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AAPM Abstract

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The Impact of Compromised Elements within an Ultrasound Transducer on Image and Doppler Quality

In diagnostic ultrasound examinations the "health" of the transducer (also referred to as the probe or scan-head) is a key component to the overall quality and efficacy of the study. Central to the transducer's performance is the integrity of the acoustic stack, and specifically the viability of the individual elements that make up the transducer array. Modern ultrasound transducers often contain 128 and in some cases 288 or more elements. It is well known that with time and normal wear and tear, individual elements within the transducer array can cease working altogether (i.e., dead elements) or demonstrate significantly reduced sensitivity compared to their original specification. Further, these compromised elements fundamentally affect the operation of the entire transducer, and therefore can have a negative impact on clinical results, and potentially, the efficacy of the entire ultrasound study. To investigate the potential of element degradation to affect clinical results, we evaluated a number of commercially available ultrasound transducers with selected elements disconnected, and compared those results with the same transducers with all elements functioning. We examined how dead elements affected: the transmitted ultrasound beams emitted by the probe, various acoustic parameters of the probe, tissue mimicking phantom imaging, flow phantom testing (spectral and Color Flow Doppler), and lastly human imaging. The results show that as few as two consecutive dead elements in an array of 128 elements can have a noticeable impact on the acoustic beam propagated into the body. Four or more dead or degraded elements in an array have a markedly negative impact on the acoustic beam, resulting in reduced resolution, reduced depth of penetration (for both Doppler and imaging), image "blooming" at depth, a higher overall noise floor in imaging modes, and both peak velocity errors as well as directional ambiguities in spectral displays. We also show that tissue-mimicking phantoms are equivocal in determining element performance. We conclude that the proper functioning of all the elements comprising the array is critical to obtaining a high quality and efficacious ultrasound study, and that the potential for misdiagnosis increases as array elements degrade.

Educational Objectives:

1) Understand how an aggregate array functions
2) Understand the mechanism of array failure
3) Understand the effect on acoustic beam profile caused by a damaged array
4) Understand the effect of a damaged array on image quality
5) Understand the effect of a damaged array on Doppler quality
6) Understand how to effectively test transducers in a clinical environment

Full Disclosure Statement: A test device designed and marketed by Sonora Medical Systems was used in the course of obtaining certain acoustic and electrical data for this study. Messrs. Moore and Gessert are employees of Sonora.