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## The ALARA (as low as reasonably achievable) concept in pediatric interventional and fluoroscopic imaging: striving to keep radiation doses as low as possible during fluoroscopy of pediatric patients—a white paper executive summary

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ALARA represents a practice mandate adhering to the principle of keeping radiation doses to patients and personnel As Low As Reasonably Achievable. This concept is strongly endorsed by the Society for Pediatric Radiology, particularly in the use of procedures and modalities involving higher radiation doses such as CT and fluoroscopic examinations of pediatric patients. There is no doubt that medical imaging, which has undergone tremendous technological advances in recent decades, is integral to patient care. However, these technological advances generally precede the knowledge of end-users concerning the optimal use and correct operation of the resulting imaging equipment, and such knowledge is essential to minimizing potential risks to the patients.

Current imaging methods must be optimized for radiation dose reduction in pediatric patients who might be as much as ten times more radiosensitive than adults. Unlike straightforward radiographic examinations, radiation dose to the patient during fluoroscopy is dependent on the operator's training, experience with the fluoroscope, and efficiency in completing a diagnostic study. The range of pediatric radiation doses from fluoroscopy is wide because this examination is performed not only by pediatric radiologists but also by general radiologists who occasionally care for children, interventional cardiologists, gastroenterologists, urologists and others. Thus, a venue where multidisciplinary interaction by this variety of operators can occur serves to improve pediatric patient care.

The third ALARA conference organized by the Society for Pediatric Radiology was held in Orlando, Fla., on 11–12 February 2006. It was co-sponsored by the Office of Rare Diseases and the National Cancer Institute of the National Institutes of Health (NCI/NIH). The conference was funded by unrestricted educational grants from three manufacturers of fluoroscopic and interventional equipment (GE, Philips, Siemens) and financial support from the Society for Pediatric Radiology and NCI/NIH. The 22 faculty members consisted of 8 pediatric radiologists, 5 medical physicists, 3 pediatric subspecialists, 3 industry speakers, and 3 radiation epidemiology researchers. A diverse cadre of 74 pediatric radiologists, medical physicists, radiologic technologists, researchers, pediatric subspecialists and vendors met to examine the risk of radiation exposure from fluoroscopic and interventional procedures, identify means by which to reduce ionizing radiation exposure, and explore future technologic modifications that could optimize imaging while further reducing radiation exposures.

### Spectrum of ALARA

As illustrated in Fig. 1, two independent yet interrelated approaches are required to achieve ALARA patient doses. First, the design of the imaging equipment should be optimized to reduce radiation dose rates during fluoroscopy and radiation doses from recorded images during pediatric fluoroscopic examinations. Second, correct operation of the machine by properly trained operators is required to reduce the duration of fluoroscopic radiation. The experienced operator also reduces the number of images recorded during the study to the minimum that properly documents the results of the study and allows for correct diagnosis.

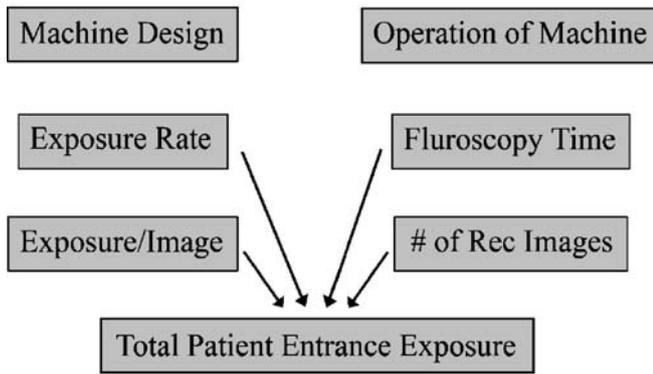
To achieve ALARA, a variety of individuals need to work cooperatively. End-users should be cognizant of the need to speak directly to imaging equipment vendors so as to delineate the needs of their practice. Specifically they need to define the patient population, the imaging studies conducted, and the standards expected in the given

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## MANAGING PATIENT DOSE



**Fig. 1** Managing of patient radiation dose involves both the equipment design, which determines the amount of radiation required per image, and the control of the image device by the operator, who determines the total number of images created during the procedure

practice. This should be initiated in the planning stage of equipment acquisition. Similarly, vendors might need to modify their equipment to meet the needs expressed by the user and must define the “best-fit” model from their product line, which might not be their “top of the line” model.

