should have favored the 14-gauge needle technique in the likelihood of a lower complication rate.

We believe the 18-gauge needle technique with real-time US guidance offers a significant advantage in improving the safety of renal allograft biopsy. Experience appears to be more important with this technique, however, in minimizing the number of needle passes required to obtain an adequate specimen. ■

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References

1. Buselmeier TJ, Schauer RM, Mauer SM, et al. A simplified method of percutaneous allograft biopsy. Nephron 1976; 16:318-321.
2. Murphy GP. Percutaneous needle biopsy of human renal allotransplants. J Urol 1972; 107:193-195.
3. Nagar D, Wathen RL. An improved method for renal allograft biopsy. Kidney Int 1979; 16:519-521.
4. Pillay VKG, Kurtzman NA. Percutaneous biopsy of the transplanted kidney. JAMA 1973; 226:1561-1562.
5. Mathew TH, Kincaid-Smith P, Eremin J, Marshall VC. Percutaneous needle biopsy of renal homografts. Med J Aust 1968; 1:6-7.
6. Matas AJ, Tellis VA, Sablay L, Quinn T, Soberman R, Veith FJ. The value of needle renal allograft biopsy. III. A prospective study. Surgery 1985; 98:922-925.
7. Parker RA, Elliott WC, Muther RS, et al. Percutaneous aspiration biopsy of renal allografts using ultrasound localization. Urology 1980; 15:534-535.
8. Appel GB, Saltzman MJ, King DL, Hardy MA. Use of ultrasound for renal allograft biopsy. Kidney Int 1981; 19:471-473.
9. Ubhi CS, Irving HC, Guillou PJ, Giles GR. A new technique for renal allograft biopsy. Br J Radiol 1987; 60:599-600.
10. Parker SH, Hopper KD, Yakes WF, Gibson MD, Ownbey JL, Carter TE. Image-directed percutaneous biopsies with a biopsy gun. Radiology 1989; 171:663-669.

Flexible Protective Gloves: The Emperor's New Clothes?[1]

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The risk of developing skin cancer is estimated for interventional radiologists who do and do not wear thin, flexible protective leaded gloves. The use of these gloves is extremely expensive in terms of dollars per potential cancer prevented. Good radiographic practice without the use of flexible protective gloves provides adequate protection.

Index terms: Radiations, exposure to patients and personnel • Radiations, injurious effects, neoplastic • Radiations, protective and therapeutic agents and devices

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WITH the introduction into radiology practice of complicated and lengthy interventional procedures, such as percutaneous stone removal, the potential for radiation exposure to the radiologist's hands has increased dramatically. Traditional lead gloves are too thick and clumsy for delicate interventional procedures utilizing catheters and guide wires. Thin, flexible protective gloves with considerably less protection are commercially available and widely advertised. With the release of the latest risk estimates on the induction of skin cancer, we decided it would be interesting to estimate the cost-effectiveness of the flexible lead gloves in relation to reducing the frequency of skin cancer.

Estimation of Absorbed Dose

The fluoroscopy time required for interventional procedures varies tremendously. We have assumed a fluoroscopy time of 4 minutes per case based on our previous measurements (1). This means that for an angiographic procedure, a radiologist would receive a scattered radiation dose to the hands of about 0.4 mGy (40 mrad). If the caseload for a busy interventional radiologist was two procedures per day for 220 days each year, the resulting dose to the hands would be 176 mGy (17,600 mrad) per year. Twenty-five years of practice would yield cumulative doses of less than 4.5 Gy (450 rad). These estimates are based on the assumption that there will be a typical mix of cases. Many percutaneous stone removals or the use of an overhead tube would increase the dose. These dose estimates are consistent with the measurements of Law (2).

Risk Estimate

Total doses of less than 5 Gy (500 rad) to the hands spread over 25 years will not cause nonstochastic effects such as skin thinning or fibrosis of the underlying tissues. There is no active marrow in the hands or forearms, so gloves provide no protection from leukemogenesis. The only tenable risk that may be reduced by the use of gloves is that for radiogenic skin cancer. The risk estimate for skin cancer from the 1988 report by the United Nations Scientific Committee on the Effects of Atomic Radiation (3) is 1×10^{-4} cancers per year per gray (1×10^{-6} cancers per year per rad). This means that one cancer per year would be expected (after the latent period) if 1 million radiologists were exposed to 0.01 Gy (1 rad). The risk factors usually quoted with regard to skin cancer are derived from radiation effects on ultraviolet-exposed skin of the head. The risk for non-ultraviolet-exposed skin may be substantially lower because the two radiations (ultraviolet and x ray) may act synergistically. We know of no data from which to derive risk data about either whole-body or hand radiation exposure. Although it may be an overestimate of risk, we have elected to use the risk factor derived from head irradiation because the hands are also exposed to ultraviolet radiation. These risk estimates do not take into consideration dose rate effects. If dose rate effects had been included, the estimates developed below of cost per cancer prevented would have been even higher.

Using the risk estimate of 1×10^{-4} cancers per year per gray (1×10^{-6} cancers per year per rad) and an estimated hand dose of about 0.18 Gy (18 rad), one calculates an estimate of 1.8×10^{-5} (18 chances per million) cancers per year per radiologist. This estimate is for a radiologist who keeps his/her hands out of the direct exit beam most of the time.

