Ultrasound Safety and Collapsing Bubbles

Physicians and medical researchers use high-frequency sound waves to examine organs or a developing fetus or to track the flow of blood. Numerous experiments and years of experience have turned up no clear evidence that diagnostic ultrasound has any harmful effects in human beings (SN: 6/12/82, p.396). However, a recent finding that pulsed ultrasound, with characteristics similar to that used in diagnosis, can kill fruit fly larvae has again focused attention on the safety of diagnostic ultrasound.

The question is whether the effects seen in larvae also show up in some way in human subjects. "Clearly, flies are far different from human beings," says Edwin L. Carstensen of the electrical engineering and biophysics departments at the University of Rochester (N.Y.). "The only way to make so great a conceptual leap," he says, "is to learn the basic physical and biological mechanisms [that] are responsible for the effects in the flies and use those concepts in experimental and theoretical evaluation of the human safety question." Carstensen was one of several speakers addressing the issue at this week's Acoustical Society of America meeting in Anaheim, Calif.

In the case of fruit fly larvae, researchers now suspect that the damage is done by a process called acoustic cavitation. When a sound wave passes through a fluid like that within a larva's body, pressure changes in the fluid cause any microscopic gas bubbles present to expand, then contract violently. This collapse creates a tremendous, highly localized shock wave and often raises the gas temperature enough to ionize the gas and produce potentially toxic chemical products.

For acoustic cavitation to occur with the short pulses typically used in diagnostic ultrasound, bubbles about 1 micron across must be present in the fluid. Insect larvae are loaded with such bubbles because oxygen, for example, must be transported through the fluid between cells directly to various types of tissue. Although such microscopic bubbles are also likely to occur in mammals, says Carstensen, little is known about their location and the conditions under which they occur.

At intensities much higher than those used for diagnosis, ultrasound pulses clearly have an effect on human tissue. A machine called a lithotripter, for example, generates intense acoustic pulses to destroy kidney stones and gallstones (SN: 4/26/86, p.265). Each pulse, says physicist Lawrence A. Crum of the University of Mississippi in University, probably produces an enormous amount of acoustic cavitation, which may play a role in destroying the stones and perhaps in damaging nearby tissue.

Similarly, experiments done by Leon A. Frizzell of the University of Illinois at Urbana-Champaign show that focused, high-intensity ultrasound beams damage liver tissue. The nature of the damage indicates that acoustic cavitation rather than a heating effect is responsible for the destruction.

Stephen Daniels of the Oxford (England) Hyperbaric Group and his colleagues have shown that continuous-wave ultrasound also produces cavitation, even at the low intensities used in ultrasound devices designed for treating injuries. Unlike diagnostic ultrasound sources, therapeutic devices usually generate a continous sound wave rather than pulses. The researchers observed bubbles expanding and contracting in the blood of guinea pigs and detected evidence for the formation of reactive chemical species. The bubble oscillations may aid healing, says Crum, by promoting the transport of nutrients to cell membranes. These and other results suggest that gas bubbles of the appropriate size are present in mammalian tissue.

"From the little bit that we know about the distribution of gas bubbles in mammal tissue," Carstensen says, "they're probably rare, and the damage that is done is highly localized." For many types of diagnosis, the risk would be very small, he says, unless something as sensitive as an embryo is involved (SN: 2/18/84, p. 102). However, such localized effects also mean that acoustic cavitation and its effects would be difficult to detect.

Crum is worried that people using diagnostic or therapeutic ultrasound devices are not being careful enough, especially in regulating the intensity and duration of exposures. "There's potential here for causing severe damage that you probably wouldn't see immediately," he says. "It's incredible how unrestricted the use of ultrasound is."

Nevertheless, says Carstensen, "it would be premature, at the present time, to set exposure limits on diagnostic ultrasound based on the effects of acoustic cavitation." Although researchers have shown that acoustic cavitation may occur at the intensity levels generally used for diagnosis or healing, no one has yet connected this phenomenon with harm to human beings.

"We know the cause," says Crum, "but we don't know the effect." Much more research is needed, first, to study the mechanisms of bubble formation in tissue and, second, to link bubble expansion and collapse with specific biological effects such as tissue damage. *—I. Peterson*

Cancer stats: Gains and losses

The cancer death rate for people under 55 in the United States decreased from 38.2 per 100,000 people in 1975 to 35.7 per 100,000 in 1984, according to the annual National Cancer Institute (NCI) cancer statistics update released this week. This 7 percent drop occurred despite a 0.2 percent yearly increase in the *incidence* rate in this age group between 1975 and 1984, according to the update, which covers incidence and death rates in the U.S. population through 1984 and five-year survival rates through 1983. For white children under 15 (there were not enough cases reported in black children for analysis), the five-year survival rate improved from 54.7 percent to 62.1 percent.

But a rise in the cancer death rate for people 55 and over, who account for about 76 percent of cancers, brought the death rate for the total U.S. population up about 0.5 percent per year since 1975 to 170.7 deaths per 100,000 people in 1984.

Blacks continue to fare worse than whites. The five-year survival rate for whites diagnosed with cancer between 1977 and 1983 was calculated as 49.8; for blacks it was 37.6 percent.

In commenting on the numbers, NCI has focused on the under-55 improvement. NCI head Vincent T. DeVita Jr. attributes the change to advances in treatment.

But statistician John C. Bailar III of Harvard University, a frequent critic of NCI's handling of statistics, says that while there has been substantial progress within subgroups of the population, the overall figures show that general improvement is very slow. The overall five-year survival rate improvement from 48.6 percent of cancers diagnosed between 1974 and 1976 to 48.7 percent of cancers diagnosed between 1977 and 1983 is "nothing to crow about," he says.

"NCI is very selective in what figures it gives prominence," he says. "I think it's unfair to the public and unfair to cancer victims and unfair to the news media and Congress to try to cover up the general failure [in the war on cancer] . . . by emphasizing the bright spots."

—J. Silberner