Ultrasound in Special Operations Medicine: A Proposal for Application and Training

Sean Keenan, MD; Andrew R. Morgan, MD; Robert Blankenship, MD; David A. Hubler, 18D

Abstract

Emergency ultrasound is gaining ground as a powerful diagnostic tool in the hospital setting. With ever-expanding indications, validated with scientific studies, it has become an accepted and relied-upon technology with daily use in emergency departments, and surgical and critical care settings around the world. Additionally, with the current worldwide combat operations and the resultant deployment of far-forward medical assets, the technology's use outside of the standard hospital setting has been demonstrated. This technology, however, has had limited use outside the forward surgical or medical officer-positioned assets, despite being standard equipment with some Special Operations units. We hope to stimulate discussion about its use in Special Operations medicine by educating the reader to the possibilities of this technology, and suggesting a reasonable training and fielding plan for its optimal use.

Introduction

Ultrasound (US) continues to gain credibility as a powerful diagnostic tool in the hospital setting. With ever-expanding indications validated by scientific studies, US has evolved from a radiology department-centric application to a routine part of daily practice in emergency departments (EDs), intensive care units (ICUs), and outpatient primary care clinics throughout the country. The military has contributed to the expanding role of US by deploying this technology to forward areas. However, no one has made any formal recommendations for training in the Special Operations Forces (SOF) community, and its adoption has been limited to date. SOF should lead the way to integrating this application into the forward-deployed environment, and place it into the capable hands of the Special Operations Medic.

The maturation of two advances in the last decade has made the landscape ripe for this opportunity in SOF medicine. First, the latest portable US technology has condensed the physical size of US equipment to make it far more practical in the deployed setting. For most laymen, the term "ultrasound" conjures images of the cumbersome cart-based machines associated with obstetric visits. Until the past decade, this was an accurate stereotype. Presently, several manufacturers make powerful portable US machines no larger than a laptop computer that, with accessories, pack to the size of a briefcase.

Secondly, emergency ultrasound (EUS) has emerged as a discrete and well studied discipline within the realm of imaging. The major impetus for this evolution was the demand for rapid answers to specific clinical questions at the patient's bedside. Formal diagnostic US studies provide a complex and detailed study of an anatomic region and require a radiologist or a registered diagnostic medical sonographer (RDMS). In contrast with a formal diagnostic study, in EUS the clinician, rather than technician, collects the images. In addition, a EUS study focuses on collecting images necessary to answer a specific clinical question rather than conducting a comprehensive survey of the anatomic region in question. Refer to Table 1 for a summary of key differences between the US disciplines.

The current worldwide combat operations were the first opportunity for military medicine to combine the principles of EUS with portable US technology on the battlefield and bring diagnostic imaging closer to the point of injury. However, most utility of this equipment has been limited to the hands of trained physicians and physician assistants assigned to Combat Support Hospitals, Forward Surgical Teams, and to the level of some lower-role field treatment facilities such as Battalion Aid Stations.[1] Many forward-stationed medical units are finding use for EUS where traditional diagnostic assets

Table 1. Comparison of "Traditional" Diagnostic US to Emergency US				
	Setting	Scope	Training Requirement	Relative Exam Time
Diagnostic US	Radiology Department/ US suite	Comprehensive for given anatomical area	Formal residency or RDMS program	Longer due to detail of exam
Emergency US	Patient's bedside	Clinical problem-focused	Practice-based pathway	Brief: seconds to minutes

(plain radiography, computed tomography [CT] scans, magnetic-resonance imaging [MRI]) are limited, non-existent, or impractical.

Special Forces battalions currently field one US machine per battalion medical section. The authors have observed several merits favoring the forward placement of this technology in SOF units. As a mobile, non-invasive diagnostic device, EUS is ideally suited for austere military settings. The existing portable x-ray system fielded in Special Forces battalions has a much smaller breadth of applications, and is much larger and bulkier than the briefcase-sized hard case that contains a complete ultrasound system. We wish to educate the reader to the possibilities of EUS technology, and suggest a reasonable training and fielding plan for its optimal use.