Proper facility planning creates an environment that allows the selected imaging device to perform at its optimum level of design. During installation, a medical physicist, the clinical users, and the vendor should work together to modify the Standard Anatomical Programming features of the imaging device that are probably optimized for adults. These features, which control the acquisition parameters of the machine and subsequent image processing of the acquired images, are modified to address the unique needs of pediatric imaging. To achieve this, the clinical users and medical physicist must clearly communicate clinical needs and pediatric imaging challenges to the vendor’s representatives. The vendor’s representatives, typically senior application specialists and senior design engineers, must communicate to the customer the operational design capabilities of the machine that can be harnessed to meet clinical objectives. When modified anatomical programming features are identified and configured on the unit, functional testing of the imaging device prior to first clinical use by the customer confirms the desired operation of the imaging device. These steps are necessary to establish ALARA exposure rates during fluoroscopy and ALARA exposure per recorded image during the examination.

Other individuals are involved in ensuring the proper operation of the imaging equipment (right side of Fig. 1). First, the validity of a clinical study involving ionizing radiation should be evaluated. Will the results of the study realistically answer the original clinical question? Should an alternative imaging modality without ionizing radiation

be substituted? Answering the clinical question with a study without ionizing radiation is the most effective ALARA step of all!

The operator of the fluoroscope must have appropriate training and experience to ensure that fluoroscopy time and the number of recorded images are minimized. Ideally, the operator should receive extensive imaging and radiation protection training during his or her residency or fellowship. If not, the operator must receive this training and demonstrate competency prior to performing fluoroscopy. After that first step, there must be complete operational training (“buttonology”) on each control feature on the unit so that the operator will be credentialed to operate it. As ionizing radiation is a known carcinogen, such credentialing might be equated to that required for prescribing and administering chemotherapy.

After the initial commissioning of an imaging device, periodic testing, at least annually, must be performed by a qualified medical physicist to ensure continued proper performance of the imaging device. Annual results should be compared to original baseline performance data collected from the machine. Representative clinical patient skin doses and effective doses of standard examinations should be calculated periodically. These data are invaluable in estimating patient risks from examinations and comparing these risks to risk data collected and maintained by the National Institutes of Health.

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### ALARA intra-networking

Interaction of members involved with the Society for Pediatric Radiology strengthened their resolve to further improve fluoroscopic and interventional pediatric imaging beyond its current practice while simultaneously decreasing patient exposure to ionizing radiation. We can expect that this focus will evolve into dissemination of the information shared at this conference to the entire Society as well as to other practices where pediatric imaging is not the primary focus.

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### ALARA networking

The ALARA 2006 Conference provided a venue for networking among individuals from multiple pediatric subspecialties in addition to pediatric radiology—pediatric interventional cardiology, gastroenterology and urology—as well as vendors and NCI/NIH. By interacting in a neutral, highly energized environment, participants were able to represent multispecialty needs, explain vantage points, and begin to understand one another’s concerns and needs. Through this interaction, ideas were interchanged, and future collaborations for refinements in clinical pediatric imaging as well as research initiatives in dose control were initiated.

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**Recommendations**

1. Form a task force through the Society for Pediatric Radiology to serve as liaison between the clinical arena and imaging industry. Encourage clinical users to communicate their needs with one another, with the imaging physics community, and with representatives of the imaging companies to develop imaging equipment better suited to ALARA pediatric imaging.
2. Develop guidelines for credentialing of operators of fluoroscopic equipment and those who work in such an environment (e.g., physicians, technologists, nurses).