Manufacturers' literature gives glove attenuation values ranging from 12% at 125 kVp to 30% at 60 kVp for a single layer of glove material. Our experimental measurements confirm these values. Therefore, if flexible lead gloves are used and a voltage of 100 kVp is assumed, the attenuation of the gloves is about 20%. This means that the hand dose to an individual wearing the gloves is reduced from 176 to 140 mGy (17,600 to 14,000 mrad) per year, and

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the risk estimate is 1.4×10^{-5} (14 chances in a million) per year. Thus, 1 million interventionalists must wear protective gloves in each of their 440 procedures per year to reduce 18 potential skin cancers per year to 14 potential skin cancers per year. At a retail price of $41 per pair and assuming that gloves are used only once, this works out to a cost of about $4.5 billion per skin cancer prevented each year.

The commercially available gloves can be resterilized and used more than once; therefore, the cost of prevention of a skin cancer would actually be reduced. For example if the gloves are reused 50 times, then the cost of prevention would drop to about $90 million per skin cancer prevented yearly. It should be pointed out that very few skin cancers are fatal. If we assume that fewer than 5% of radiogenic skin cancers are fatal, the cost of prevention is more than $1.8 billion per possible life saved annually.

Some might ask, "What is the problem with spending such sums of money to prevent cancer?" Certainly the wearing of leaded gloves is consistent with the principles of ALARA (As Low As Reasonably Achievable) in radiation protection. Or is it?

Let us look at the other side of the coin. Consider an interventional radiologist who reads the package insert provided with the gloves, which indicates that the gloves provide some protection. He/she might assume therefore that it may be acceptable to place a hand in the direct beam a little more often than before. Suppose this is done only 5% more often than usual, or the hand is exposed for an extra 15 seconds (5% of 5 minutes). With an under-table tube, exit radiation levels are about 6.5×10^{-4} $\mathrm{C \cdot kg^{-1} \cdot hr^{-1}}$ (2,500 mR/h) or 1.8×10^{-7} $\mathrm{C \cdot kg^{-1} \cdot s^{-1}}$ (0.7 mR/sec) for an entrance exposure of 9×10^{-3} $\mathrm{C \cdot kg^{-1} \cdot min^{-1}}$ (3,500 mR/min). This would raise the average hand exposure from 1.0 to 1.32×10^{-7} $\mathrm{C \cdot kg^{-1}}$ (40 to 51 mR), but the attenuation of the gloves would keep the hand dose about the same as would be achieved with no gloves and the hand out of the beam. If the radiologist mentally changes his/her methods of practice based on the fact that the gloves are of significant benefit, then the change in attitude may actually result in increased dose and potential risk.

We conclude that flexible protective gloves are a phenomenally expensive way of preventing potential cancers and are no substitute for good radiographic practice. We also conclude that a very minor change in practice by persons who assume they are protected when they wear flexible leaded gloves will actually increase absorbed dose and potential risk. The best way to provide adequate radiation protection is to monitor hand dose with a ring badge, remain conscious of the level of radiation to which one is exposed, and practice good radiographic technique in minimizing the exposure to the unprotected hands. ■

References

1. Tryhus M, Mettler FA, Kelsey CA. The radiologist and angiographic procedures: absorbed radiation dose. Invest Radiol 1987; 22:747-750.
2. Law J. Radiation dose to urological surgeons during x-ray fluoroscopy for percutaneous stone extraction. Br J Radiol 1989; 61:185-187.
3. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). 1988 report to the General Assembly: sources and effects of ionizing radiation. New York: United Nations Publications, 1988.

Facial Surface Coil for MR Imaging[1]

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A local-reception counter-rotating-current coil for magnetic resonance imaging at 1.5 T was developed. It consists of two parallel coaxial racetrack-shaped loops. The planes of the loops are orthogonal to the surface of the body, and the space between the loops is open. The separation between the loops allows the device to fit over the nose and mouth for oral-maxillofacial imaging without the threat of occlusion to the patient's air passages. The sensitivity of this coil is similar to that of conventional surface coils of the same dimensions. The two active current elements conform to other anatomic objects including the eyes and anterior portion of the neck.

Index terms: Magnetic resonance (MR), surface coils • Mouth, MR studies, 262.1214 • Nose, MR studies, 261.1214 • Orbit, MR studies, 22.1214

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An obvious application of magnetic resonance (MR) imaging with surface coils is imaging of the oral-maxillofacial region. However, patients severely object to the use of any surface coil that might occlude the nose or mouth; in addition, the nose interferes with the use of many possible surface coil designs. We have found an open-coil geometry that solves the problems of patient nonacceptance and surface irregularity around the nose.

Our work began with a search for surface coil designs suitable for imaging the maxilla both for presurgical planning in the positioning of titanium implant tooth supports and for diagnosis in the event of implant failure. Presurgical planning is presently done in our institution with the use of computed tomography (CT). Closely spaced axial images are obtained, and the data are reformatted to obtain the desired sagittal display. The CT voxel dimensions are 1 mm^3, and our hypothesis was that the higher resolution of MR could be of value. CT fails completely in the presence of implants because the implants produce severe streak artifacts. Because of the small size of the implants and the low radio-frequency conductivity of titanium, it was hoped that artifacts in the MR image would be minimal.

Because of the open structure of the coil, we were encouraged to search for other applications. Since the coil fits without interference over the nose, it is obviously of use for imaging of that structure. Plastic surgeons at our institution have expressed interest in MR imaging of the nose to assist in preoperative planning for the correction of a deviated nasal septum. The device also can be used for both dual-orbit and single-orbit imaging. Thus, we propose that a single local-coil geometry can be used to image the highly curvilinear structure of the face.

Materials and Methods

We previously introduced the counter-rotating-current (CRC) coil (1).

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