Common Ultrasound Probe Failures

G. Wayne Moore, B.Sc., MA

From the Transducer Analysis and Repair Laboratory,
Sonic Technology Laboratories,
Sonora Medical Systems, Longmont, Colorado USA

Correspondence: G. Wayne Moore, Sonora Medical Systems,
1751 South Fordham Street, Suite 100, Longmont, CO 80503 USA
E-mail: gwm@4sonora.com

Copyright 2006
All Rights Reserved – No portion of this document may be reproduced without written permission from Sonora Medical Systems
INTRODUCTION

The proper care and regular testing of probes substantially influence the level of operating expenses related to the ultrasound systems in your department. In fact experience has shown that more than 70% of ultrasound service calls are in some fashion probe related. Published studies have also shown that improperly functioning probes can materially impact the results of the ultrasound examination. Probe failures, when discovered early enough, can more often than not be repaired, potentially saving the department tens-of-thousands of dollars per year in operating expense. This paper is designed to present the Sonographer with examples of common probe problems and how to spot them in a timely manner, while effective repairs can still be made. Further, suggestions are presented concerning what steps a Sonographer may take to insure optimal performance from the probe as well as obtaining the longest effective use of the product. While it is clear that everyone involved with the maintenance of the ultrasound devices in your department is responsible for providing the patient with a safe and efficacious study, the lead for ensuring this falls to the Sonographer, the professional who handles the probes on a daily basis. The Sonographer, by virtue of their work is the first to spot any changes in the ultrasound image, feel any slight electrical “tingles” from the probe, see any holes in the lens, cracks in the case or tears in the cable. Any of these signs of failure should be reported to the Hospital Biomedical Engineer or Clinical Engineer as soon as they are discovered. Additional ultrasound QA documents are available to Sonographers and Biomedical Engineers free of charge from Sonora Medical Systems.
A Suggested Probe Inspection Routine

Inspecting The Transducer (Probe)

- Cracks on the handle
- Cracks on the nose piece
- Cuts or gouges on the lens material
- Swelling of the lens material
- Condition of the bend relief(s)
- Cracks or other signs of damage to the connector
- Bent or damaged pins in the probe connector
- If using a “pin-less” connector (e.g., Siemens/Acuson Sequoia probes) inspect the surface of the connector to insure it is clean
- Integrity and flexibility of the cable
- Bite marks on the bending rubber (TEE probes)

What Can Hurt a Transducer?

- Gels that have perfume or other molecular changing substances
- Electro-static discharge on or around the lens of the probe, or the pins on the probe connector
- Rapid deceleration trauma (dropping the probe), or other blunt force trauma
- Using the wrong sterilizing agents, or using the correct ones in the wrong manner
- Improper storage
- Not freezing the image before removing or connecting a probe to the system
- Improper or insufficient cleaning, or cleaning with wrong substance (e.g. alcohol-based wipes on the lens tends to dry the lens and make it detach from the probe)
- Not using bite guards when performing a TEE examination

What Preventative Measures Can I take?

- Inspect the probe on a daily basis – use a magnifying glass to inspect the lens
- Follow the recommendations for use and cleaning in the probe manual
- Have the probe tested on a six-month basis, or if a problem is suspected
- Keep transducer cables off the floor
- Use the system probe holders when probe is not in use

What Else Should I Be Doing?

- Electrical leakage testing as recommended by the Original Equipment Manufacturer
- Involve your hospital Biomedical Engineer in regularly testing the probe elements
- Establish with your Biomedical Engineering Department a comprehensive ultrasound QA program that includes not only the probes, but the ultrasound system as well
- If you suspect a probe is compromised in some manner, don’t use it until it is tested.

Copyright 2006
All Rights Reserved – No portion of this document may be reproduced without written permission from Sonora Medical Systems
Common Probe Failures

Array housing separating from the seam normally occurs when the probe has been in use for some time, or if there is a manufacturing defect. Many OEMs use glue in the manufacturing process to seal the cap of the array housing to the body of the probe. This glue can deteriorate as a function of time as well as to exposure to cleaning agents. This probe should not be used as it may present an electrical shock hazard to the patient and the sonographer. Further, if cleaning agents get inside the probe they will normally destroy the array. This type of failure can be repaired if caught early.

