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# AIUM Routine Quality Assurance of Clinical Ultrasound Equipment Subcommittee

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## Purpose

The purpose of a quality assurance (QA) program in medical ultrasound is to define and follow steps that evaluate safety and performance of ultrasound equipment. Sonographers and ultrasound physicians seek assurance that the information obtained in a clinical ultrasound procedure is as accurate as can be determined and that equipment and clinical practices are safe. Administrators and practice managers often require formal steps that are directed toward these same purposes. Finally, laboratory accreditation groups require that QA programs be in place in installations that receive accreditation.

This document outlines a basic QA program for clinical ultrasound facilities. Sonographers, physicians, or other technical staff, including medical physicists and biomedical engineers, can carry out these procedures easily. The QA procedures outlined are intended to address requirements for QA in the clinic set forth by laboratory accrediting agencies, such as the American Institute of Ultrasound in Medicine (AIUM) and the American College of Radiology. Although they require a QA procedure to be in place for accreditation, many of these agencies allow flexibility in defining the program. This document will list QA procedures that may be followed when setting up and maintaining an equipment QA program.

This document does not provide an exhaustive test of factors that measure ultrasound instrument performance. More complete ultrasound QA manuals and methods for assessing ultrasound equipment performance are listed in “References.” In a busy ultrasound clinic, it is not always possible for staff to carry out detailed performance testing of all scanners, transducers, and modes of operation. This document is intended to outline a very basic QA program that will help detect occasional scanner/transducer/display malfunctions. Basic QA steps also include safety and cleanliness checks that are followed under good laboratory practice.

## Who Is This Document Intended for?

This document is aimed at clinical ultrasound personnel who are setting up and maintaining an equipment QA program for their facility. It also will be useful to physicists, engineers, and other individuals, including ultrasound equipment service personnel, who consult or otherwise assist with QA programs. Engineers and physicists frequently can assist a clinic with more detailed performance tests than the basic tests included here. Examples of such tests are described in “References.”

## Equipment and Operating Modes Covered

QA procedures listed in this manual are for an ultrasound machine operating in a gray scale imaging mode. Although most scanning machines also operate in Doppler and color flow imaging modes, the basic performance tests may be performed only in a gray scale mode.

However, because recommended tests emphasize the performance and integrity of the transducer, the test results apply to a limited degree to Doppler and color flow performance as well.

## Types of Ultrasound QA Programs

An important part of a QA program consists of routine checks and procedures carried out daily by the sonographer to ensure cleanliness and safety of scanning equipment. Sonographers also can readily detect some equipment malfunctions, such as extensive element dropout in array transducers. QA checks routinely done by the sonographer are listed in “Section A: Cleanliness and Safety.”

A second facet of a QA program is making sure that equipment operates consistently at its expected level of performance. “Section B: Image Display and Performance” lists a very basic program that includes practical procedures that are known to identify some malfunctions.

Facilities may choose from a variety of methods to achieve the goals of a QA program. Some clinics contract with ultrasound equipment manufacturers or their scanner maintenance engineers, who typically will do routine testing and perform preventive maintenance procedures on scanning equipment. Other clinics engage a hospital physicist or engineer or other technical staff to conduct tests of equipment using phantoms and test objects that are imaged with the machines. Third, many facilities conduct their own QA tests by scanning and analyzing images of phantoms or patients. In many cases, when equipment malfunctions occur, they are most often detected during routine clinical examinations, for example, when a sonographer notices evidence of element dropout in the transducer, or when tissue penetration seems to become compromised. Routine QA tests help verify whether such observations are equipment or patient related.

## Equipment Manufacturer's Role

The ultrasound equipment manufacturer provides valuable resources for QA. Most provide a list of recommended QA procedures in the operator's manual for each machine. This list should be consulted when designing a clinical QA program. Some ultrasound systems can be tested online, for example, through Internet or telephone connections to the manufacturer's facility, and this type of testing can be a valuable part of a routine QA program. Finally, the operator's manual usually contains valuable information on equipment safety and cleaning methods, including recommendations for disinfecting ultrasound probes. This information should also be readily available to individuals setting up and maintaining a QA program.