The technology

Emergency ultrasound is best known for its traditional use in the evaluation of unstable patients. The focused abdominal sonography in trauma (FAST) exam is used in trauma centers around the world to rapidly assess free fluid in the abdomen and around the heart as a potential cause of hypovolemic shock. The extended FAST exam (eFAST) also includes views into the pleural cavity and is a common modification, as well as its use in the evaluation to exclude pneumothoraces. Table 2 details the respective sensitivities and specificities.

Table 2. Sensitivities and Specificities for Common Trauma Uses of EUS.[2-9]		
	Sensitivity	Specificity
FAST	64-98%	86-100%
Pericardium	97-100%	???
Pneumothorax	59-100%	94-100%

The technology also can reliably identify abdominal aortic aneurysms and can image gall bladders and intrauterine pregnancies, as well as detect deep venous thromboses (DVT). More recent indications include evaluation of tendon integrity, as well as detection of fractures, foreign bodies under the skin, and abscesses. Ophthalmologic indications include detection of intraocular foreign bodies, detached retinas, and estimates of intracranial pressure.[10-12] Vascular access with ultrasonography is another common indication, as well as ultrasound guided-pleurocentesis and peritoneal drainages. Another potentially useful application is its emerging use with ultrasound-guided peripheral nerve blocks.

With each of these indications, many of which have been proven to be effective with relatively little time for hands-on instruction and practice, the technology can be a powerful tool in the hands of the properly trained clinician or technician. Additionally, the machine is easily transported, intuitive in its operation (user-friendly), and provides a rapid degree of sustainable and reproducible results in the end-user. Each U.S. Army Special Forces battalion has already fielded the technology, but the requirement for effective training remains.

Avoiding diagnostic pitfalls in clinical application

As with any new technology, there is a temptation to find applications that fit it, rather than first identifying a need, then applying the technology. With our recent combat experience and proven applications, EUS has found its way onto the medical landscape. Understanding its potential, and especially its limitations, is essential to integrating the technology into practice.

As with any diagnostic tool, the clinician should first delineate a question for the test to answer. For example, in the case of FAST exam, the question should be: "Is this patient's hypotension being caused by free-fluid (intra-abdominal hemorrhage) in the abdomen or in the pericardium (tamponade)?" This binary question directs the patient to a surgeon if a positive result is found in the right patient and appropriate clinical scenario. Another example would be: "Does the patient with multiple shrapnel wounds to the back with shortness of breath need a chest tube?" And if the answer to the previous question is "yes", then the next question should be: "Which side is affected?" thereby directing chest tube placement. Applying these same tests to a patient with chronic ascites, or pericardial effusion from cancer, or scarring of the lungs from severe tuberculosis, rather than the trauma patient in a correct scenario, clinicians may derive a false positive result, with a resultant incorrect overall assessment and ultimately an incorrect triage or evacuation decision.

The examples above demonstrate the need to understand not only the technical aspects of the technology (what we would consider the proper training of the individual), but also the *clinical application* of the technology. The medical officers implementing this strategy must understand not only the use but potential *misapplication* of this technology. Proper training should include vignettes to illustrate these pitfalls.

Training

Central to cultivating this new SOF capability is development of a training program to introduce and sustain US scanning and image interpretation skills. There are currently no guidelines for instructing non-physicians in pre-hospital US techniques. However, in 2001 the American College of Emergency Physicians (ACEP) issued a policy statement on EUS guidelines to guide emergency physicians seeking initial training in US in the post-residency setting.[13] Since ACEP intended the training model and guidelines for clinicians without a formal background in US, it closely mirrors the intent of a SOF Medic-specific US curriculum. In this section we incorporate some of ACEP's guidance and introduce a preliminary outline for starting a *de novo* US capability in SOF units and a basic outline for an introductory program of instruction.[13] Our intent is to initiate a dialogue and establish a starting point for the SOF community rather than dictate precise "how to" instructions.

We recommend establishing a Special Operator-level clinical ultrasound (SOLCUS) program with a 4-step process:

1. Analyze operational mission set and develop corresponding learning objectives.
2. Establish medical officer oversight and create a cadre of US subject matter experts.
3. Plan an introductory course for the general target audience.
4. Develop a skill proficiency plan and privileging criterion.