Seam line separating from nose cone becoming the site of fluid infiltration. Less obvious than the example above, this is the beginning of the cap detachment. The compromise of the seam can be seen with the aide of a small magnifying glass. If the problem is found at this stage, the probe is easily repairable.
Lens Problems

Lens separating from housing

Multiple holes in the lens

Hole in Lens

Swollen Lens

Copyright 2006
All Rights Reserved – No portion of this document may be reproduced without written permission from Sonora Medical Systems
Various Structural Defects

- Bent pins in the connector
- Dents in connector housing
- Dirty pin-less connector
- Crack in Lens Cap
TEE Problems

- Broken seal near head of TEE probe
- Scratch on TEE lens
- Contaminated bending rubber
- Holes in bending rubber
- Stained bending rubber with hole
- Bite Mark in Bending Rubber
Cable Problems

Cable pulled out from under strain relief

Strain relief pulling away from array housing

Cable pulled away from strain relief

Copyright 2006
All Rights Reserved – No portion of this document may be reproduced without written permission from Sonora Medical Systems
Tears and Scratches

Cable Tear

Strain Relief Tear

TEE Array Housing Scratches
One of the more common needs for repair on a TE probe is to re-coat and re-label the depth markers. These marks fade as a function of use and through the disinfecting process. After the Sonora re-coat and re-label process the TE probe is fully restored to its original condition.
Testing for Dead Elements

Transducer Evaluation Report

Manufacturer: ATL  Customer: Customer  Contact: Contact
Probe Model: C4-2  Address: Address
Serial Number: 808Q7  City: City  State: CO  Zip Code: Zip
Test Date: 10/15/2004 8:57 AM  Phone Number: Phone
Test ID: 17842  Operator: Jeremiah Moore  Fax Number: Fax
Purpose: Repair Final Test  DX/Comments:

Sensitivity

Mean: 0.498  Max: 0.596  Min: 0.006  Std Dev: 0.380  Gain: 7 dB

Capacitance

Mean: 472.547  Max: 490.947  Min: 263.514  Std Dev: 19.129

Sonora FirstCall Test Report – Each crystal within the array is tested
The Sonora FirstCall test is definitive in testing for dead elements versus some problem with the system, or some problem with the probe (e.g., bad connector pins, tear in cable or delaminated lens). Although apparent that something is wrong in the image above, studies have shown that as few as two dead elements can distort Doppler signals resulting in underestimation of velocity and increases in spectral broadening\(^1\).

Dead elements appear to be relatively common in probes in clinical use with various published data showing that 20 to 30% of probes in use having some form of clinically relevant performance problem. The Table below was part of a recent ultrasound quality assurance presentation given at the American Association of Physicists in Medicine and demonstrates the high percentage of probes found in clinical use with dead elements. The probes were tested with the Sonora FirstCall probe tester.

### 57 Probes from the UW-Hospital Department of Radiology were tested

<table>
<thead>
<tr>
<th>Scanner</th>
<th># of probes tested</th>
<th>&lt;2 “bad” elements</th>
<th>&gt;5 “bad” elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACUSON Sequoia (2 systems)</td>
<td>18</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>ATL HDI 5000 (3 systems)</td>
<td>18</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Philips iU-22 (4 systems)</td>
<td>15</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>GE Logic 9</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Courtesy of Dr. James Zagzebski, University of Wisconsin - Madison
Another concern for ultrasound departments has been the illegal introduction of both counterfeit and misbranded probes into the after market. These probes are made to appear like they are built by the Original Equipment Manufacturer (OEM), but have identifying marks that an observant sonographer can spot. As shown above the two probes are very similar in appearance. The probe on the left is the counterfeit as is distinguished by the different font color in the number 4, as well as the absence of the name of the manufacturer, in this case Acuson. There is a potential safety concern if using this probe relative to both the level of acoustic power being transmitted by the counterfeit as well as electrical leakage and material biocompatibility. If the hospital has a FirstCall probe-testing device, it will also reveal performance variance between the counterfeit probe and an actual OEM probe.
Detailed Testing and Use/Don’t Use Example

The flow chart shown below indicates when to call in the Biomedical or Clinical Engineer to execute a detailed test of a suspected transducer. The branching points are all binary (yes or no, pass or fail, etc.).

