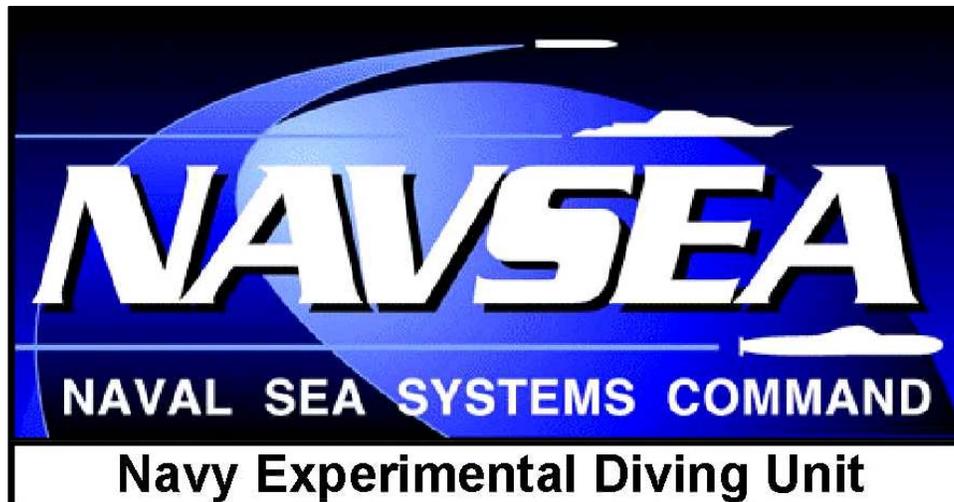


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**POINT-OF-CARE ULTRASONOGRAPHY FOR UNDERSEA MEDICAL
OFFICERS**



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14. ABSTRACT For more than 50 years, ultrasound imaging has been used by physicians to aid in diagnosing and treating patients and has played a vital role in the evaluation of injured military personnel since the First Gulf War. Point-of-care ultrasonography has become more prevalent with the advent of newer, smaller, and more capable ultrasound equipment. The goal of this paper is to illustrate the improved remote care of patients and cost benefits to providing an ultrasound curriculum to Undersea Medical Officers (UMO). A comprehensive literature review was performed using PUBMED and search terms such as ultrasound, pre-hospital, remote, military, non-radiology providers, and non-physician providers. In addition, three experts in military ultrasound education, training, and curriculum implementation were consulted. The Special Operator Level Clinical Ultrasound (SOLCUS) program will provide the education needed to train UMOs in ultrasound. This program will fit conveniently into the Undersea Medical Officer Candidate (UMOC) curriculum and can be easily incorporated into UMO training around the fleet. All of this can be accomplished with minimal monetary and time costs. Fully equipping and training UMOs in emergency ultrasound will make Navy medicine stronger by improving patient care and management in austere and operational environments.					
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CONTENTS

STANDARD FORM 298	i
CONTENTS	ii
INTRODUCTION.....	1
METHODS	1
DISCUSSION.....	2
Ultrasound Basics	2
Current Military and Civilian Point-of-Care Ultrasound Use.....	3
Current Uses for Ultrasound among UMOs.....	4
Potential Uses for Ultrasound among UMOs.....	5
Ultrasound Curriculum Guidelines and Costs.....	6
Establishing a SOLCUS Program.....	9
Evaluating a SOLCUS Program	9
Example UMO SOLCUS Curriculum	9
CONCLUSIONS	11
RECOMMENDATIONS.....	12
REFERENCES.....	13
APPENDIX A: List of Standard Questions Asked of Experts.....	A-1
APPENDIX B: NSW3 Ultrasound Portion of AMAL List.....	B-1

INTRODUCTION

For more than 50 years, ultrasound imaging has been used by physicians to aid in diagnosing and treating patients and has played a vital role in the evaluation of injured military personnel since the First Gulf War (1, 2, 3, and 4). Point-of-care ultrasonography has become more prevalent with the advent of newer, smaller, and more capable ultrasound equipment (5, 6).

Ultrasound has been embraced by all branches of the military to aid in the diagnosis, treatment, and disposition of patients injured in combat operations (2). The use of ultrasound in operational medicine is critical to the decision-making process when resources and other testing modalities are severely limited (7). If an ultrasound curriculum is provided to Undersea Medical Officers (UMO), then UMOs will have the information needed to warrant the use of limited resources as well as mitigate the significant risks associated with medical evacuation to a higher level of care. UMOs that employ point-of-care ultrasonography, whether working as a Naval Special Warfare (NSW) physician or as a hyperbaric chamber physician, can provide their patients with real and, potentially, life-saving benefits.