1. **Analyze operational mission set and develop corresponding learning objectives.**

The first step in establishing a training program is to analyze the unit's operational and medical mission and derive appropriate terminal learning objectives for the target audience, the SOF Medic. For example, Medics from units with a direct action focus may have particular interest in developing EUS skills in trauma applications. In contrast, Civil Affairs units may also benefit from many of the non-trauma applications to complement their foreign internal defense (FID) missions. Mission requirements will help tailor the scope of the training to align with the SOF unit's unique needs. Catering objectives to the specific requirements will hone efforts and eliminate time wasted on superfluous topics. Below are examples of learning objectives for the topics most relevant to a SOLCUS program:

General

- Define EUS in terms of its goals and limitations and contrast it with traditional diagnostic US.
- Delineate the list of applications relevant to a SOF Medic's scope of pre-hospital practice.
- Describe the training process and practice privileging for SOF Medics.

Physics

- Define basic physics terminology and concepts as they apply to US imaging: echogenicity, frequency, resolution, artifact, etc.
- Understand basic physics principles as they apply to US imaging.
  - Describe the basic physical characteristics of a sound wave and discuss the path of an ultrasonic wave as it travels from the probe to an object and reflected back to the probe.
  - Describe the appearance of fluid, soft tissue, bone and air in an US image and explain in terms of their respective physical properties.
- Operate and maintain the issued US unit.
  - Turn-on machine, change battery, and change probes.
  - Change modes, label images, save images and video loops.
  - Proper cleaning techniques and general maintenance.

Trauma

- Identify the indications for a focused abdominal sonography in trauma (FAST) exam and discuss the clinical algorithm for evaluating a patient with both a positive and negative examination in context of the austere, pre-hospital setting.
- Conduct a FAST examination by correctly identifying the four basic views and describing the relevant anatomy and relationships as well as the criterion for positive and negative examinations.
- Identify the indications for evaluating a patient with a suspected pneumothorax with US and discuss the treatment algorithm.
- Conduct a pneumothorax exam and describe the findings in a positive and negative examination.

Procedural

- Use real-time guided US to establish vascular access and discuss indications and contraindications.
- Use real-time guided US to assist a peripheral nerve block and discuss indications and contraindications.
- Use US to identify and remove a foreign body.

Extremity soft-tissue and musculoskeletal

- Distinguish superficial soft-tissue abscesses from simple cellulitis.
- Identify simple extremity fractures.
- Identify ruptured/severed tendons.

Special applications (supplementary)

HEENT

- Identify a retinal detachment.
- Distinguish peritonsillar abscess from cellulitis.

Vascular

- Employ doppler function to verify distal flow in an extremity.
- Approximate fluid volume status through caliber measurement of the IVC.

2. Establish medical officer oversight and create a cadre of US subject matter experts.

An effective SOLCUS program will require a cadre of subject matter experts under the direction of a EUS-competent medical officer. The variety of specialty backgrounds among medical officers in SOF medicine accounts for variable degrees of exposure to US. Of the specialties that routinely employ US in their practice such as radiologists, general surgeons, OB/GYNs, and cardiologists; few of these specialties routinely serve in SOF units. Even within emergency medicine, a specialty that *is* well represented in SOF medicine, US entered the residency curricula as recently as the last decade leading to a discrepancy in US skills across the experience of this specialty. A medical officer's lack of training in this technology may be the biggest impediment to propagating the merits of this skill. For this reason, it is imperative that SOF physicians and physician assistants anticipate their plan to train their target audience of SOF Medics with preemptive training in US.

The second portion of this step is creating a cadre of subject matter experts or "champions" by hand-picking a small number of motivated, innovative, clinically savvy Medics with longevity in the unit and aptitude for teaching. These champions, selected from the target audience's peer group, will become essential trainers within the unit because they lend credibility to the instruction by demonstrating the attainability and relevance of the skill. In addition, a cohort of champions will help assure continuity amidst inevitable unit turnover. The process of building US champions may more conveniently occur in conjunction with the medical officer train-up period.

The final portion of this step involves the identification of an appropriate training venue for a small group of medical officers and SOF Medics presumed to have no prior US experience. The advantage of beginning with a small cadre of soon-to-be SMEs is the ability to travel to a site with organized training. Many national medical conferences offer breakout sessions and seminars in US, to include the annual Special Operations Medical Association Conference (SOMA) in Tampa, FL. In addition, some teaching hospitals and physicians' groups have developed commercial courses in EUS, and the Army and Navy now send medical officers out to formal US fellowships, providing a formal military medical expertise that should be utilized to train the cadre for SOLCUS training.

