Biomedicine

Lithotriptor therapy coming of age

For the past two years, researchers have been experimenting with extracorporeal shock wave lithotripsy as a means of breaking up gallstones. The nonsurgical technique — which uses high-pressure shock waves to dissolve mineral deposits — has proved extremely effective against kidney stones (SN: 9/6/87, p.157), but early results with gallstones were only moderately encouraging (SN: 4/26/86, p.265). Recent research using a new model of lithotriptor has been more successful, however, and the Food and Drug Administration (FDA) recently announced it will sponsor U.S. clinical trials of gallstone lithotripsy beginning this fall.

The new research was reported at a recent series of digestive-disease meetings in Chicago and is discussed in the Sept. 11 JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION.

Using a modified version of the $1.5 million lithotriptor already being used to break up kidney stones, researchers in West Germany have recorded a greater than 80 percent success rate in breaking up stones in the gall bladder and bile duct. The new device differs from the original kidney lithotriptor in that it uses ultrasound rather than X-rays to locate the stones. Kidney stones, which are made largely of calcium, show up well with X-rays. But gallstones, which are usually made of cholesterol, are more easily visualized with ultrasound.

Another innovation in the gallstone lithotriptor — and an improvement being incorporated into newer versions of the kidney lithotriptor as well — has the patient resting on a cushion filled with 25 gallons of water. (The original model required that the patient be immersed in a tank of water.) A layer of ultrasound gel between patient and cushion ensures minimal loss of energy as the shock waves are generated by spark discharge in the water-filled cushion. The newer system also boasts a computer-controlled guidance system that more accurately aims the shock waves at the stones.

Short of surgery, the only gallstone therapy currently approved in the United States is treatment with chenodeoxycholic acid. When used over a period of many months, the acid is able to dissolve some types of gallstones. In many cases, however, gallstone sufferers have no choice but to undergo cholecysectomy, or removal of the gall bladder.

More than 400,000 Americans undergo gallstone surgery each year — nearly four times the number of surgeries performed annually for kidney stones. The operation typically involves a six- to eight-day hospital stay and a four- to six-week recovery period.

In contrast, gall bladder lithotripsy requires a two- to three-day hospitalization, and that may decrease before too long. Physicians who are familiar with the technique are predicting that it will become available as an outpatient procedure. Such optimism is strengthened by recent reports that mild sedatives — rather than general anesthesia — are sufficient to keep the procedure painless.

In one such study, appearing in the September ANNALS OF INTERNAL MEDICINE, intravenous analgesics were given to 10 patients who underwent gallstone lithotripsy. Gustav Paumgartner and his colleagues at the University of Munich, West Germany, found that pain was not a problem in any of the cases. Moreover, they found, the procedure was made easier because the patients were conscious and were able to position themselves on the water-filled cushion.

In the United States, 10 hospitals have been selected by the FDA to participate in clinical testing of the new gallstone lithotriptor. Physicians from those hospitals are now in Munich being trained to use the new machine. The U.S. trials, which are expected to run until the end of next year, will look at the safety and efficacy of the procedure as performed on 600 carefully selected patients.

Mathematics

Rectangles within rectangles

Anyone who has gone through the chore of tiling a floor or installing a suspended ceiling can appreciate how much easier the job is if the tiles or panels evenly fit the area to be covered. For example, panels that are 4 feet long and 2 feet wide nicely cover a ceiling that happens to be, say, 6 feet by 8 feet. No panels need to be cut, and all the space is filled. Mathematically, this tiling problem can be generalized to the statement that if an $a \times b$ rectangle is tiled with copies of a $c \times d$ rectangle, then each of c and d divides evenly into one of a and b. The theorem, in a form that applies in higher dimensions as well, was proved about 20 years ago by Dutch mathematician N.G. de Bruijn of the Eindhoven (Netherlands) University of Technology.

Mathematicians subsequently suggested and proved a more general theorem: Whenever a rectangle is tiled by rectangles, each of which has at least one integer side, then the tiled rectangle has at least one integer side. The original proof for this theorem, as in the case of de Bruijn's theorem, required the use of complicated mathematics involving double integrals and complex numbers. It was like using "a cannon to kill a mouse," says Solomon W. Golomb of the University of Southern California in Los Angeles.

At a meeting in 1985, mathematician Hugh L. Montgomery of the University of Michigan in Ann Arbor discussed the problem and stimulated a search for a more elementary proof of the theorem. The results of that search, as compiled by Stan Wagon of Smith College in Northampton, Mass., appear in the August-September issue of THE AMERICAN MATHEMATICAL MONTHLY. Wagon describes 13 alternative proofs proposed by various mathematicians. "The variety of techniques that have been brought to bear is striking," says Wagon.

Richard H. Rochberg of Washington University in St. Louis and Sherman K. Stein of the University of California at Davis independently came up with one of the simplest proofs. Each rectangular tile is colored to produce a checkerboard pattern in which each square is half a unit wide. Because each tile has an integer side, it carries an equal amount of black and white. If such tiles completely cover a large rectangle, then it, too, must have equal amounts of black and white. Therefore, at least one of the sides of the large rectangle has an integer length. Otherwise, the whole rectangle can be split into four pieces, three of which have equal amounts of black and white while the fourth does not.

Other proofs involve double integrals with real instead of complex numbers, various ways of counting squares, and the use of prime numbers, polynomials, step functions or graph theory. Although several of the proofs are mathematically related and most have similar ingredients, important differences show up when the methods are tried on extensions of the original theorem. What if the tiles are like flexible postage stamps pasted on the surface of a cylinder or a doughnut-shaped form called a torus? What happens in higher dimensions, that is, when n-dimensional bricks are stacked in n-dimensional boxes? Some methods of proof are more powerful than others because they yield more general results, says Wagon. However, which proof is the best isn't easy to decide. That depends on the criteria used to define "best." Perhaps the best possible proof hasn't even been found yet.

Voting on military funding

After a lengthy debate at its meeting last January (SN: 1/31/87, p.71) and further discussion in the pages of one of its publications, the American Mathematical Society, based in Providence, R.I., has decided to poll its 20,000 members on the issue of military funding of mathematics research. The mail vote, to be taken in January 1988, will be on five motions touching various aspects of federal support for mathematics.