The education and training requirements needed to train UMOs in ultrasound already exist and can be easily incorporated into UMO training with minimal monetary and time costs.

METHODS

A comprehensive literature review was performed using PUBMED and search terms such as ultrasound, pre-hospital, remote, military, non-radiology providers, and non-physician providers. Navy Experimental Diving Unit (NEDU) Institutional Review Board (IRB) determined that this research thesis is not human subject research and, therefore, does not require IRB review.

Three experts in military ultrasound education, training, and curriculum implementation were consulted: 1. MAJ William Vasios, APA-C, USA. MAJ Vasios is the spearhead for Special Operator Level Clinical Ultrasound (SOLCUS) program (see below), 2. Brian Hall, M.D., RDMS, RDCS, LTC, MC, FS, DMO, FACEP, FAAEM. LTC Hall is the Fellowship Director for the Emergency Ultrasound Department of Emergency Medicine at Darnall Army Medical Center and he is also an Assistant Professor of Military and Emergency Medicine at Uniformed Services University of the Health Sciences (USUHS), and 3. James Palma, MD, MPH, CDR, MC, USN. CDR Palma is an Assistant Professor of Military and Emergency Medicine at USUHS where he is also the Director of Ultrasound in Medical Education. Appendix A includes a list of standard questions asked of experts.

DISCUSSION

ULTRASOUND BASICS

Ultrasound is a method of imaging that uses a hand-held transducer connected to a visual display and utilizes high-frequency sound waves to generate images (1, 8). These high-frequency sound waves are at a frequency greater than 20,000 Hertz (Hz), above the range which human ears can detect. Ultrasound does not produce any significant level of radiation. Diagnostic ultrasound uses megahertz (MHz) frequencies. Lower MHz ultrasound is used for deeper penetration applications such as abdominal or cardiac imaging. Higher MHz ultrasound is used for shallower penetration and greater resolution applications such as dermatologic imaging. There are many methods for displaying ultrasound images; however, the most common method is called B-mode or two-dimensional mode.

Ultrasound images are created by an array of piezoelectric crystals that are positioned across the face of the hand-held transducer. An electric current is applied from the transducer across the piezoelectric crystals, which produce a sound wave. This sound wave travels through the body bouncing off structures and returns to the hand-held transducer, where the piezoelectric crystals now act as a detector turning the sound waves into an electric current that ultimately produces the B-mode images displayed on the ultrasound image screen. Transducers are also referred to as probes and there are several types of probes for different, specific applications.

Ultrasound penetrates well through fluids such as blood, urine, bile, and ascites that appear nearly black and are described as anechoic, which means without internal echoes. Highly echogenic structures such as bone cortex have a high degree of internal echoes and appear nearly white. Ultrasound also penetrates well through solid organs such as the liver and spleen, but their image is somewhere between anechoic and highly echogenic structures.

One of the most common ultrasounds used in the deployed military setting is the SonoSite M-Turbo, which is a portable ultrasound that can be hand carried or carried in a back pack (E1). For ultrasound applications that apply to all UMOs, only two types of probes would likely be needed – linear and curvilinear probes. According to SonoSite, Inc., the M-turbo is extensively used in the military with over 5,000 units deployed across the spectrum of U.S. Military operations to include surface ships, fixed and rotary wing aircraft, forward surgical hospitals, and Special Forces (E2). SonoSite, Inc., also outfits the Veterans Affairs (VA) medical centers and foreign U.S. based hospitals with ultrasound. This ultrasound will need to be tested and approved for use in military chambers; however, it is important to note that it is currently used inside Duke University's hyperbaric chamber for both research and clinical applications. The SonoSite M-Turbo comes with a 5 year warranty which includes service, maintenance, damage, replacement, and calibration. If there are any issues with the

ultrasound, the company will either send a replacement or a technician to fix it. Brian McHugh, (brian.mchugh@sonosite.com, office # 412-559-7559), the SonoSite, Inc. representative for military and government sales, provided an M-Turbo quote which came to a total of \$46,586.80. However, this quote includes a great deal of non-vital equipment. The total for required equipment (M-Turbo, Power Supply, extra battery, curvilinear transducer, and a linear transducer) is \$31,124.90. An additional \$620 to that total would include a portable field case.

