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Techniques in Vascular and Interventional Radiology

Baby on Board: Managing Occupational Radiation Exposure During Pregnancy

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This article reviews the issue of occupational radiation exposure as a deterrent to recruitment of women into the field of interventional radiology and provides the reader with three strategies to optimize radiation protection during fluoroscopically guided procedures. These include personal protective shielding, use of ancillary shielding, and techniques that limit fluoroscopy x-ray tube output. When optimal radiation safety practices are implemented as the norm in the IR suite, very little extra needs to be done to ensure that fetal dose of a pregnant interventionalist is negligible.

KEYWORDS Occupational radiation exposure, Pregnant worker

Introduction

Concerns related to occupational radiation exposure during pregnancy are commonly thought to be a significant deterrent to the recruitment of women into fields that involve fluoroscopically guided interventions (FGI) such as interventional radiology and interventional cardiology.[1,2] These two specialties have fewer women practitioners and trainees than do the fields of general surgery, cardiothoracic surgery and orthopedic surgery, traditionally very male dominated specialties.[3] The recruitment issue stems from the fact that ionizing radiation is known to affect the health and development of fetal tissue. The doses that have been associated with measurable deleterious effects are exponentially higher than those measured on dosimeters of physicians who do FGI.[4] However, no study has stated in its conclusion that all fetal ill effects of radiation have a distinct threshold dose. Therefore, no written material advising women on management of occupational radiation exposure can say that low exposure carries no risk. They say the risk is "minimal", but none say that the risk is zero.

The problem this creates for women is that in our current culture, we are not supposed to do anything that carries any risk to the fetus during pregnancy. Every activity we engage in should have zero risk. Published advice of risks to avoid during pregnancy is extremely broad and far reaching (see BabyCenter.com or pregnancy.org). In addition, complete strangers are apt to provide their unsolicited opinions regarding pregnancy risks to pregnant women in ways that are remarkably judgmental and intrusive. In this environment, who can blame women for avoiding careers that include occupational exposure to ionizing radiation?

The result of this career avoidance is significant. Interventional Radiology needs diversity to provide the best care to patients and the broadest creativity of thought. Half of all medical students are women. If IR does not recruit from the full breadth of medical school graduates, the specialty will miss out on its share of half of the best minds.

The goal of this article is to provide information and work strategies to support the view that minimal risk is, in practical terms, the same as no risk. IR can be, and should be, a safe profession for everyone with respect to occupational radiation exposure. I include my personal experience in the discussion.

Background

Pregnancy is inherently not a safe undertaking. Background risk of a negative outcome is high. In all, 15% of known pregnancies end in spontaneous abortion. Approximately 3/100 babies are born with a major congenital malformation, while 4/100 have minor congenital abnormalities.[5]

It is known that the developing fetus is radiation sensitive, based primarily on mammalian animal studies.[5]

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Studies have shown that embryonal/fetal dose less than 0.1 Gy (100 mGy) does not increase the risk of ill effect in humans.[5] Extrapolating that number to the dose unit used in occupational dosimetry, a dose equivalent of 100 mSv is not known to cause ill effect in the developing fetus.

The United States sets the limit on fetal dose at 5 mSv/pregnancy, and 0.5 mSv/month after declaration of pregnancy.[6,7] These limits are well below the 100 mSv dose noted above. In Europe, fetal dose limit is set at 1 mSv/pregnancy, which is the same as the dose limit for a member of the general public.[8]

Published data regarding occupational dose under lead indicate that occupational dose among IRs at waist level under lead are within the regulatory limit. My study, published in 1992, found that IRs wearing 0.5 mm Pb eq thickness aprons had average recorded under-lead doses of 1.3 mSv/year which translates to ~0.1 mSv/month.[9] In the same study, IRs wearing 1 mm Pb eq thickness aprons had an average yearly dose at waist level under lead of 0.4 mSv/year, or 0.03 mSv/month (a dose not detectable by standard dosimeters).[9] More recent studies in interventional radiology and interventional cardiology have similar results.[10,11] One of these demonstrated significant reduction in operator dose following implementation of radiation safety training and routine use of boom-mounted shielding.[11] A study that included 32 pregnant vascular surgeons involved with endovascular work, found that the average fetal dose tracked by dosimetry was minimally above background.[12]

