# Care of Equipment

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As ultrasound technology becomes more accessible in the form of handheld devices and as the price of devices also falls, its utility in the prehospital setting has become more apparent. Handheld devices and transducers that connect to users' existing smartphones or tablets seem practically purpose-built for the prehospital environment. Despite their portability and ease of use, ultrasound devices are medical diagnostic equipment that must meet the same industry standards. Additionally, ultrasound devices utilized in the prehospital environment are subject to environmental stresses that devices which always remain indoors may not be [1-3]. Their small size and portability makes handheld ultrasound devices subject to potential damage, loss, or theft. Prehospital providers utilizing ultrasound must be keenly aware of these equipment considerations.

## Device Care and Protection

Unlike a hospital which has access to a clinical engineering department that can be relied upon to inspect, repair, and maintain equipment, most prehospital care agencies maintain their own equipment, or contract with equipment vendors to provide routine maintenance and updates. At the time of purchase of an ultrasound device, the purchaser should understand fully what types of maintenance and repair are included in the purchase package. It should be noted whether warranty covers specific threats unique to the prehospital environment. Purchasers should be aware of the length of the warranty, and be informed regarding at what point a device will no

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longer be serviced. What tests does the manufacturer recommend to ensure that image integrity is preserved over time, and that the device continues to display images with high resolution and sharp contrast?

Numerous multidisciplinary groups have issued professional recommendations on how ultrasound transducers should be cleaned and disinfected. Low-level disinfection is suitable for most prehospital point-of-care ultrasound application (surface ultrasounds performed on closed skin). A soap and water cleanse or the use of a quaternary ammonia spray or wipes is recommended. Device manufacturers will provide lists of approved brands of solutions suitable for use with their product. Prepackaged disinfecting wipes are convenient, but it should be noted that these may desiccate if stored for a period of time in high heat, low humidity conditions. Disposable barrier devices such as sterile ultrasound probe covers, clean gloves, transparent film dressings (***tegaderms – copyright name***) or condoms could be utilized to minimize contamination and facilitate efficient cleanup, yet these add to operational costs and direct probe disinfection is still recommended after use [4].

As with adding any device to the field or in the hospital regular device maintenance and daily quality checks may be necessary. Establishing a routine and even a checklist will assist in keeping a device in-service and increase the ultrasound's lifespan. Examples of checklist topics include: sufficient battery life/power supply, ensuring that the probes are clean and cleaning supplies are restocked, checking for software updates, adequate amount of non-expired gel and inspecting for any damage to the probe or cables/connections.

Protecting ultrasound equipment is an important consideration. Storage of prehospital ultrasound devices will vary greatly depending on the planned use of the device, the environmental threats anticipated and the configuration of the ultrasound components. Hard-lined cases with internal customizable foam offer a great deal of protection from falls and environmental elements yet they are usually large and add substantial weight. While larger bulky cases are reasonable for storage on a vehicle or aircraft, their size and weight can hinder responders from bringing ultrasound devices to the scene or on prolonged field responses [5]. Storage devices that piggyback onto or are built into "first-in bags" are more likely to make it to the patient bedside yet could subject the device and transducer to structural damage and environmental exposure. Adjunct supplies for ultrasound use (disinfection supplies, procedural equipment, non-sterile and sterile gel) should ideally be co-stored with the ultrasound device to ensure availability and utilization by prehospital personnel.

Storage considerations should be specific to the type of ultrasound device and transducers chosen and most manufactures can provide storage and device protection recommendations. The prehospital setting has become an ideal opportunity to examine the use of application-based platforms (tablets, smartphones, laptops) given their multi-functional capabilities, light-weight, small size and long battery life. Popular application-based devices offer innumerable options when considering device protection, such as fall and water proofing. Many of the cases utilize military standardization for protective ratings/classification. In the future ultrasound software and the appropriate connectivity (cabled vs wireless) may also be integrated

into cardiac monitors which will require attached storage of transducers and possibly cables.

While commercially available cases have many advantages, only a select few cases may provide additional support for sensitive cable connections that are frequently at risk for structural damage. Reinforcing cords at the point of connection to the probe/device and purchasing cable protectors may require more initial investment but can mitigate long term replacement costs by increasing cord life and preventing cord/connection damage [6]. During selection of ultrasound and probe devices prehospital providers should critically identify the vulnerabilities of each device individually. For example, exchangeable probes which can detach from connecting cables at their base, can be efficient and more functional in the prehospital setting due to their smaller size, yet this convenience comes with increased susceptibility to damage as compare to probes with permanently attached cords. While traditional systems only have one connection interface, these systems have two connection interfaces. The benefits and pitfalls of each unique ultrasound setup need to be evaluated in order to appropriately safeguard this valuable and expensive resource.

Devices that are anticipated to be used primarily during transport could be mounted into an ambulance, which protects the device from nearly all potential hazards. However, permanently affixing the device in this manner may decrease the device's functionality if it cannot be brought out of the vehicle to a scene.