Transducer testing begins with a visual inspection of the probe contact or wear-surface. As the name implies, frequent use can wear or damage this surface, permitting caustic fluids, gels, or microorganisms admittance to the inner portions of the transducer. A simple magnifying glass is needed for this inspection.
Conclusion

The transducer is the most sensitive and most often damaged link in the ultrasound image quality chain. Because the sonographer or physician handles the transducer during the ultrasound examination, it is susceptible to all manner of physical damage resulting from accidental dropping, aggressive cleaning methods, or other traumatic occurrences such as banging. Many antiseptic solutions, and even seemingly innocuous “perfumed” coupling gels, can have a negative long-term impact on both the acoustic lens bonding of a transducer, which can cause either lens de-lamination or material decomposition, and affect the actual molecular composition of the lens itself, resulting in a change in its acoustic transmission and reception characteristics. The end result of either occurrence is a shorter transducer life. In our experience, high-use ultrasound transducers often display some form of performance compromising anomaly within 18 to 24 months after being placed into service. During the ten-year (120 months) operational life span of a premium quality ultrasound system, a transducer could potentially be replaced up to five times, simply due to “normal” use. At an average cost of ~ $10,000 per transducer, the financial impact of replacing transducers to the hospital or clinic becomes quite apparent.

An active and comprehensive ultrasound EBQA (evidence-based quality assurance) program can substantially lower costs for hospitals by identifying probes early enough in the failure process that they can be repaired rather than replaced. For example, a new transesophageal (TE) probe can cost as much as $40,000 or more and a replacement (meaning the damaged one is exchanged for another one) TE probe normally costs as much as $24,000 from the OEM. If the TE probe is damaged and the damage discovered in time so that it is repairable, the repair cost is normally 25% or less than the cost of replacement, or $6,000. Over the ten-year lifespan of the ultrasound system in this scenario it would mean the difference between $120,000 in replacement costs versus $30,000 in repair costs, or a difference of $90,000 for one probe alone. That $90,000 comes directly off the bottom-line of the hospital’s profit. For a hospital operating on a 4% margin that would mean an additional $2,250,000 of top-line billings would have been required to generate that $90,000. And that is for one probe. Typically a hospital with a cardiac surgical service would have multiple TE probes thereby compounding the financial impact.
About Sonora Medical Systems

The dramatic cost containment health care environment in the United States, coupled with the rapid industry consolidation into the hand of three major companies (General Electric, Philips and Siemens) has put tremendous pressure on hospitals to seek new and innovative ways to not only maintain profitability, but to survive. It is the driving purpose of Sonora to provide hospitals with a comprehensive portfolio of after market products and services designed to allow our customers to dramatically reduce the costs associated with managing and maintaining their diagnostic imaging capital assets for longer periods of time, and in many cases obviating the need for expensive OEM service contracts. From service training, to parts and industry leading advanced probe repair, Sonora provides a turnkey cost-effective solution for the hospital contemplating maintenance of its own ultrasound systems and probes. Sonora’s team members have a combined 200+ years of experience in diagnostic imaging to put to use for our valued customers. Sonora is an active member of NEMA (National Electrical Manufacturers Association) – Ultrasound Section (www.nema.org), is ISO9001 and ISO 13485 certified to the Medical Device Directive, and has established probe repair facilities in cooperation with international partners in seven countries around the world. Sonora has been voted in the Top Ten of the Reader’s Choice Awards and is cited in the DotMed Top 100 Medical Companies.

At Sonora we test and repair more than 3,500 probes per year, saving the health care system in the United States alone more than $25 million per year in unnecessary probe replacement costs. For more information on our probe repair, and other after-marker services go to www.4sonora.com, or call us at 303.682.5871. We look forward to serving you.