Introductory courses typically include a combination of lecture and hands-on practical exercise and can range from a a half day to three days in length, with more advanced courses lasting longer. The ACEP guidelines recommend of minimum of 16 hours of didactics before attempting to collect cases in clinical practice. It may take two or three different courses to gain competency in the principles of US before applying them in practice.

3. Plan an introductory course for the general target audience.

The next phase of program development transitions the focus to the ultimate customer, the SOF Medic. In contrast with the champion development phase, the greater number of students in a general target audience course may preclude the ability to travel to a commercial activity leaving two alternatives: bring a commercial course to your unit, or plan and execute an internal course with your own SMEs. The advantage of contracting a course at your home station is the assurance of expert instruction and availability of training aids (extra US units, simulation aids, etc.), the obvious disadvantage is cost.

The greatest advantage of hosting your own course is the ability to tailor the objectives to precisely support your specific objectives. Courses instructed by civilians or even hospital-centric military personnel may not accurately cater to the unique requirements of the SOF environment. The biggest disadvantage is the significant investment of time required to train, plan, and execute a quality course with limited training aids and resources. In the event that your unit's medical team designs a custom course, first refer to the model learning objectives in phase one. Following the model of a commercial course, reverse engineer the lectures from the learning objectives and organize the course into alternating periods of instruction and practical exercise.

4. Develop a skill proficiency plan and privileging criterion.

After gaining the didactic background of a basic course in EUS, establishing a proficiency plan is paramount for *every* type of clinician, whether Medic or medical officer. The lectures and practical exercises of an introductory course merely expose neo-ultrasonographers to the skill. The clinical acumen to discern appropriate use of US and develop the hand-eye coordination required for effective scanning matures after many exams. The ACEP guidelines for EUS recommend collecting a minimum of 25 exams for each indication, e.g., 25 FAST exams in addition to 25 soft tissue and extremity exams. During this learning period, two primary methods of collecting these proficiency exams include proctored and case-control.[13] Proctored exams require the oversight of the exam by an US-proficient physician or ultrasonographer as the US trainee conducts the exam, providing real-time quality control. Case-control method involves obtaining a confirmatory test, such as a formal diagnostic ultrasound or an X-ray. This method defers clinical decisions from the trainee's exam until the confirmatory test can verify the results. Military emergency departments may have staff who are subject matter experts in EUS that could be a ready source for training and practice.

The quintessential goal of US for our community should be to incorporate a SOLCUS-like curriculum into the SOF Medic's initial curriculum at the Joint Special Operations Medical Training Center (JSOMTC). The ad hoc training program described above would become superfluous for SOF Medics if they could receive their didactic instruction in the course and begin collecting cases for proficiency during the subsequent phases of training. Then, as with many other perishable skills obtained in initial training, incorporate periodic review as part of Non-Trauma Module (NTM) training, the biennial blocks of instruction for Special Forces Medical Sergeants (18Ds) that include topics in dentistry, veterinary medicine, preventive medicine, and physical therapy. Medical Proficiency Training (MPT), the required hospital-based clinical rotations required for 18D recertification, can also serve as a venue for enhanced exposure to US. Alternatively, establishing the SOLCUS curriculum as an elective course at the JSOMTC with an associated additional skill identifier relieves the burden of packing additional training into the mainstream Medic pipeline while permitting the centralized creation of US champions that line battalions can then distribute among their teams.

Proposed application in Special Forces

We are confident that SOLCUS will find a niche in support of each type of SOF mission. As a case example, we propose a concept for applying SOLCUS to a Special Forces battalion. In this section we address two distinct issues: Aligning US application to support the Special Forces mission, and fielding the US asset within the battalion.

