

How much noise does a diagnostic sonography transducer produce?

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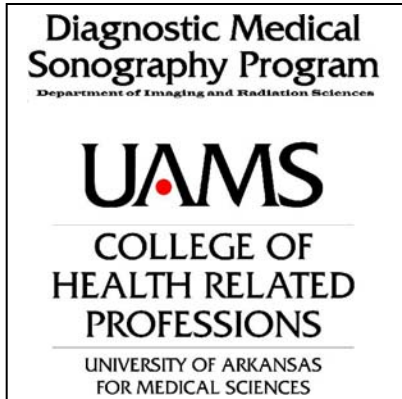
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Introduction:

Recent research reported that "It should be noted that the sound in the uterus is the result of very localized vibrations. At the point where the ultrasound is focused these vibrations may be equivalent to a 100-120dB (decibel) sound, which is very loud for a person hearing sound through the air. A 100-120 dB sound in air is similar to the sound level of an approaching train. But the sound level decreases rapidly away from the region excited by the ultrasound pulses."¹

As a result of this report, there have several messages on the sonographic related internet discussion groups as to whether or not it could be true that the acoustic levels could reach the "sound level of an approaching train". As a result some experts in the field of sonographic Bioeffects and physics were asked to comment.

Marvin Ziskin, MD, Temple University Medical School, Center for Biomedical Physics, and first author of "Ultrasonic Exposimetry"², had this to say:

"Thank you for bring this article to my attention. This is a topic that I became interested in many, many years ago, when there was concern that diagnostic ultrasound might damage the fetal ear. I even went in a swimming pool to listen to a Doppler device. However, this was in the days in which all Doppler was using continuous wave. Consequently I was not able to hear anything.

However this report of up to 120 dB has to be put into perspective. For the same pressure, the dB calculated for sound in water is approximately 40 db more than that calculated in air because of the approximately 3500 fold difference in specific acoustic impedances of air and water. Therefore, the 120 dB should more realistically be compared to about an 80 dB sound level in air. Besides, the frequent occurrence of maternal borborygmus (the normal digestive sounds coming from the gastrointestinal tract) produces sound levels as high as 90 dB as have been measured in the amniotic fluid in vivo.

I hope this helps. Cheers, Marv"

In addition, James Zagzebski, PhD, University of Wisconsin, Medical Physics Department, and author of "Essentials of Ultrasound Physics"³, said this:

"I would certainly believe this. I have been mentioning to many people that this is a likely effect, following work by this same group at least 5 years ago. The acoustic frequency associated with the PRF seemed the most likely source. It appears now that the group at Mayo has actually obtained measurements/estimates of the levels. I would have to review how the levels were determined, so I cannot comment on the 100-115 dB range. But I have challenged sonographers to stick their heads in a water bath and let me transmit a Doppler beam at their ears to determine whether they can hear anything, and if so, how loud it seems. So far, no takers. But they all seem determined to keep the MI to the lowest possible levels when they image the fetus.
Jim"

And finally, Jonathan Ophir, PhD, Professor and Director Ultrasonics Laboratory, Dept. of Diagnostic and Interventional Imaging, University of Texas Medical School, added these comments:

"I agree with Jim's observation. The low PRF frequency components are certainly in the audible range. These frequencies may propagate in the body unimpeded due to lack of significant attenuation, and also w/o any appreciable directivity because at those frequencies the xducer would essentially be a point source--i.e. the noise will be audible 'anywhere'.

*Anecdotally, this reminds me of the high pitch 15.75 KHz horizontal TV line retrace frequency which I used to hear (when I was much younger and my hearing frequency response covered these frequencies) in any room that had a TV running. Fortunately, the 'geezer low-pass filter' eventually set in and the noise was gone at age 30!
Cheers, JO"*

Because the research claim of sonography producing "similar to the sound level of an approaching train" simply did not have the "ring of truth" to me, and prompted by Dr. Zagzebski's challenge to his students, and Dr. Ziskin's swimming experiment, I asked my colleagues to assist me in our own experiment.