CURRENT MILITARY AND CIVILIAN POINT-OF-CARE ULTRASOUND USE

In civilian and military medicine, non-radiology and prehospital physicians have been effectively using ultrasound for the acute evaluation of trauma patients for more than 30 years (8, 9, and 10). Specifically, after completing a primary survey, the focused assessment with sonography for trauma (FAST) examination has been used by physicians to assess patients with blunt abdominal trauma (BAT) and penetrating injuries for blood in the intraperitoneal, pericardial, and pleural spaces (11). In remote locations, this limited ultrasound scan is the first-line imaging modality for traumatic injury. The ability to perform this type of bedside assessment provides critical information to guide triage, treatment, and evacuation decisions. The extended FAST (EFAST) examination also includes evaluation for additional thoracic injuries such as pneumothorax (PTX) or hemothorax.

There is a vast amount of research that has been conducted regarding the utility of FAST and EFAST examinations in both civilian and military applications (3, 4, 5, 6, 14, 15, 16, 17, and 18). Both examinations have been shown to be accurate in diagnosing or ruling out emergency situations with regard to blunt abdominal or thoracic trauma. Other benefits noted included shortened time to operative care, reduced exposure to ionizing radiation, and feasibility in minimally trained physicians and non-physicians alike. Stated risks included a theoretical possibility of non-radiology physicians over or under reading examination results. However, these risks can be minimized with appropriate education and training leading to specific and limited ultrasound certification and the use of quality assurance measures.

Physicians deployed with land-based military units often have a portable ultrasound for the immediate evaluation of patients. Portable ultrasound is commonly used among this population for FAST exams; however, EFAST exams are gaining popularity because of ultrasound's ability to identify thoracic pathology. Pleural-based, life-threatening injuries like pneumothoraces can be identified and subsequently definitively treated in the field. According to the literature, ultrasound is a tool that can be used by physician and non-physician providers to better diagnose, triage, and treat acutely injured personnel (19).

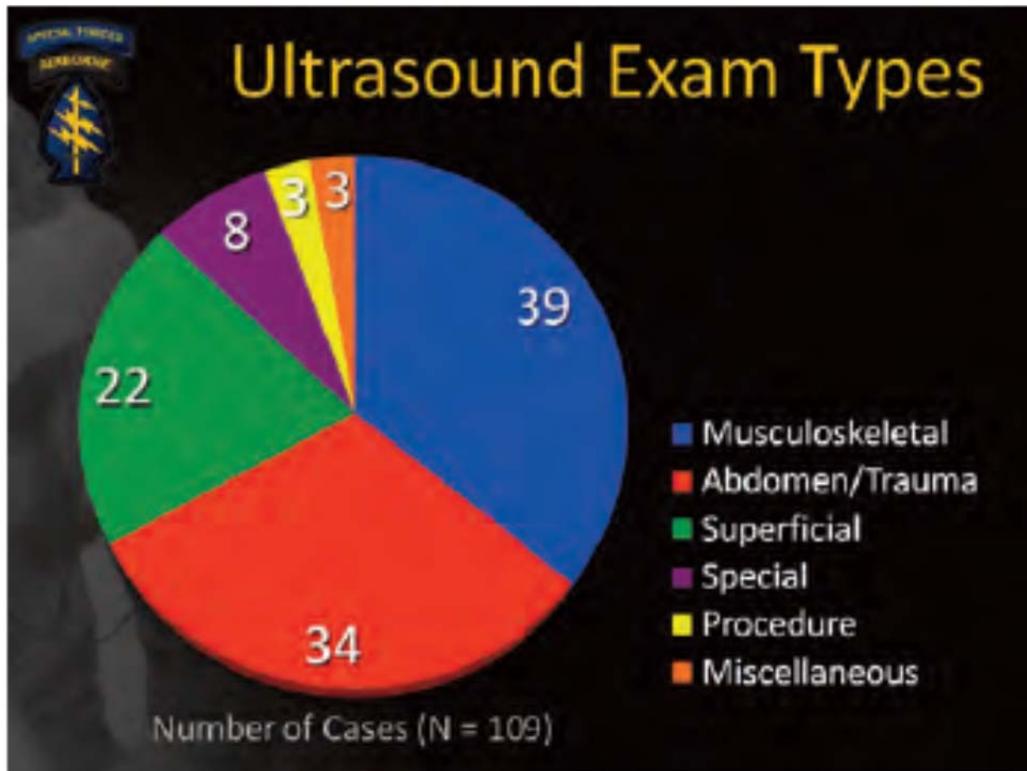


Figure 1: The pie chart above is from the article “Special Operator Level Clinical Ultrasound: An Experience in Application and Training” which was published in the Journal of Special Operations Medicine in 2010. Note that this chart indicates that the two most common reasons that deployed medical personnel use ultrasound are musculoskeletal and abdominal trauma.

