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Radiation and Your Brain

Possible measures to reduce radiation exposure in the cath lab.

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Endovascular interventionalists are exposed to radiation every time they are in the cath lab. To combat this exposure, aprons with a lead equivalent between 0.5 and 0.75 mm are used to mainly protect their trunk and thyroid, as well as protective glasses, which are recommended but not always used. An 0.25-mm lead-equivalent apron absorbs about 96% of scatter radiation, whereas a 0.5-mm lead-equivalent apron absorbs about 98%.1 However, the operator's legs, arms, and head are not fully protected. Even when using all of the protective shielding in the cath lab (ie, ceiling suspension drop-down shielding, lower body shielding, mobile shielding), the unprotected head is exposed to radiation.

Two trials have shown that the left side of the brain is exposed to a higher radiation dose than the right side. This is due to the operator's routine working position in which the left side of the head is closest to the scatter radiation coming from the patient.2,3 Interestingly, a protective head cover was shown to reduce the radiation measured inside the cover3,4 and equalize the amount of radiation to both sides of the head.3 Wearing a lead-based head cover may have a protective role in the cath lab, but are there published data showing that this protective measure should indeed be implemented?

OCCUPATIONAL RADIATION EXPOSURE AND THE BRAIN

In recent years, a series of articles were published on physicians working in the catheterization laboratory who had brain and neck tumors.5,6 In 1998, Finkelstein described two cardiologists in Toronto who were diagnosed with glioblastoma multiforme (GBM), an aggressive brain tumor, at a very young age and died shortly after diagnosis. The author concluded that, "The occurrence of these two cases is a statistically unusual event—a 'cluster'—and there are several possible explanations for this cluster. First, this may be a chance occurrence, and the tumors may have no causative factors in common. Second, the cause may be radiation exposure. A connection to occupational radiation exposure is biologically plausible, but risk assessment suggests that it is

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reminded to practice radiation safety methods during fluoroscopic procedures.[5]

At our medical center in 2009, a 63-year-old physician who worked in the cath lab for 32 years died due to a left-sided GBM less than 1 year after diagnosis. To understand whether this was related to the working environment and radiation exposure, we acquired information and reported on three additional cases6 and subsequently published an update that included 31 physicians, all with head and neck tumors.7

Currently, we have data on 43 patients: 33 interventional cardiologists, six interventional radiologists, two electrophysiologists, and two nurses. All patients had worked for prolonged periods of time in an active interventional practice with radiation exposure (latency period, 12–32 years; mean, 23.5 ± 5.9 years). The tumors included 24 GBMs (57%), two astrocytomas (5%), and five meningiomas (12%).

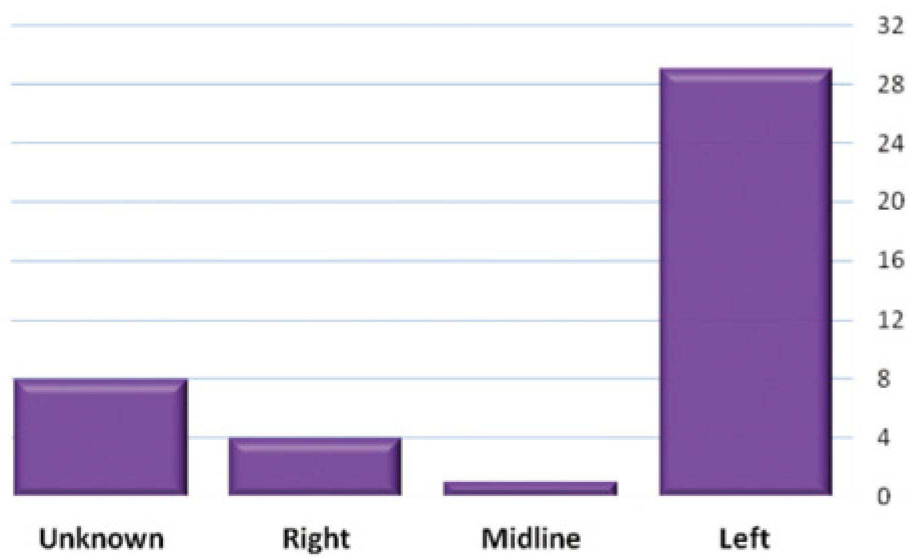

Figure 1. Data were available for 35 of 43 cases on the side of the brain involved. The malignancy was left-sided in 30 (85%), midline in one, and right-sided in four cases.

In the general population, the side involved in these tumors is distributed equally (left, 50%; right, 50%). What was interesting in this series of self-reported cases was that the tumor was on the left side in 85% of cases (Figure 1). The left side has higher radiation exposure; even with these small numbers, there is a statistical difference than the expected 1:1 side involvement ratio.