All this data is reassuring and indicates that working in the fluoroscopy environment during pregnancy is safe and can be done within regulatory dose limits. However, regulatory dose limits do change. For example, the regulatory limit for lens of eye has been decreased in Europe due to the increased information related to radiation-induced cataracts in physicians.[13] This type of regulatory evolution contributes to a widely accepted view that fetal radiation exposure should be kept well below levels that regulations require. Strategies to help women achieve that goal are reviewed below and include: using dosimetry data as a guide, tailoring use of personal and ancillary lead shielding, and active fluoroscopy practices that can minimize occupational dose.

Dosimetry Data: Know Yourself

The first step to developing an evidence-based strategy of managing occupational dose during pregnancy is to know dosimetry data. The dosimetry study I published in 1992 was in part motivated by a drive to learn about occupational dose in planning my own work strategy during pregnancy.[9] By measuring over-lead and under-lead dosimetry data prospectively on 30 IRs for 2 months, the study established that average under-lead doses for this group of busy practitioners was below regulatory limit for fetal exposure, and especially low for IRs wearing 1 mm Pb eq thickness aprons. I found this information very reassuring, and made plans to manage my occupational radiation exposure based on it. More recent dosimetry work has demonstrated similar results, despite the increased complexity of modern FGIs.[10–12] I am hopeful that increased awareness of published dosimetry data will encourage more women to enter the field of IR.

Knowledge of personal dosimetry data is a powerful tool in allowing us to manage our work practices during pregnancy. I encourage all IRs to use under-lead dosimeters, in addition to over-lead dosimeters for at least some period of time to get personalized information about occupational dose. The dose reports will tell you two things: (1) what your monthly under-lead dose is, and (2) indirectly, how well your lead apron attenuates the radiation in your work environment. This latter piece of information is particularly relevant given the information provided in one of the articles in this journal.[14] A few months of accurate dosimetry data will allow you to decide if you need/want to change your personal shielding system during pregnancy. Another option to learn about personal dosimetry is to wear a dosimeter for a short period of time that provides realtime feedback; this method has been demonstrated to lead to behaviors that reduce occupational dose.[15] The best way to make sure you have access to 2 dosimeters and to the data they provide, as well as to investigate the realtime feedback option, is to work with your medical physicist and/or institutional radiation safety officer on an ongoing basis.

Personal Shielding: the "Lead" Apron

The standard type of shield used to protect the most radiation sensitive organs (lungs, GI tract, bone marrow, and gonads) from occupational radiation exposure during fluoroscopy is the 0.5 mm lead equivalent (Pb eq) thickness apron. Most IRs currently use 2 piece wrap-around style aprons for comfort. These aprons typically have 0.25 mm Pb eq thickness and provide 0.5 mm Pb eq protection in the front where they overlap. Based on published and personally recorded dosimetry data, this standard level of shielding is extremely likely to be sufficient to keep fetal exposure below regulatory limits. However, as mentioned in the introduction, women are likely to prefer to add a higher level of shielding during pregnancy. Women are also likely to be very mindful of the current conversation related to lack of standardization of protection provided by lead aprons materials[14] and want the highest quality product to wear during pregnancy.

Multiple options exist to achieve the goal of increasing abdominal shielding. One option is to wear a 2 piece wrap-around lead apron that is made of 0.5 mm thick Pb eq material. This provides 1 mm Pb eq thickness across the portion of overlap, which should be wider than is typical to accommodate not only the front of the abdomen but also the sides. This might require buying multiple aprons