In many ways, the mission and assumed risks that the National Aeronautics and Space Administration (NASA) astronauts are faced with onboard the International Space Station (ISS) are very similar to the issues facing deployed military physicians and their troops (16, 20). That is, both are operational in remote areas performing high risks assignments with very limited medical support and supplies. In addition, medical evacuation of injured personnel is costly, negatively impacts the mission, and endangers the lives of many others. Similar to the military, NASA astronauts’ greatest risks while on a mission are acute trauma and acute medical sickness. To aid in medical diagnosis in space, NASA has instituted a teleradiology ultrasound program that allows minimally trained astronauts to receive remote guidance from physicians on Earth in order to perform diagnostic and surgical procedures (20, 21). Since NASA implemented this teleradiology ultrasound program, there have been several papers that validate this new application of ultrasound by documenting positive outcomes during actual space missions (16, 20, 21, and 22).

CURRENT USES FOR ULTRASOUND AMONG UMOs

Currently, it is unclear the level of use of ultrasound among UMOs. At NEDU, there are currently 5 UMOs and only one has been formally trained in ultrasound during an emergency medicine residency several years ago. There are a few ultrasounds

available for use at NEDU, however, they are rarely used in a medical or clinical setting and are mostly reserved for research protocols. The scarcity of use in a clinical setting may be due to insufficient training and comfortability in using ultrasound among the UMOs. Perhaps, it is due to the absence of penetrating and blunt abdominal trauma in NEDU's patient population along with NEDU's access to local emergency medical services.

UMOs that function as NSW physicians have ultrasound capability but not necessarily any formalized, approved training (E3, E4, and E5). Portable ultrasound is part of the Authorized Medical Allowance List (AMAL) for Seal Delivery Vehicle (SDV) Teams onboard U.S. Navy (USN) submarines (E3). Appendix B is a Sample NSW3 AMAL list. SDV Independent Duty Corpsmen (IDC) are trained by their UMOs to use ultrasound for both routine and emergency situations (E4). However, many, if not most, of the UMOs that are responsible for teaching the SDV IDCs have no previous ultrasound training because most 1st tour UMOs are non-residency trained physicians. In addition, despite the ability to use ultrasound, there is no education or training process for NSW UMOs or their SDV IDCs that ensures competency. Just as important, there are no quality assurance measures or controls despite ultrasound use.

The undersea community is vast and UMOs function in a variety of roles. Of the UMOs that regularly use ultrasound, some have formalized training from a prior residency but the requirement for effective training within the entire undersea community still remains.

POTENTIAL USES FOR ULTRASOUND AMONG UMOs

Despite the variability in UMO job descriptions, most UMOs take calls for the local military hyperbaric chamber. Prior to any recompression in a hyperbaric chamber, it is the UMO's responsibility to rule out a PTX. Failure to do so could result in a tension PTX during decompression. When a patient with decompression sickness (DCS) presents to the hyperbaric chamber, there is no access to an x-ray machine; therefore, the only way to currently rule out a PTX is with a stethoscope, which is especially difficult in an obtunded patient (E1). Ultrasound is both specific and sensitive for PTX and, if chamber tested, could prevent a delay from entering the hyperbaric chamber if a PTX does exist. This leads to more timely and adequate treatment prior to recompression or in the chamber after recompression. Other foreseeable examples in which ultrasound could prove invaluable for an UMO include:

1. Trauma – Ultrasound could differentiate between the pain around a joint from a broken bone versus injured tendon versus Type 1 DCS.
2. Procedural guidance – A dehydrated patient presents with Type 2 DCS and needs IV access, which is proving difficult and timely given the patient's hydration status. Ultrasound for vascular access could virtually guarantee access even in the most difficult of patients. In addition, this could be performed in the chamber preventing an unnecessary delay outside the chamber trying to acquire access. However, in order for these procedures to be performed in a chamber, ultrasound

needs to undergo hyperbaric chamber testing at NEDU and then be approved by the Bureau of Medicine (BUMED) for use in chambers.

