patients tend to be less delirious postoperatively but regain alertness quicker in the recovery area.TIVA may be used for a full spectrum of casualities.

Supplies that will be needed to deliver "field TIVA" include, but are not limited to, the following:

- 100 mL NS bag
- Two 20-mL vials of propofol (10 mg/mL)
- Ketamine (50 mg/mL)
- Fentanyl (50 μg/mL)
- Macro-Dripper set (20 gtt = 1 mL)

To prepare the mixture, remove 50 mL of NS from the 100 mL bag, and replace it with the following: propofol 400 mg (40 mL), ketamine 250 mg (5 mL of 50 mg/mL concentration) and fentanyl 250 μg (5 mL of 50 μg/mL concentration). The final concentration of the mixture can be said to have a concentration of "P4-K2.5-F2.5." This mixture will provide for hemodynamic stability because of the high relative concentration of ketamine.

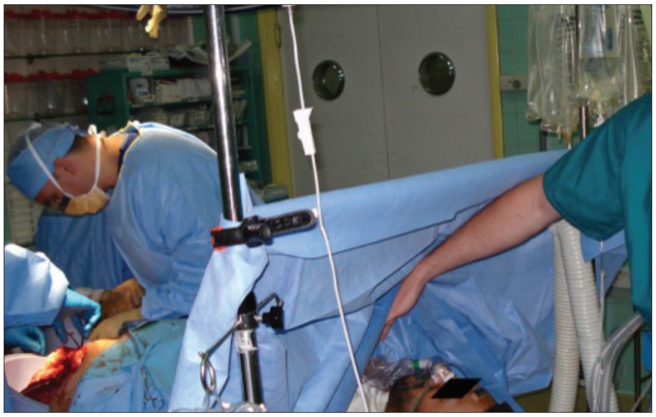

**Figure 3:** A patient receiving TIVA without the need for mechanical ventilation. The white IV solution shown in the picture is Propofol-Ketamine-Fentanyl mixture

**Figure 4:** Picture of the anesthesia configured bag compartment A

**Figure 5:** Picture of the anesthesia configured bag compartment B

Additionally, the provider can deliver a 4 mL bolus of the mixture every 5 min. This will be approximately the same as an infusion of propofol 100 µg/kg/min in an 80 kg patient, as well as ketamine 5 mg/min and fentanyl 150 µg/30 min. To infuse Propofol-Ketamine-Fentanyl, a macro-dripper set capable of delivering 20 gtt/mL is necessary. Utilizing this dripper set will allow the provider to deliver 150 µg/ kg/ min (1 drop/s), 75 µg/kg/min (1 drop every 2 s), or 50 µg/ kg/ min (1 drop every 2 s). Start at 1 drop/s. Once surgery is underway, continually titrate down. When the surgery is close to completion, the old recommendation was to stop the infusion about 10 min before completion. However, as long as spontaneous ventilation is established, a nasal trumpet can be inserted and extubation can be completed ad libitum [Figure 3]. One bag of PKF should last about 90 min at a rate of 50–100 µg/kg/min. Additionally, nondepolarizing muscle relaxants can be used as needed.

## ANESTHESIA CONFIGURED MEDIC BAG

The Blackhawk Stomp II Medic Bag can be used in emergency situations to start and/or complete one anesthesia case, provided that there is not sufficient time to unpack all of the medical supplies that will be needed to complete the mission. Specifications of the bag are that it weighs 7 lbs. and 9.6 oz, has dimensions of 20″ × 10″ × 13″, and has a cubic capacity of 2600″. The purpose of the bag is to be able to deliver an anesthetic within minutes of notification that a casualty is arriving, especially if a proper setup cannot be completed. It will not contain everything needed, but it will include the essential tools to deliver a safe, efficient anesthetic. The bag can be divided into two compartments A and B [Figure 4] and each compartment has two sides, the bag can contain limited supply of the most commonly needed anesthesia supply materials, from IV line placement to a difficult airway management tools replacing the regular OR anesthesia supply cart with a much compact and easily mobile item [Figure 5].

## CONCLUSION

Anesthesia delivery including the art and science has developed over the course of years, mainly to improve the safety and efficacy. State-of-the-art ORs have developed into a sophisticated anesthesia delivery environment; however, they were designed with peace and stability in mind. In situation where neither peace nor stability exists, such as armed conflicts, natural disaster or crisis situations, a more portable, compact, and mobile tools become the goal.

Reviewing the knowledge of how to provide anesthesia in crisis and disaster situations away from a regular OR provide the evidence that anesthesia can be safely and efficiently delivered in emergency situations in remote areas with limited tools and technology.

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