Imaging Technique Passes Muster

Magnetic resonance imaging, a new but widely used technique for medical diagnosis, receives a vote of confidence from an NIH consensus panel

THE National Institutes of Health recently convened a Consensus Development Conference* to assess the current state of the art of magnetic resonance imaging (MRI), a medical diagnostic technique that began moving into clinical application 5 to 6 years ago. By and large, the consensus panel gave MRI high marks, concluding that it "is an innovative technique that provides images of the body in many different planes and represents an extraordinary addition to our diagnostic armamentarium."

For diagnosing some diseases, especially those involving the brain and spinal cord, the panel says, MRI is now superior to older techniques such as computer-assisted tomography (CT). Moreover, MRI, as currently performed, appears to be safe for most people, although the panel pointed to some circumstances in which it either should not be used or should be used with caution.

Magnetic resonance images are obtained by placing a patient inside the bore of a powerful magnet. Certain atomic nuclei act like small magnets that align themselves with the direction of the magnetic field. These nuclei include those of hydrogen, an element that is in very high concentrations in living organisms and is therefore the target of current MRI techniques.

A second, oscillating magnetic field is then applied to the patient in the magnet. This second field causes the hydrogen nuclei to move out of alignment with the first, thereby generating signals that are influenced by the chemical and physical environments of the nuclei and can be mathematically transformed into images of the body.

In the half dozen years since commercial MRI instruments became available, they have been installed in about 650 hospitals and other medical facilities, according to consensus panel member J. Sanford Schwartz of the Hospital of the University of Pennsylvania in Philadelphia. This number of instruments can perform about 2 million patient examinations per year. Since the cost of an examination runs from $500 to $1000, MRI contributes in excess of $1 billion annually to the nation's health expenditures.

The cost effectiveness of MRI was not part of the consensus panel's considerations, however. Panel chairman Herbert Abrams of Stanford University School of Medicine noted that the cost issue needs to be addressed by society at large.

"MRI . . . represents an extraordinary addition to our diagnostic armamentarium."

The panel was specifically charged by NIH to address four questions. What are the clinical indications for using MRI, and how does it compare to other diagnostic methods? What are the technical advantages and disadvantages of using MRI? Does the technique pose any risks for the patient and are there circumstances in which it should not be used? And what directions should MRI research take in the future?

Speakers at the consensus conference surveyed MRI's applications literally from head to foot. At its current stage of development, the technique is particularly suited to obtaining images of the brain and spinal cord. It is roughly equivalent to CT for detecting most brain tumors, and superior to CT for diagnosing tumors located at the rear and base of the skull, the panel concluded.

Moreover, MRI is now the preferred technique for detecting the brain lesions caused by multiple sclerosis. The panel emphasized, however, that an apparent positive finding is not sufficient to diagnose this degenerative nerve disease, but that the entire clinical picture must be considered.

MRI is also becoming the preferred technique for diagnosing problems of the spinal cord, such as herniated ("slipped") disks. In addition, researchers have recently found it to be very helpful in diagnosing diseases and injuries of the joints, especially the knee. As Herbert Kressel of the Hospital of the University of Pennsylvania puts it, "Examination of the joints has really come on like gangbusters in the last year."

In other diagnostic areas, CT still has the edge. For example, it can detect brain hemorrhages much earlier than can MRI, an advantage that makes CT the method of choice for examining possible stroke patients. The presence of hemorrhage has important therapeutic implications as it precludes the use of the anticlotting agents that are otherwise given to patients with blocked blood vessels.

The technical advantages of MRI include the ability to obtain images in any dimension. Moreover, calcium does not give a magnetic resonance signal. Bone, with its high calcium content, is therefore transparent to the imaging method. These two characteristics of MRI contribute to its value in obtaining images of the brain and spinal cord.

The absence of a calcium signal may be a disadvantage, however, when it comes to using MRI to detect malignant tumors in soft tissues, which often bear calcium deposits that are more readily picked up by CT. CT methods are preferred for diagnosing tumors of the lungs, spleen, pancreas, and kidney. Further development of MRI may change this situation, however.

Because magnetic fields can interfere with the operation of cardiac pacemakers, the consensus panel recommends that individuals who are wearing the devices not be examined by MRI. Individuals who are dependent on life-support systems constitute another group for whom MRI examination may not be possible. The presence of metal shrapnel or surgical clips in patients also indicates a need for caution, although some of the speakers at the meeting pointed out that they had not experienced difficulties in conducting MRI examinations of such individuals.

The experience with MRI to date generally suggests that the technique is not hazardous for those patients who undergo the procedure. Unlike CT, it does not use ionizing radiation, which increases the risk of cancer and birth defects, nor does it require

*The consensus panel met on 26 to 28 October in Bethesda, Maryland.

the potentially hazardous injection of radioactively labeled materials to provide contrast and enhance the images.

The ability to obtain images without such injections is one reason why MRI is becoming the favored diagnostic method for spinal conditions, for example. CT myelography, which has been used to diagnose lower back problems, requires the injection of a contrast dye into the spinal column and has a risk of side effects, including allergic reactions and paralysis. The images obtained by the two techniques are equivalent, but MRI can be performed without the invasive injection—a significant consideration in these litigious days.

Although the magnetic fields produced by MRI instruments have the potential of heating body tissues and of generating potentially fatal disturbances of heart rhythms, neither of these possibilities is a problem with MRI as it is now done, according to Thomas Budinger of the University of California, Berkeley, and the Donner and Lawrence-Berkeley laboratories.