3. In addition, ultrasound could prove indispensable onboard an SSGN, onboard the Submarine Rescue Diving Recompression System (SRDRS), and onboard the Saturation Flyaway Diving System (SATFADS).

Given the different types of communities that UMOs work with, the potential applications are numerous. However, for commands that already have ultrasounds as part of their armamentarium, for example NSW physicians and SDV Team IDCs, a requirement for formal, effective, and validated training remains.

ULTRASOUND CURRICULUM GUIDELINES AND COSTS

There are several organizations that have developed ultrasound training and proficiency curriculums that are designed to either meet the needs of certain physicians or certain patient populations.

Across the country, there are several primary care ultrasound fellowships. One such program has been created by The University of South Carolina School of Medicine to train internal medicine, family medicine, and pediatric physicians to use ultrasound in both outpatient and inpatient settings. This program is one year in length and covers the following topics: vascular ultrasound, abdominal ultrasound, obstetrics and gynecology ultrasound, lung ultrasound, musculoskeletal ultrasound, emergency medicine ultrasound, echocardiography, and ultrasound guided procedures. In addition, the fellows are required to participate in research and publish at least one peer-reviewed article as the lead author. While there are many merits to a program like this, the length of the program is not feasible and the content is too broad for the undersea community.

As mentioned previously, NASA astronauts that will be part of long-duration missions onboard the ISS receive ultrasound training as part of their pre-mission work-up curriculum. These astronauts are non-medical crew members who undergo ultrasound training at the Johnson Space Center in Houston, Texas (20, 22). Each astronaut receives training in ultrasound basics and hardware familiarization lasting three hours. After completing the training, each crew member is provided with a small reference card, called a cue card, that tells them exactly what transducer to use and where and how to place it for each potential application. While onboard the ISS, crew members are able to perform ultrasound while a physician on Earth remotely interprets the image. Despite only short 3-hour training for non-medical crew members, there have been a number of peer-reviewed, published papers documenting the successes of this program. This type of curriculum only teaches students how to obtain quality diagnostic images but not how to interpret the images. A course similar to this NASA program may eventually serve a role in the military if a reliable military teleradiology service could be established. However, the undersea community would be better served by UMOs receiving training that provides them the ability to obtain diagnostic quality images for select ultrasound applications along with the knowledge to then interpret these images.

The American College of Emergency Physicians (ACEP) published a policy statement in October 2008 titled “Emergency Ultrasound Guidelines.” Although this guideline was developed specifically for board-certified emergency medicine physicians, it could just as easily be applied to operational physicians. This guideline states that ultrasound is suited for use in an austere battlefield environment by military physicians. According to the ACEP, there are two pathways for ultrasound training (7). The first pathway is through residency-based training which is not feasible for all undersea medical officers since many UMOs are non-residency trained physicians. The second pathway is through practice-based training and is intended for clinicians without a formal background in ultrasound, making this pathway uniquely suited to the undersea community. For the practice-based pathway, the initial training should include a 16 to 24-hour introductory course covering the core applications with practical hands-on sessions. For each unique ultrasound application, 25-50 cases are needed to be considered competent. The ACEP Emergency Ultrasound Curriculum is quite extensive covering a range of topics and can be found in appendix 2 on pages 22 – 26 of their policy statement.

Appendix 4 of the ACEP Emergency Ultrasound Guidelines is a suggested outline for implementation of an introductory ultrasound course for physicians. According to this outline, 1 machine with appropriate transducers and at least 1 instructor per every 5 students are needed. There should be approximately 8 hours of didactics, at least 6 – 8 hours of hands-on skills laboratory looking at both normal and abnormal anatomy, and a syllabus or standard text to supplement lectures and the skills laboratory.

The American Institute of Ultrasound in Medicine (AIUM) is a multidisciplinary medical association committed to advancing the safe and effective use of ultrasound in medicine (23). AIUM is one of the leading organizations for professional and public ultrasound education and research. AIUM is equally important in the development of ultrasound guidelines. With regards to ultrasound training, AIUM states “completion of training as recommended by the ACEP is accepted as proof of sufficient training.”