Methods:

By holding my head horizontally, my ear was filled with degassed water (Figure 1). A commercial 5-2 MHz curvilinear transducer was used to insonate my ear, producing a two-dimensional real-time image (Figure 2).

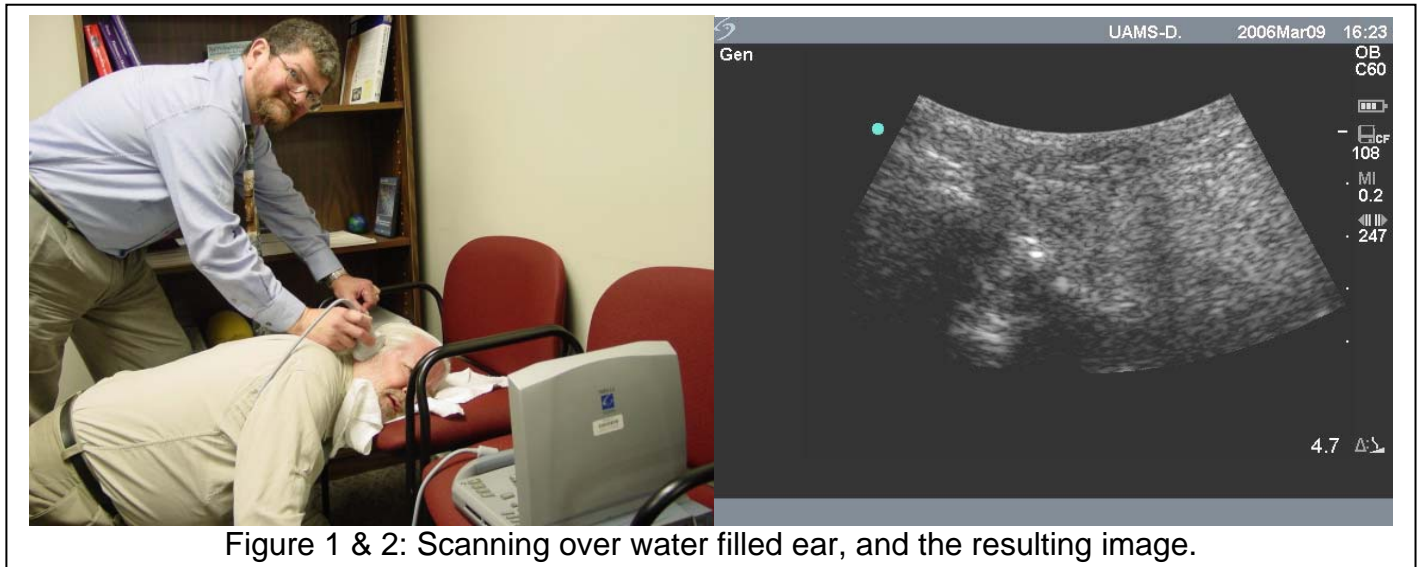
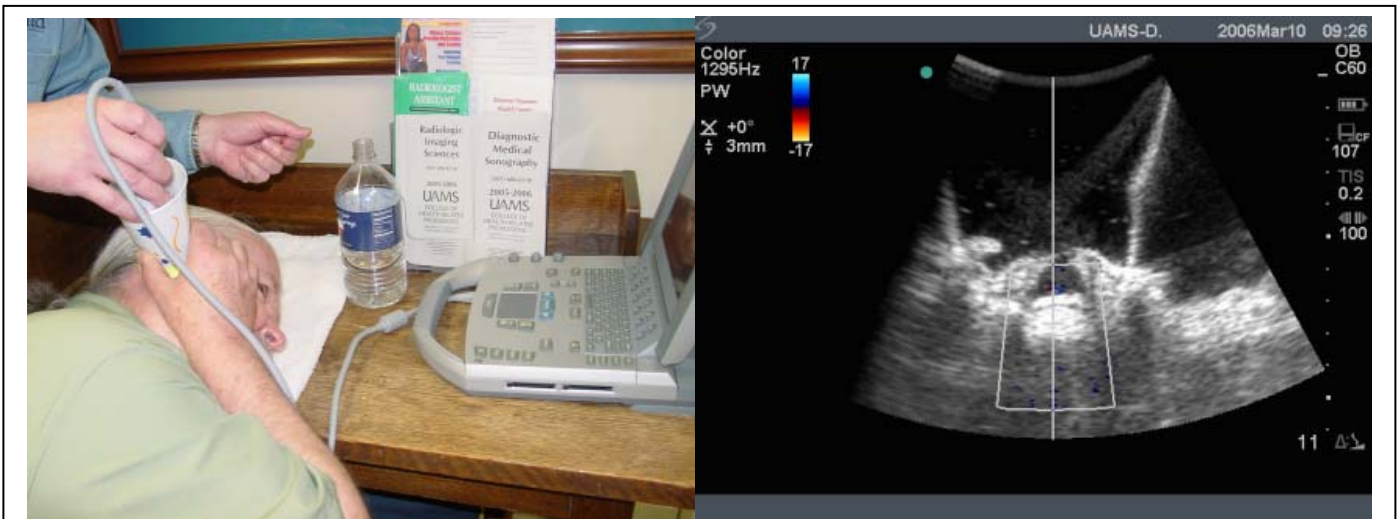


