National Standards Institute has issued criteria for the transmission of UV light by sunglasses.

Meeting these standards is voluntary. Ultraviolet A could be transmitted no more than visible light. Up to 30% of UV-B could be transmitted in cosmetic models, 5% in general-purpose models, and 1% in special-purpose models. *Consumer Reports* tested sunglasses from a wide variety of prices. All models tested met these standards for general-purpose sunglasses and most also met criteria for special-purpose sunglasses.

If sunglasses do not fit closely, this protection is lost. For example, 32 pairs of inexpensive glass or plastic sunglasses were tested for transmission of UV radiation.

When sunglasses were in contact with the forehead, 0.8% to 14.1% of incident UV radiation reached the eye. When the frames were moved 6 mm from the forehead, 3.7% to 44.8% reached the eye (*Amer J Public Health.* 1988;78:72-74).

Therefore, experts say, it is important to choose sunglasses that keep light from reaching the eyes around the frames. Side shields that are attached to some models have almost no effect on peripheral vision, Hopkins' Taylor adds.

Intraocular Lenses

For those needing cataract surgery, 80% of intraocular lenses now being implanted have compounds that absorb UV light.

Taylor offers one final method for reducing ocular exposure to UV light that's as American as apple pie: he says wearing a brimmed baseball cap can cut ocular exposure to UV by half to one fourth (*Photochem Photobiol.* 1985;42:163-171). As a rule of thumb, he says, if there's enough sun to cause sunburn, you should protect your eyes.—by Carin M. Olson, MD, 1988-1989 Morris Fishbein Fellow in Medical Journalism

Magnetic Resonance Spectroscopy May Hold Promise in Studying Metabolites, Tissues

ALMOST 15 years ago, in a basement at Chicago's University of Illinois Medical Center, Michael Barany, MD, PhD, measured phosphorus metabolites in an intact frog muscle using magnetic resonance spectroscopy (MRS). Prior to that, chemists used spectroscopy solely to analyze the contents of test tubes. Only a British group preceded Barany in proving that it would work in tissue as well. Today, he does spectroscopy clinically, one day a week, at the Greenberg Radiology Institute in Highland Park, Ill, north of Chicago.

Barany says that he can distinguish malignant from benign tumors in the living brain. The tool he uses is a standard magnetic resonance imaging (MRI) machine.

While MRI capabilities have forged ahead, human MRS has been awaiting improvements in magnet and computer technology. Barany is one of a number of researchers who, since the early 1980s, have been developing MRS technology and techniques so that it can be done in the human body.

Metabolites, Tissues

Magnetic resonance spectroscopy detects the presence, or absence, of specific metabolites and can be used in other molecular studies. Barany and other researchers say it can be used to tell when tissue is alive or dead, when a tumor is responding to therapy, and when the mass that shows up on an image is, for example, a tumor or an abscess.

Researchers say that, now that they have proved that MRS can be done in the body, their efforts are on the verge of fruition. Because spectroscopy affords an unprecedented opportunity to study the metabolism and function of healthy and diseased tissues in the living body, they say its research potential is tremendous.

Metabolic studies with spectroscopy have been able to pick up abnormalities in stroke, brain tumors, reduced brain perfusion, iron overload in the liver, glycogen storage diseases, hepatitis, and fructose intolerance. Michael W. Weiner, MD, an associate professor of medicine and radiology at the University of California, San Francisco (UCSF), has been studying cardiomyopathies, alcohol metabolism, and alcoholic liver disease with spectroscopy.

Clinical Applications

Many groups have begun searching for clinical applications also. They use commercially available imaging machines, the so-called high magnetic field (1.5 tesla) imagers.

According to estimates, about one third of the 1200 clinical MRI units in this country are high magnetic field machines. Those centers could do spectroscopy without an additional major investment.

To convert an imager to spectroscopy requires only a computer program and a special radio-wave coil that can be placed on the body. The four major manufacturers of magnetic resonance imagers have already developed spectroscopy computer programs for their units.

Most of the work to date has been done in tumors. In the cancer work, the hope is that spectroscopy will prove useful for early diagnosis and potentially for monitoring progress during therapy.

Spectroscopists say that there is already some evidence that a tumor that is responding to therapy exhibits detectable metabolic changes long before there is actual shrinkage of the tumor. Those tumors that are unresponsive do not show the same change.

Although Barany's claims about brain tumors are considered bold by some spectroscopists, others have made the same observation (*Magn Reson Imaging.* 1986;4:503-508). He says that he distinguishes the malignant brain tumors from the benign tumors primarily by measuring the levels of *N*-acetylaspartate. Spectroscopy shows that it is largely absent in the cells of malignant tumors, whereas benign tumors have amounts somewhat more comparable with healthy areas, he says.

To Monitor Rejection?

Two groups in this country have begun looking at spectroscopy as a noninvasive alternative to biopsy for monitoring organ rejection in heart transplants. Spectroscopists at The Johns Hopkins University School of Medicine, Baltimore, Md, have just finished their preliminary animal research and are ready to begin with their heart transplant recipients.

The Duke University School of Medicine (Durham, NC) group has started working with patients. The Duke group recently reported results—they compared spectroscopy findings with biospy specimens—at the Radiological Society of North America meeting in Chicago.

Robert Herfkins, MD, one of the principal investigators, calls their results

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"reasonably impressive." (Herfkins has since left Duke to become director of MRI at the Cedars-Sinai Medical Center in Los Angeles.)

Magnetic resonance methods are based on the fact that when certain atoms are placed in a strong magnetic field, they will absorb, and then emit, radio waves. Each element responds to (that is, will absorb and emit) a specific range of radio-wave frequencies. More important, electromagnetic fields affect the atom, determining the exact frequency that a particular atom responds to.