There are several civilian ultrasound training opportunities that are based on both ACEP’s and AIUM’s guidelines (P1, E6). However, these courses are very expensive. A typical 2 -3 day course may cost as little as \$747 per person for the introductory ultrasound training offered by The Emergency Ultrasound Course, 3rd Rock Ultrasound, LLC (<http://www.emergencyultrasound.com/>) all the way up to \$2045 per person for similar training offered by The Gulfcoast Ultrasound Institute, Inc., (<https://www.gcus.com/>). In addition to the costs of the course, each UMO will need to travel to the location where the course is offered which may mean additional costs for transportation, per diem, and lodging. The benefits to this type of training are threefold. First, UMOs will receive training that prepares them to achieve diagnostic quality ultrasound images with the ability to interpret the images as well as the ability to use ultrasound for procedural guidance. Second, this training follows the ACEP and AIUM guidelines that have already been verified by numerous studies to be successful ways to train physicians. Lastly, this type of ultrasound training only requires 2-3 days of time versus a year or longer. However, the costs associated with this type of training might

be prohibitive. It is not possible to get a complete cost analysis for these courses because the TAD costs are unknown. Assuming two classes of UMOCs get trained per year with roughly 20 UMOCs per class and then using the cheaper of the two courses mentioned above (i.e. \$747 per person), the total costs to train UMOCs only would be \$29,880 per year, excluding TAD expense or training for already graduated UMOs. Table 1 addresses these additional TAD costs by applying an average travel costs of \$300 per person and per diem rate and lodging costs equal to the current New London, CT rate.

There are military ultrasound education and training opportunities that already exist as with some key costs differences (P1, P2, E6, and E7). The most validated and UMO relevant military ultrasound training program is called the Special Operator Level Clinical Ultrasound (SOLCUS) program (3, P2, E7). The SOLCUS program is based on the ACEP’s practice-based training pathway as described above (4). The U.S. Army sends SOLCUS instructors TAD to teach the course that appears to be a huge cost-savings compared to sending all students who need to be trained to the instructors.

Assuming 20 UMOs and a 5-to-1 student to instructor ratio (based on the ACEP guidelines), a minimum of 4 instructors would be required to teach one UMOC class. This would mean approximately 8 instructors for 2 days out of the entire year. Current maximum per diem (this includes lodging at \$97 and meals and incidental expenses at \$56) in New London, CT, is \$153 per day. Presuming an average travel cost of \$300 roundtrip per person, this yields a total cost of \$4848 per year. Expenses could be decreased if a command vehicle is made available with no need for a rental car. The benefits to this type of ultrasound training is the same as the ACEP and AIUM civilian courses mentioned above with the additional benefit of being significantly cheaper. Of note, this type of course will require ultrasounds and training phantoms (a training phantom is an ultrasound training device used to teach a specific application) at each training location. This would be a one-time expense. Other expenses would include supplies for procedural guidance lectures if applicable.

<u>ULTRASOUND PROGRAM COST COMPARISON</u>		
	<u>Civilian Program</u>	<u>SOLCUS Program</u>
Class cost per person	\$747.00 to \$2045.00	\$0.00
Number of travelers	20 UMOCs x 2 classes = 40 / yr	4 instructors x 2 classes = 8 / yr
Travel cost per person	\$300	\$300
Per diem per person	\$56	\$56
Lodging cost per person	\$97	\$97
Total number of days per course	2 to 3	2
Total costs per year	\$54,120.00 to \$112,160.00	\$4,848.00

Table 1. Ultrasound Program Cost Comparison

ESTABLISHING THE SOLCUS PROGRAM

The United States Army was the first service to recognize a need for formal training recommendations for medical personnel who had access to ultrasound but had not received training in a residency (4). The U.S. Army also recognized that all of their physicians and medics attached to the Special Operations Forces (SOF) community had access to ultrasound, but, despite the access, the use of ultrasound was limited (4). In 2008, *Keenan et al* published an article titled, "Ultrasound in Special Operations Medicine: A Proposal for Applications and Training," in the Journal of Special Operations Medicine that defined the goals for establishing the SOLCUS program. It included the following 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, and 4. Develop a skill proficiency plan and privileging criterion. Since the SOLCUS program was founded on these 4-steps and has been a huge success, this same process can be applied to developing the UMO ultrasound program.