The full spectrum of Special Forces missions apply to both the lethal and nonlethal battlefields. In a similar manner, the imaging power of US enhances the complete spectrum of Special Forces medical missions by providing versatile imaging capability at the team level. Special Forces Soldiers are adept at an incredible array of missions to include unconventional warfare (UW), foreign internal defense (FID), direct action (DA), special reconnaissance (SR), counterproliferation (CP), and combat search and rescue (CSAR) to name a few.[1] The independent nature of the 12-man Operational Detachment – Alpha (ODA) at a remote forward operating base (FOB) in current combat theaters, or during a joint combined exercise for training (JCET) in other remote corners of the world epitomizes the austere conditions where evacuation to a higher level of care is at best difficult, at worst unfeasible or non-existent. Optimizing the 18D's medical independence in these situations becomes mission critical. Both the combat trauma and non-combat applications of SOLCUS are tools that can benefit these mission sets.

The distinction between the combat trauma and non-combat applications of SOLCUS is important because it highlights its relevance to both settings. Combat trauma applications of US are those used to diagnose conditions as a result of contact with an enemy. This may be either direct contact that results in small-arms fire exchange, or indirect as in the case of stand-off weapons such as improvised explosive devices (IEDs). US has applications to both penetrating and blunt trauma; however, it is important to note that penetrating combat trauma to the abdomen indicates a surgical laparotomy, obviating the need for an abdominal US exam to verify the presence of intra-abdominal bleeding. Penetrating trauma to the chest however, begs the clinical question of significant hemo- or pneumothorax, or risk of cardiac tamponade, the detection of which is ideally suited for US application. While US enjoys relatively fewer indications in penetrating abdominal trauma, it is especially relevant to blunt thoracoabdominal trauma. This fact is particularly poignant given the prevalence of improvised explosive device (IED) blast injuries and motor vehicle accident (MVA) trauma in current combat operations. In these cases, US evidence of intra-abdominal bleeding or pneumothorax will influence patient management. Another indication equally applicable to the military setting is the accurate results used in initial triage, and patient reassessment, in mass casualty situations.

Ultasound's non-invasive and reproducible imaging is ideal for rapid triage and emergency clinical decision-making in combat-induced trauma scenarios. However, we acknowledge the irrelevance of US during "care under fire" phase of combat casualty care. In the same way, since this is not an aid-bag carried item, it will be equally irrelevant during "tactical field care." There may be some merit to pre-positioning the US unit at a predesignated casualty collection point (CCP) or on a ground or air CASEVAC platform to use for en route care.[14,15] Some ODAs may find use for an US unit on long-duration, vehicle mounted patrols, while others operating in close proximity to their FOB may choose to leave it in a fixed location. Only the creativity of the SOLCUS-trained 18D limits how the team practically employs this asset.

Non-combat applications are those that support medical treatment resulting from non-hostile intent. These may be traumatic or non-traumatic injuries or illnesses. The best examples of these applications include the routine and urgent care provided at sick call, or at a local national clinic or guerilla hospital.[16] The Special Forces Medic may be responsible for the care to his immediate teammates and allied troops, but also provide area medical and surgical support to indigenous populations as part of a medical civil actions program (MEDCAP), counter-insurgency (COIN) operations, or unconventional warfare (UW) operations. The diagnostic prowess of a SOLCUS-trained 18D could help identify a fracture, tendon rupture, foreign body, or differentiate an abscess from cellulitis. The information provided by this simple study influences management decisions by potentially affecting the treatment plan or strengthening an argument for evacuation.

The plan for fielding and positioning US units in an SF battalion may take a variety of forms; however, we believe that the ultimate goal should be to field one US unit per ODA, ODB, and medical section to pre-position this imaging modality in the most forward locations, widely distributing this capability throughout the battalion's battle space. The ODA's basic medical equipment set, known as the SF Tactical Set, has no organic diagnostic imaging capability. Each SF battalion headquarters medical section currently fields one cumbersome digital x-ray machine that requires multiple large storage containers to transport. In addition, the battalion medical section also owns a single US unit. With only two diagnostic imaging units in the battalion, the vast majority of the 18 ODAs in the battalion improvise without advanced diagnostic capability. Knowing that a transition to multiple US units per battalion will not happen at once, one interim course of action is to increase the authorization for US units in the battalion medical section to a number short of the unit-per-team goal, and allow the battalion medical officers to issue the US units to teams on a mission-by-mission or rotation-by-rotation basis. The criterion to distribute the US could be based upon the team's tactical mission, their accessibility to the next level of care, and the presence of SOLCUS-trained Medics.