## Environmental Operating Conditions: Challenges Posed by the Prehospital Setting

The prehospital setting poses environmental hazards that could damage an ultrasound device, markedly degrade image quality, or cause the device to temporarily malfunction. Manufacturers provide information regarding the optimal temperature and humidity ranges for both storage and operating conditions for their device. Providers utilizing the ultrasound device and gel should be aware of these temperature and humidity parameters and avoid using the device when conditions are clearly outside of these ranges. Bright sunlight, while unlikely to acutely damage ultrasound equipment in short exposure intervals, can significantly impair one's ability to visualize ultrasound images on a screen [7, 8].

Resourcing adequate power supply and planning for sustained field usage is a vital component of prehospital ultrasound systems. EMS agencies must decide whether to power the device directly, or to charge it for portable, cord-free use. Internationally, considerations regarding the available power grid as well as the type of plug adaptors are essential to ensuring continuity of care. In general, the manufacturer will supply information regarding battery life and recharging time for portable devices. The type of batteries utilized by the ultrasound system may also change the management and planning for a prehospital ultrasound program. While lead acid batteries are less expensive, they tend to function poorly in cold environments. In addition, lead acid batteries tend to be less power efficient (ie. weigh more

and carry less usable energy) than the more expensive Lithium based batteries. While one may favor lithium batteries, deployable agencies that utilize commercial airliners may have difficulty in traveling with Lithium based devices [5]. In situations where a power supply may be inconsistent or non-existent, programs may investigate off-grid recharging solutions such as solar-based, hydro-based and wind-based charging or even human-powered generators ("hand cranks"). While easily overlooked, battery selection and power sources must be thoroughly considered when implementing prehospital ultrasound systems [5, 9, 10].

Variability and limitations in patient access can be an unforeseen difference between hospital based and prehospital ultrasonography. Patient's in the field are frequently in less than ideal locations and body positions for ultrasound use. In addition, modern day stretchers do not allow for easy patient access to the retroperitoneal spaces which can limit fast exams. Some ambulance and aircraft configurations may not allow for 360 degrees of patient access and this may limit space between the patient and vehicular interior frame. Larger and longer ultrasound probes can provide excellent images or allow a single transducer to function across multiple frequencies [11], yet these larger devices may be difficult to utilize in the presence of limit space and physical obstructions such as those encountered in the less spacious prehospital setting (i.e. consider trying to perform a FAST exam in a confined space or even with specific interior ambulance configurations. Given some of these limitations the physical size of the probes selected for prehospital use should be carefully trialed in their anticipated operational setting.

The use of ultrasound for procedures in the field requires additional logistically planning and management. In the hospital setting, procedural equipment is located in systematic fashion with accessibility based on the critical nature of the procedure. Ideally, equipment for critical procedures would be available at the point of patient contact. This patient-centered concept has been the basis for "jump bags" and "first-in bags" in the field. Equipment for ultrasound-based procedures, especially interventions to address life-threats, need to be readily accessible. These procedural instruments should be co-located or attached to the ultrasound device to ensure immediate availability to prehospital personnel. For example, if within the scope of practice of the prehospital clinician, one should consider storing supplies for emergent ultrasound guided pericardiocentesis with the ultrasound device. Additionally, storing intravenous access supplies and specialized angiocatheters with the ultrasound device for ultrasound guided peripheral access care can improve prehospital care efficiency. While not realistic for all procedures, prehospital providers can improve delivery of care via logistical pre-planning and equipment staging.

While once a distant consideration, the implementation of transesophageal ultrasound in the field is no longer a thing of the future. For those programs and individuals considering implementing the use of transesophageal echocardiogram in the field one must select between disposable and re-usable probes. The current selection of portable TEEs is limited in comparison to hospital/ facility based devices. Cleaning re-usable probes will require close coordination with a sterile-processing department, likely within the hospital system, as well as consulting manufacture recommendations. In addition, given their invasive nature, these probes are

temperature sensitive by design and only operate within certain temperature ranges which may limit their functionality in austere settings. Field deployment of these expensive devices usually requires large, heavy protective cases, which is another current limitation. Continued research and evolving technology are needed to determine the future utility and functionality of TEE in the field especially given the logistical considerations in mobilizing this device.

## Connectivity and Maintaining Application-Based Platforms

Smartphone and tablet-based ultrasound platforms often require internet connectivity, which may be lacking in many prehospital settings. For this reason, it is important to keep application-based platforms up-to-date whenever connection to the internet is possible. Most of these devices will require at least intermittent internet access in order to download updates; if this is not performed at routine intervals, the platform may not function when desired.

## Protecting Patient Information

Several handheld ultrasound devices now permit users to upload images to a cloud-based format, or to save images to a DICOM system for review or storage. Tablet or smartphone-based devices allow images to be shared through email or file sharing. The ease with which images can be shared can potentially violate patient confidentiality. Whenever possible and appropriate, the de-identification of images will protect patient privacy and prevent protected health information (PHI) from being inadvertently shared. A secure cloud-based platform is another storage option, but its degree of encryption must be compliant with requirements set forth by the HIPPA Security Rule. Other technical safeguards to protect patient information must be utilized whenever feasible. In the future, with potential integration of ultrasound software into cardiac monitors, the data and images will require similar protection as electrocardiograms and vital sign data.

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