EVALUATING THE SOLCUS PROGRAM

In the Journal of Special Operations Medicine in 2010, *Morgan et al* published, "Special Operator Level Clinical Ultrasound: An Experience in Application in Training," which evaluated the results of the previous two years of ultrasound use in the SOF community after formal training implementation. Retrospectively, the authors reported that the program was an overall success and that the SOLCUS curriculum should focus on EFAST examinations, basic fracture detection, superficial soft-tissue applications, and procedural guidance (3). In addition, the authors did identify areas of concern they recommended for future studies (3). After a thorough review of the issues identified as areas of concern, it is important to note that none of those concerns would negate the importance or possibility of establishing an UMO ultrasound program. In fact, most of the concerns raised were related to optimizing the ultrasound program through feedback and retrospective analysis.

EXAMPLE UMO ULTRASOUND CURRICULUM

Below is the standard 2-day introductory course taught to students of the SOLCUS program (E7). This 2-day course would be the most useful for introductory training at Naval Undersea Medicine Institute (NUMI). There is flexibility built into this course and it can be modified based on the operational mission set. For example, if NUMI is graduating several UMOCs who are going to commands that engage in foreign internal defense, then NUMI may choose to substitute one of the lectures for an OB/GYN lecture.

Day 1:

Introduction to Basic Ultrasound

Extended FAST with Inferior Vena Cava interrogation

Procedures (IVs & blocks) (need supplies: needles, syringes, wipes, & lidocaine)

Free Scan

Day 2:

Musculoskeletal and Soft Tissue

DVT

Ocular

Renal

Free Scan

CONCLUSIONS

The SOLCUS program will provide the education needed to train UMOs in ultrasound. This program will fit neatly into the UMOC curriculum and can be easily incorporated into UMO training around the fleet. All of this can be accomplished with minimal monetary and time costs, particularly when considering that money and time are being balanced against human costs. UMOs who are formally trained and then employ point-of-care ultrasonography can provide their sailors with concrete monetary and time cost benefits. Furthermore, the use of point-of-care ultrasonography may be life-saving.

Since many UMOs operate in the SOF community, it is easy to apply the five SOF Truths (<http://www.soc.mil/USASOCHQ/SOFTruths.html>) listed below throughout the undersea community:

1. Humans are more important than hardware.
 - Ultrasounds are not going to hurt anyone, but their use may save a life or, at the very least, provide a better patient care and management decisions.
2. Quality is better than quantity.
 - Portable ultrasounds may prove very valuable to the community but only in the hands of formally trained individuals.
3. SOF cannot be mass produced.
 - Special training is required for UMOs because the job set is unique and requires an equally unique skillset.
4. Competent SOF cannot be created after emergencies occur.
 - The time for training UMOs and other deployed medical assets is now before the need is painfully evident.
5. Most special operations require non-SOF assistance.

The UMO is responsible for ensuring that the best possible healthcare is provided to all members of the undersea community. The UMO needs to be prepared to make the right clinical decision for every patient who seeks his or her help. Sometimes this means sending the patient to a specialist at a larger Military Treatment Facility (MTF) or civilian emergency room because the clinical presentation is outside the UMO's scope of practice. However, in the operational setting or at a hyperbaric chamber, this may be difficult. The UMO and, in some cases, the SDV Team IDC are the patient's only hope. There are many sailors in the undersea community who willingly volunteer to put themselves into harm's way to accomplish the needs of the Navy. Sailors do this because they know they have the full support of the Navy.

The portable ultrasound technology and guidelines for curriculum implementation needed to start a robust UMO ultrasound program already exist and can be procured at minimal costs. Fully equipping and training UMOs in emergency ultrasound will make Navy medicine stronger by improving patient care and management in austere and operational environments.

RECOMMENDATIONS

Navy undersea medicine leadership should appoint 3-5 UMOs from a variety of billets who have the knowledge and motivation to accomplish the following:

- I. Establish a connection with SOLCUS program managers, like MAJ Bill Vasios, with the goal of joining forces to avoid duplicating efforts that have already been solved by the Army.
 - a. Implement the 4-step process specifically to the UMO community:
 - i. Analyze operational mission set and develop corresponding learning objectives
 - ii. Establish medical officer oversight and create a cadre of ultrasound subject matter experts
 - iii. Plan an introductory course for the general target audience
 - iv. Develop a skill proficiency plan and privileging criterion
 - b. Looking at the U.S. Army's experiences, it seems most prudent for an UMO ultrasound curriculum to be based off of the SOLCUS introductory 2-day schedule (as detailed above)
 - i. NUMI could use this to train all new UMOCs entering the fleet
 - ii. NUMI should purchase 2 – 4 US and appropriate phantoms to begin training
- II. Work with Navy Medicine's Department of Radiology to investigate the implementation of a teleradiology service.
- III. Fund testing at NEDU to certify the SonoSite M-Turbo ultrasound for use in U.S. Navy hyperbaric chambers. Again, this ultrasound is used at Duke University and a few other locations, both inside and outside the hyperbaric chamber.
- IV. For commands that have ultrasound as part of their AMAL:
 - a. Require the non-residency trained UMOs at these commands to complete SOLCUS training and competency measures prior using ultrasound
 - b. Encourage these commands to share their experiences with NUMI to help change and further develop the UMO ultrasound curriculum
- V. In the future, after successfully implementing a formal UMO ultrasound curriculum, the following items will be required:
 - a. Privileging: Limited ultrasound privileges could be granted to UMOs in a fashion similar to how privileges for hyperbaric treatment of decompression sickness are granted to UMOs after successfully completing the NUMI training.
 - b. Although not discussed in this paper, it will be necessary to start developing quality assurance (QA) measures. Again, the U.S. Army already has a robust, easy-to-implement system in place for QA of their SOLCUS program. The UMO community should use a similar model to perform QA.

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PHONE CALLS

P1. PHONCON Uniformed Services University of the Health Sciences CDR James Palma/ Navy Experimental Diving Unit LT Joseph Yetto 6 November 2013.

P2. PHONCON SOLCUS Program Manager MAJ William Vasios/ Navy Experimental Diving Unit LT Joseph Yetto 29 December 2013.

EMAIL CORRESPONDENCES

E1. EMAILCON Darnall Army Medical Center LTC Brian Hall/ Navy Experimental Diving Unit LT Joseph Yetto 28 October 2013.

E2. EMAILCON SonoSite, Inc. Brian McHugh/ Navy Experimental Diving Unit LT Joseph Yetto 16 January 2014.

E3. EMAILCON NSWLSU3 LT Grace Landers /Navy Experimental Diving Unit LT Joseph Yetto 31 October 2013.

E4. EMAILCON NSWLSU3 CDR Daniel Moloney /Navy Experimental Diving Unit LT Joseph Yetto 22 November 2013.

E5. EMAILCON Naval Special Warfare Center CDR David Durkovich/ Navy Experimental Diving Unit LT Joseph Yetto 16 January 2014.

E6. EMAILCON Uniformed Services University of the Health Sciences CDR James Palma/ Navy Experimental Diving Unit LT Joseph Yetto 4, 6, 7 November 2013.

E7. EMAILCON SOLCUS Program Manager MAJ William Vasios/ Navy Experimental Diving Unit LT Joseph Yetto 12 November 2013, 30 December 2013, and 14 January 2014.

Appendix A

Sample List of Standard Questions Asked of Experts

1. What off-the-shelf options are available to start an ultrasound program for UMOs?
2. How do you guarantee competency?
3. How do you perform quality assurance or quality control?
4. What type of ultrasound do you use?
5. What kind of batteries does your ultrasound use?
6. What are the initial and sustainment costs associated with your ultrasound? Who services, replaces damaged, calibrates ultrasounds? Is there a point-of-contact for the ultrasound vendor?
7. Can you please provide any other information based on your experiences? Do you suggest any specific articles as part of a comprehensive literature review?

Appendix B

NSW3 Ultrasound Portion of AMAL List

ER MEDICAL LOAD OUT UPDATED: 14 APR 2011

REQUIRED UNITS		NEED	UNIT PRICE
AIRWAY BOX	1650	1	\$9,300.00
DRUG BOX	1650	1	\$32,987.33
IV BOX	1650	1	
HEMIOSTASIS BOX	1650	1	\$1,719.20
VENTILATOR BOX	1650	1	\$15,399.00
REFRIDGERATOR		1	\$6,164.83
ULTRASOUND / ISTAT BOX	1650	1	\$57,000.00
SURGICAL BOX	1650	1	\$14,672.00
PRIMARY	1650	1	\$756.00
SECONDARY BOX	1650	1	
BEAR HUGGER BOX	1650	1	
OR KIT BOX	1650	1	\$198.00
ZOLL/ HYFREATOR BOX	1650	1	
EMERGENCY LIGHTING		1	
SCHEDULED DRUGS (Locked)			\$0.00
		LOAD OUT TOTAL	\$138,196.36