Imaging uses hydrogen atoms because they are the most plentiful and they emit more signal than other elements. In imaging, the external magnetic field, created by the magnet, is varied across the imaging plane.

Because the strength of the magnetic field differs in different regions, the hydrogen atoms in each area respond to a unique frequency. The computer recognizes the atom's location by its frequency. The amount of signal tells how many atoms and, therefore, how bright or dark that part of the image should be.

In spectroscopy, the external magnetic field is kept uniform. This allows the magnetic influence of the atom's host molecule to emerge.

When the external magnetic field is homogeneous, an atom in one particular molecule will respond to one frequency, while that same atom in a different molecule will respond to another. For example, a phosphorus atom in a phosphocreatine molecule will absorb, and then reemit, different frequency radio waves than will a phosphorus in an inorganic phosphate molecule.

To do MRS, the spectroscopist tunes in the specific frequency for a particular molecule and measures the amount of signal that comes back from the area of interest. Spectroscopy data is most often presented as ratios of metabolites, not absolute amounts.

90-Minute Examination

A full examination lasts about 90 minutes. The patient is placed in the magnet and then images are obtained first.

A small radio-wave transmitter/receiver called a "surface coil," appropriately enough, is placed on the body to direct the radio waves to the desired area. Spectroscopy measures an area about 3 cm^3 in size. Says UCSF's Weiner, "It's good for a mass the size of a tennis ball, and not good for the size of a pea." The tissue measured should be close to the surface of the body.

Currently, human spectroscopy can be done using five atoms: phosphorus 31, hydrogen, carbon 13, sodium, and fluorine.

Phosphorus has been studied the most, in part because it is an ideal element for human spectroscopy. It is plentiful (elements that are not cannot be measured), it has a strong signal (some elements don't), it plays an integral role (mainly in the adenosine triphosphate cycle, but also in the cell membrane as a component of the phospholipids), and, most important, the necessary isotope, phosphorus 31, is the most prevalent isotope of phosphorus in the body (magnetic resonance can only be done using isotopes with an odd number of particles in the nucleus).

In the heart transplant work, the investigators have found that the ratio of phosphocreatine to inorganic phosphate narrows in rejection, presumably as the storage form of phosphorus, phosphocreatine, is depleted, while there is a buildup of the waste product of adenosine triphosphate breakdown, phosphate. William Baumgartner, MD, director of the heart and lung transplant program at Hopkins, says that the process is not understood well enough to know exactly why this would be happening.

But, Baumgartner says, the finding was consistent in the studies performed on dogs. Moreover, when immunosuppression was increased, he says, the ratio returned to normal.

Two developments are on the horizon. Robert Schulman, PhD, a professor of biophysics at Yale University, New Haven, Conn, has been using tagged molecules.

Schulman has a glucose solution of which 90% of the carbon atoms are carbon 13, a rare carbon isotope, and has been using it to study glucose metabolism in diabetes. The development of other molecules tagged with an appropriate isotope could significantly enlarge the types of processes that can be looked at, though spectroscopy will probably never be sensitive enough to measure, for instance, neurotransmitters, say researchers.

In addition, groups at Stanford (Calif) University and at the University of Pennsylvania, Philadelphia, primarily, have begun developing techniques that will allow the spectroscopy data to be incorporated into an image, presenting a picture of metabolism much like a positron emission tomography scan. Robert Lenkinski, PhD, an associate professor of radiology at Pennsylvania, says that although the resolution of the images is not very good yet, "we're doing it." He says that there is no reason why they can't improve the resolution somewhat in the future.

Not Without Critics

If the ability to measure substances and metabolism noninvasively and without exposing the patient to harmful radiation sounds too good to be true, that's because it is, according to Leon Kaufman, PhD, director of the Radiologic Imaging Laboratory at UCSF. Says Kaufman: "Everything I have ever seen in spectroscopy is hype." He is a proponent of low magnetic field imaging and has been building low-field machines—machines that are too weak to do spectroscopy.

Five years ago, Kaufman says, reseachers were predicting that clinical spectroscopy would be possible in 5 years. "The big answers aren't coming," he says. "I'm from Argentina. And in Argentina there is a saying. Brazil is the country of the future and it always will be. Well, spectroscopy is the technology of the future and it always will be."

Kaufman also says that recent work done with very high–field experimental magnets is showing that the spectroscopy done with clinical imaging machines is neither as accurate nor precise as had been believed (*Radiology*. 1988; 169:864-865). And, he says he is concerned that the cost of fruitless spectroscopy research is being born by everyone, contributing to the problem of the high cost of medical care.

Companies have to pass on their research costs to customers, Kaufman says, and hospitals are being sold big, expensive imaging machines on the promise of spectroscopy, when a smaller, cheaper machine would probably meet their needs. "It's not a conscious hoax in the sense that people are malevolent," he says. "There is just this hope."

On the other hand, if spectroscopy has taken so long to come around, it is because not only the technology, but so much of the information is entirely new, says Cecil Charles, PhD, director of magnetic resonance research at Duke. Even if spectroscopy is never used clinically, says Charles, the research is still of benefit because it is providing a tremendous amount of new information about normal and abnormal function.

Says George Radda, MD, the British Heart Foundation professor of molecular cardiology at Oxford University, Oxford, England, and one of the world's foremost authorities on spectroscopy, in an editorial (*Science*. 1986;233:640-645): "Nuclear magnetic resonance has much to offer as a source of new biochemical information, and as a technique that brings clinical practice and biochemical understanding closer together."—by Timothy F. Kirn