RECENT ANALYSES OF CANCER RISK ASSOCIATED WITH INTERVENTIONAL PROCEDURES

Recently, two studies showed for the first time a statistical difference in malignancy rates and

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interventional procedures. The authors examined a nationwide prospective cohort of almost 91,000 radiologic technologists who responded to a survey between 1994 and 1998, which collected information on whether they had ever worked with fluoroscopically guided interventional procedures. Survey participants were followed through completion of a subsequent cohort survey during 2003 to 2005 (for cancer incidence) or 2003 to December 31, 2008 (for cancer mortality). Sex-adjusted hazard ratios (HRs) and 95% confidence intervals (CIs) were calculated using Cox proportional hazards models for incidence and mortality from all cancers. The outcomes for technologists who reported performing fluoroscopically guided interventional procedures were compared with technologists who never performed these procedures.

Among technologists who performed fluoroscopically guided interventional procedures, the risk of brain cancer mortality was more than twice as likely as compared with those who never performed the procedures (HR, 2.55 [95% CI, 1.48–4.4]), and the risks of melanoma and breast cancer were modestly elevated (HR, 1.3 [95% CI, 1.05–1.61] and HR, 1.16 [95% CI, 1.02–1.32], respectively); however, the mortality risk for these two cancers was not increased (HR, 1.07 [95% CI, 0.69–1.66]). Incidence of all cancers combined was slightly increased, excluding nonmelanoma skin cancers (HR, 1.08 [95% CI, 1.00–1.17]), but mortality from all cancers was not elevated (HR, 1.00 [95% CI, 0.88–1.14]).

The authors concluded that there was an elevated risk of brain cancer, breast cancer, and melanoma among technologists who performed fluoroscopically guided interventional procedures, and results could be due to low-dose radiation exposure or chance or unmeasured confounding by risk factors not related to radiation. Additional studies with individual data on radiation dose are needed to confirm these results.[8]

In another study, Ho et al reported that cardiologists who frequently perform percutaneous coronary interventions (PCIs) have a higher risk of cancer compared with other internists or cardiologists who perform fewer PCIs.[9] Data from 2000 to 2011 were obtained from the Taiwan National Health Insurance Research Database. A cohort of 542 cardiologists was matched according to age and sex with a cohort of internists and noncardiologist controls. The incidence of cancer was measured for both cohorts, who were followed until the end of 2011. The risk of cancer between cardiologist and control cohorts was analyzed using Cox proportional hazards models.

In general, the cardiologist cohort did not have a higher risk of cancer compared with the other internists. However, cardiologists who worked in medical centers or regional hospitals had a higher risk of cancer than the other internists in the same work settings. Furthermore, the cardiologists performed < 15 PCIs per year.9

BEHAVIORAL/NEUROLOGIC EFFECTS OF RADIATION

Andreassi et al observed a sixfold increased rate of self-described anxiety/depression in staff exposed to radiation. This could represent an occupational illness due to high stress and psychological strain posed by the work of the interventionist; however, another interesting explanation for self-described anxiety/depression may be a direct effect of radiation. This explanation may be especially relevant with regard to radiation to the unprotected head of the first operator (≤ 1–2 Sv on the left hemisphere after a lifetime exposure). Chronic low doses may have a detrimental impact on hippocampal neurogenesis and neuronal plasticity, with possible negative effects on mood stability and psychiatric morbidity.10

Another study compared neuropsychological test scores in 83 cardiologists and nurses working in the cardiac catheterization lab and 83 control participants (nonexposed group) to explore possible cognitive impairments. The radiation-exposed group had significantly lower scores on delayed recall, visual short-term memory, and semantic lexical access ability than the nonexposed group. No dose response could be detected. Exposed group participants showed lower memory and verbal fluency performances as compared with the nonexposed group. These reduced skills suggest alterations of some left hemisphere structures that are more exposed to ionizing radiation in interventional cardiology staff.11

CONCLUSION

The results presented raise additional concerns regarding brain cancer and behavioral changes developing in physicians who perform interventional procedures. Given that the brain is relatively unprotected, and the left side of the head is more exposed to radiation than the right, these findings of disproportionate reports of left-sided tumors suggest a possible causal relationship to occupational radiation exposure. Therefore, based on these findings, head protection would be a mandatory good practice to reduce effects of head exposure to ionizing radiation among personnel working in the cath lab and other professionals exposed to radiation.

It should be noted that due to many confounding factors, it is difficult to demonstrate a direct correlation between radiation exposure and cancer. A connection to occupational radiation exposure is biologically plausible, but risk assessment is difficult given the small population of fluoroscopy-guided interventionists. Because interventional cardiologists and radiologists have the highest radiation exposure among health professionals, awareness of radiation safety and training in radiological protection are essential and imperative and should be used in every procedure.12

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medical specialty. Therefore, in every procedure, certain steps must be followed to reduce radiation.

including minimizing fluoroscopy frame rate and time, reducing the number of acquired cine images, collimating, avoiding high-scatter areas (steep caudal and cranial angulation), and using available patient dose reduction functions and technologies. It is important to use a quality assurance program to control performance of imaging equipment, as well as to routinely wear personal dosimeters to follow radiation exposure among personnel. Protecting the head seems logical, although proof is lacking.

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