## Who Should Be in Charge of the QA Program?

The AIUM recommends that clinical facilities appoint an individual to be responsible for the program. If a medical physicist or biomedical engineer is available, this individual is usually trained in general QA techniques and could organize and maintain the program. Some QA procedures are those that are routinely carried out as good clinical ultrasound practice; these include, for example, inspection of transducers for cracks and taking steps to ensure proper cleaning. Furthermore, sonographers usually are familiar with complex ultrasound equipment and how to set it up properly for scanning. Therefore, physicists or engineers must work closely with clinical personnel in running a program, and a partnership with a designated QA sonographer is recommended.

Many facilities do not have a medical physicist or biomedical engineer available to do ultrasound QA procedures. Here, a sonographer, physician, or other qualified staff member usually is designated to organize and run the program.

## Using Phantoms

Although daily QA steps done by sonographers do not require a phantom, more detailed checks of image display and performance are best done using a phantom or other test device. With a tissue-mimicking phantom, periodic test results are compared with baseline results of machine or transducer performance. The baseline results are obtained either when a machine is accepted or when the QA program is initiated. Records are maintained of baseline and periodic test results, and Goodsitt et al<sup>2</sup> provide examples of forms for this purpose. Another example of a form that includes checks of cleanliness and safety is included below. Goodsitt et al<sup>2</sup> also list tolerance and action levels that guide clinical users if periodic QA test results drift from baseline levels.

Physicists, biomedical engineers, and service personnel often use phantoms or test objects when carrying out QA procedures, and some clinical facilities purchase their own phantoms for in-house testing. Phantoms have been known to drift or otherwise deteriorate over time, so it is important to follow the phantom manufacturer's recommendation for storage and for its certification or recertification schedules. It is recommended that the date of production and dates of recommended recertification of a phantom's properties be clearly indicated on the device.

## Frequency of Tests

We recommend that equipment operators become familiar with the QA tasks listed in the tables below. In particular, those listed as "daily" are routine tasks that trained sonographers follow to help ensure patient safety and proper equipment operation. Less frequently performed "periodic" tests, such as target detection, overall sensitivity, and close inspection of transducers, are done by manufacturer representatives or on-site trained personnel. The AIUM recommends that such periodic tests be done annually, and the tables below follow this recommendation. Other accrediting bodies, such as the American College of Radiology, may require more frequent performance testing. Users should follow the recommended frequency as indicated by their accrediting agency.

## Probe Tests

Modern array transducers contain a large number of transducer elements, all of which must operate satisfactorily to obtain the most effective imaging performance from the ultrasound machine. Frequently, an individual element or a group of elements in an array may become nonfunctional because of damaged electrical connections, lowered sensitivity of the element(s), partially detached matching layer or lens materials, or reduced performance of specific electrical circuits in the

machine. So-called dropout of individual elements or groups of elements in the transducer is a frequent source of ultrasound equipment malfunction, and sonographers, physicists, and engineers must be alert for this problem. Obvious cases of transducer malfunction usually can be detected on images of patients or when scanning uniform phantoms.

Anytime probe damage is suspected, for example, if it has been accidentally dropped, it is recommended that the probe be tested for element dropout before being used clinically. This can sometimes be done using a straight edge or slide translated across the probe surface or by imaging a uniform phantom.

It has been shown that it is difficult to detect minor cases of element dropout on images of patients or phantoms, even though these may compromise the information generated in B-mode or Doppler studies.<sup>7</sup> To overcome this, some facilities use specially designed probe-testing devices<sup>7</sup> to do QA tests of transducers. Typically, these devices test each element and its connecting wire in the transducer cable to assess the element sensitivity and whether electrical connections are intact. At this time, the use of a probe tester is believed to provide the most rigorous assessment available of transducer performance. Electronic test equipment and software are not available for all probes, however, and users should take this potential limitation into account when planning to incorporate electronic probe tests in their facility. Consult the probe test device manufacturer on whether all transducers available for your equipment can be tested in this manner.