In fact, Budinger says, the most serious hazard of the method is "flying projectiles," if metal objects are brought too close to the strong magnets used in the instruments. Nevertheless, the panel recommends that caution be used when examining patients who have fevers or whose systems have a lessened ability to regulate body temperatures, for example, the elderly or persons taking certain drugs.

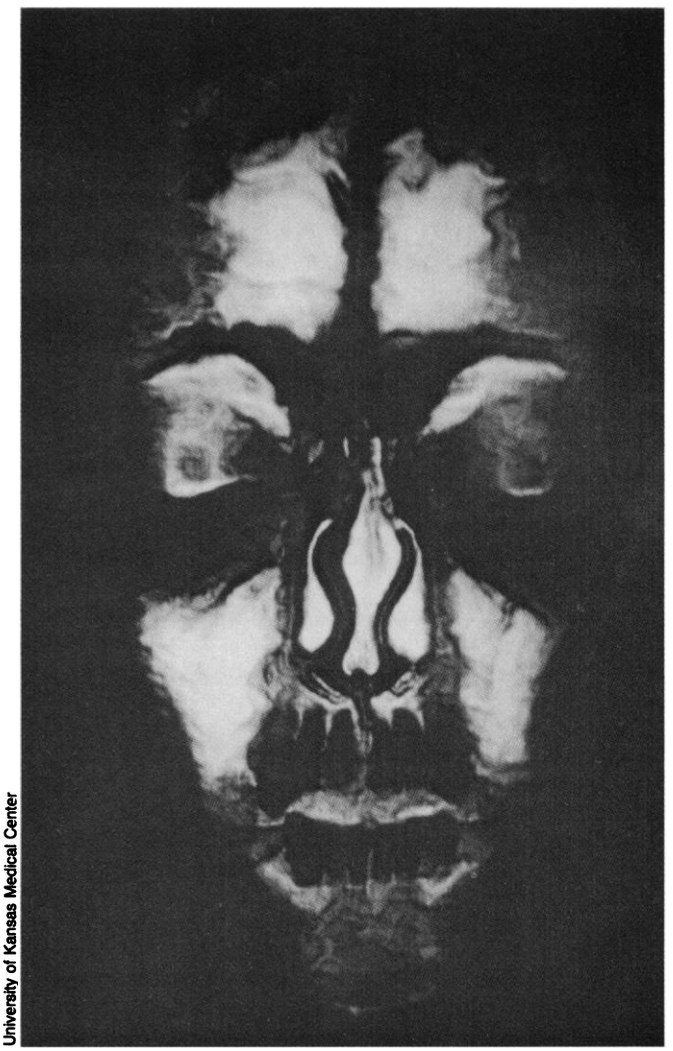
Animal studies that were described by W. LeRoy Heinrichs of Stanford University Medical Center indicate little or no risk to fetuses exposed to MRI in the womb. The panel urges, however, that pregnant women, especially early in pregnancy, not undergo the procedure unless they have a clear medical need that cannot be resolved by other means.

Finally, the consensus panel identified a number of new research developments that may lead to further improvements in MRI. The soonest to be realized will probably be the use of contrast-enhancing agents. As mentioned previously, MRI can be performed without such materials. Virtually all the work to date has been done without them, but many researchers think their use will permit better images to be obtained.

One such contrast agent, an organic chelate of the rare earth element gadolinium, is already near clinical application. If the Food and Drug Administration gives the gadolinium compound the go-ahead, it will be available for patient use early in 1988. Presentations at the consensus conference indicated that this agent is safer than those used for CT, but experience with it is much more limited.

An MRI view of the human face

Current MRI instruments focus on hydrogen atoms. Tissues with high water content, such as the nose, cheeks, and forehead therefore give an intense magnetic resonance signal. Bones and teeth disappear because they have a high content of calcium, which does not give a signal.



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Another promising area of investigation is magnetic resonance spectroscopy, which can be used to obtain information about the metabolic states of tissues, not just about their anatomy. Spectroscopy will require high magnetic fields—10 tesla or so. Now MRI instruments generate fields of up to about 5 tesla, although most of the work is done below 1.5 tesla. With the high magnetic fields that spectroscopy requires, problems such as tissue heating, may become much more severe than they now are. Researchers will have to determine just how much more severe.

Although most of the presentations at the consensus conference were upbeat concerning MRI's diagnostic capabilities, a report given by Eric Larson of the University of Washington School of Medicine in Seattle was an exception. With his Washington colleague Daniel Kent, Larson analyzed the literature on MRI of the brain and spinal cord through 1986. The researchers concluded that some 90% of the studies contain methodological biases that tend to inflate the efficacy of MRI in detecting disease.

Larson noted, however, that the technique was undergoing rapid technological development during the time covered by the literature analysis, a circumstance that makes assessment of its clinical efficacy difficult. The changes are continuing, as several additional speakers pointed out. "We're shooting at a moving target," says Nolan Karstaedt of the Bowman Gray School of Medicine in Winston-Salem. "It's very hard to evaluate a technology that changes with the rapidity that this one does."

In any event, Larson and Kent's conservative assessment of the capabilities of MRI was definitely a minority viewpoint among the consensus speakers. According to Abrams, the panel members were fully aware, and so noted in their report, that some of their judgments were based on studies that were less rigorously designed than is desirable. But he says, "This is a dispassionate report that is deliberately guarded and appropriately thoughtful." ■

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