Figure 1 & 2: Scanning over water filled ear, and the resulting image.

After receiving the expert comments above, and because the original research indicated that:

"At the point where the ultrasound is focused these vibrations may be equivalent to a 100-120dB (decibel) sound, which is very loud for a person hearing sound through the air. A 100-120 dB sound in air is similar to the sound level of an approaching train. But the sound level decreases rapidly away from the region excited by the ultrasound pulses."¹

We decided that we should also do the experiment using a water-path offset with the focus near the eardrum. In addition, because Dr. Ziskin suggested that Doppler may be an added variable, we used color and spectral Doppler, with the sample-volume near the eardrum. Using a plastic water cup with the bottom cut off, a seal of Play-Doh® was fashioned, filled with water after placing the apparatus over my ear. See figures 3 and 4.



Figures 3 & 4: Scanning through water-path offset with 2D, color and spectral Doppler with the sample volume near the eardrum.

Results:

In the first experiment, Figures 1 and 2, during the time of insonation, I heard only my own blood flow pulse. In the second experiment, with the water path off-set using color and spectral Doppler, I again heard my own blood flow; but also heard a very faint, almost imperceptible, tapping or clicking noise. I assume this slight clicking was related to the pulsed Doppler. However, there were no noises that could be classified as anywhere close to being “similar to the sound level of an approaching train.”

Conclusions:

While these experiments do not measure the acoustic energy generated in decibels, we believe that it shows the original research by Fatemi, Ogburn, and Greenleaf is either misleading or misinterpreted. Even with the *'geezer low-pass filter'* we do not believe the acoustic noise levels produced by contemporary diagnostic sonographic machines are as loud as they report; however, the issue deserves more research.

Credits:

Terry DuBose, research design, volunteer
 Anthony Baker, sonography
 Quinnie Young, photography

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<http://www.uams.edu/chrp/sonography/links.asp>

References

- ¹ Mostafa Fatemi, Paul L. Ogburn, James F. Greenleaf; "Quiet, Please!" Says the Fetus; 142nd ASA Meeting, Fort Lauderdale, FL; Mayo Foundation Rochester, MN 55905; <http://www.newscientist.com/article.ns?id=dn1639>; <http://www.acoustics.org/press/142nd/Fatemi2.html>; Accessed March 10, 2006
- ² Ziskin, Marvin. and Lewin, Peter, Ultrasonic Exosimetry, CRC Press Boca Raton 1993
- ³ Zagzebski, James A; Essentials of Ultrasound Physics, Mosby 1996