**Section A: Cleanliness and Safety**

	Task	Personnel	Minimum Frequency					Mandatory or Recommended
			Multidaily	Daily	Weekly	Monthly	Annually	
A.1	Ultrasound machine control panels should be cleaned of gel at the end of each exam for infection control, if necessary.	Sonographer	X					Mandatory
A.2	Transducers should be cleaned of gel for infection control after each exam.	Sonographer	X					Mandatory
A.3	Transducer cables should be checked for damage; transducer housing and transmitting surface should be checked for cracks, separations, and discolorations.	Sonographer		X				Mandatory
A.4	Immediate cleaning should occur anytime there is a spill of bodily fluids or hazardous material.	Sonographer, housecleaning, environmental, or health and safety	X					Mandatory
A.5	Monitors should be cleaned of dust, gel, streaks, and inspected for cracks.	Sonographer		X				Mandatory
A.6	Power cords and picture archiving and communications system connections should be checked for damage.	Sonographer		X				Mandatory
A.7	Operation of switches and knobs on machine console should be checked; burned-out indicator lights should be identified.	Sonographer		X				Mandatory
A.8	Machine console air filters should be cleaned for dust.	Sonographer			X			Mandatory
A.9	Machine should be checked for dents and other damage.	Sonographer			X			Mandatory
A.10	Ultrasound machine console and other equipment in the exam room should be cleaned thoroughly for dust, dirt, and infection control.	Sonographer				X		Mandatory
A.11	Rooms should be cleaned for dust, dirt, and infection control.	Housecleaning		X				Mandatory

**Section B: Image Display and Performance**

	Task	Personnel	Minimum Frequency					Mandatory or Recommended
			Multidaily	Daily	Weekly	Monthly	Annually	
B.1	Check that brightness and contrast controls on the machine monitor have not been misadjusted and are at calibration points used for setting up hard copy and/or workstations.	Sonographer		X				Mandatory
B.2	Check that machine displays entire gray bar.	Sonographer		X				Mandatory
B.3	Check that gray levels on image hard copy and/or image display workstations match those on the machine monitor.	Sonographer		X				Mandatory
B.4	Examine images for vertical shadows and streaks caused by dead elements in the transducer.	Sonographer		X				Mandatory
B.5	Verify that cables, housing, and transmitting surfaces of each transducer are free of cracks, separations, and discolorations.	Physicist, engineer, or sonographer					X	Mandatory
B.6	Transducer Uniformity: For each transducer used with the ultrasound machine, scan a uniform region in a phantom, and note dropout streaks caused by dead elements; alternatively, inspect for nonuniformities using a straight edge translated over the transducer surface, or inspect the transducer using an electronic probe tester.	Physicist, engineer, or sonographer					X	Mandatory
B.7	Maximum Depth of Visualization: For each transducer used with the ultrasound machine, scan a uniform region in a phantom, and find the maximum depth of visualization for detecting background echoes; repeat for each frequency setting of the transducer.	Physicist, engineer, or sonographer					X	Mandatory
B.8	Target Detection and Imaging: Scan a phantom containing focal targets, such as simulated cysts or low-contrast objects; evaluate target resolution for each transducer. The choice of phantoms is at the discretion of the facility.	Physicist, engineer, or sonographer					X	Recommended
B.9	Distance Measurement Accuracy: Scan a phantom containing discrete high-contrast targets in known geometric configurations; evaluate accuracy of measuring distances between targets visualized in reconstructed scan planes generated with 3-dimensional probes; evaluate volume estimates; evaluate horizontal and vertical distance accuracy for measurements done offline on workstations.	Physicist, engineer, or sonographer					X	Mandatory



## References

1. American Institute of Ultrasound in Medicine. Quality Assurance Manual for Gray Scale Ultrasound Scanners. Laurel, MD: American Institute of Ultrasound in Medicine; 1995.
2. Goodsitt M, Carson P, Witt S, Hykes D, Kofler J. Real-time B-mode ultrasound quality control test procedures: report of AAPM Ultrasound Task Group No. 1. Med Phys 1998; 25:1385–1406.
3. Zagzebski J, Kofler J. Ultrasound equipment quality assurance. In: Papp J (ed). Quality Management in the Imaging Sciences. 2nd ed. St Louis, MO: Mosby; 2002:216–230.
4. American College of Radiology. ACR Ultrasound Accreditation Program. Reston, VA: American College of Radiology; 2001.
5. American Institute of Ultrasound in Medicine. Standard Methods for Measuring Performance of Ultrasound Pulse-Echo Equipment. Laurel, MD: American Institute of Ultrasound in Medicine; 1990.
6. Gray J. Test pattern for video display and hard copy cameras. Radiology 1985; 154:519.
7. Weigang B, Moore GW, Gessert J, Phillips WH, Schafer M. The methods and effects of transducer degradation on image quality and the clinical efficacy of diagnostic sonography. J Ultrasound Med 2003; 19:3–13.