Conclusion

The progress in ultrasound technology has made it increasingly compatible with the practice of medicine in austere environments. The imaging power of ultrasound enhances the full spectrum of SOF medical missions by filling a void in total body imaging capability at the Medic level in most SOF units. This adjunct will significantly impact the independent medical decision-making capability of the SOF Medic and facilitate the medical care of patients treated by SOF medical personnel.

With applications to trauma as well as routine medical care, the portable ultrasound system will save lives on the battlefield. In addition, this instrument will serve as a force multiplier on the non-lethal battlefield by bringing diagnostic capability to the patient and aiding difficult triage decisions. In contrast, existing portable X-ray systems have a much smaller breadth of applications and are much larger and bulkier than the solitary, hand-carried case that contains the ultrasound system. Fielding an ultrasound unit at the Medic level pre-positions this imaging modality in the hands of the SOF clinician in the most forward locations, widely dispersing this capability throughout a unit's area of operations and allowing better accuracy with mission-critical triage decisions and routine medical care

In a mature combat environment with routine medical evacuation and surgical support readily available, traditional clinical assessment and evacuation is still the best practice. However, there are many situations and missions where limited availability of evacuation assets and the need for greater diagnostic accuracy at the point of care will greatly influence triage and mobilization of limited and expensive assets. Initiating debate on this subject will direct future prospective research and refine the training requirements for the SOF medic to achieve the essential learning objectives. By training SOF Medics in the applications and limitations of the technology, the mature combat medical provider can weigh risks and benefits, and determine optimal use for this specialized tool to maximize the preservation of human life while assuring responsible stewardship of scarce resources.

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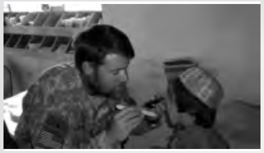
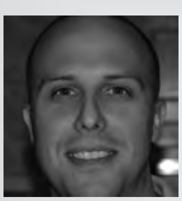


LTC Sean Keenan, MC, USA, is a staff emergency physician at Evans Army Community Hospital, Fort Carson, CO, and Director of the Fort Carson Ambulance Service. He formally served as the Battalion Surgeon for 1st Battalion,3rd Special Forces Group (Airborne), Fort Bragg, NC, and, prior to that, staff emergency physician at Womack Army Medical Center, Fort Bragg, NC. LTC Keenan is a 1991 graduate of the United States Military Academy; a 1995 graduate of the Uniformed Services University of the Health Sciences; and a 2003 graduate of the San Antonio Uniformed Services Emergency Medicine Residency. He has four deployments with Special Operations Forces in support of the Global War on Terrorism.

MAJ Andrew Morgan, MC, USA, is the Battalion Surgeon for 1st Battalion, 3rd Special Forces Group (Airborne) in Fort Bragg, NC. Prior to his assignment to 3rd SFG(A) he served in joint overseas assignments with various SOF units while practicing as a staff emergency physician at Womack Army Medical Center, Fort Bragg, NC. He is a 2002 graduate of the Uniformed Services University of the Health Sciences and a 2005 graduate of the Madigan AMC-University of Washington Emergency Medicine Residency.

MAJ Morgan's on the left and SFC Hubler (scarf) is on the right.

SFC Hubler is the NCOIC and Senior Special Forces Medical Sergeant for 1st Battalion, 3rd Special Forces Group (Airborne) in Fort Bragg, NC. Before his assignment to the Battalion Medical Section, SFC Hubler served five years as a Medic on an operational detachment. Prior to his selection into Special Forces he served as an infantryman in XVIII Airborne Corps Long Range Surveillance Detachment.



Dr. Robert Blankenship is a board certified emergency physician. He did his emergency medicine residency at Carl R. Darnall Army Medical Center. During his 11 years of active duty he served as an Emergency Medicine Assistant Residency Director, Ultrasound Director, and the Transitional Year Program Director at Madigan Army Medical Center. Dr. Blankenship also developed the Army's First Tactical Ultrasound Course in 2007 after returning from Iraq where he was awarded the Bronze Star for his service with 1-66 Armor, 4th Infantry Division, Fort Hood Texas.