SAFE PRACTICE 34: PEDIATRIC IMAGING

The Objective

Ensure that an appropriate radiation dose is delivered to pediatric patients during computed tomography (CT) studies.

The Problem

The frequency of pediatric CT has rapidly increased. In March 2009, the National Council on Radiation Protection and Measurements (NCRP) reported that there is a 6-fold increase in the amount of medical radiation exposure to the U.S. population since the early 1980s. This medical radiation now accounts for 48 percent of the total radiation exposure and 25 percent of the total yearly exposure; and 50 percent of the exposure from medical imaging is from CT. [NCRP, N.D.] There are more than 60 million CT scans performed annually in the United States; 11 percent (7 million) of those are on children. [Brody, 2007] The use of CT in the past 10 years has increased nearly 700 percent. [NCI, 2008] Furthermore, growth in the use of CT scans on children is estimated to be 10 percent per year. [Frush, 2004a] The amount of ionizing radiation generated to patients imaged by CT depends on protocols and equipment settings used for individual examinations. Current settings often default to adult parameters. A change in CT exam parameters for children could reduce the dose delivered to them from 5 percent to 90 percent, while retaining diagnostic accuracy. [Brody, 2007] Several consensus statements suggest that the low-level radiation used in diagnostic imaging may pose a risk, albeit small, of causing cancer. [Brody, 2007] The severity of adverse events that can be sustained by patients exposed to ionizing radiation is greater for children than it is for adults. Children are particularly susceptible (2-5x) to the harmful effects of ionizing radiation for three reasons: 1) growing tissues and organs are more sensitive to radiation effects; 2) children have a longer lifetime during which radiation-related cancers may manifest; and 3) children receive a higher dose than necessary when adult CT settings are used. [Brody, 2007] The dose from each CT scan is cumulative over a lifetime; multiple scans may result in greater lifetime risk of fatal cancer for an individual. Children may receive a higher dose than necessary when adult CT settings are used for children. [Brody, 2007; NCI, 2008] The radiation from a single abdominal CT can be 100 to 250 times that of a plain chest radiograph (average effective estimated dose for abdomen CT is 5 mSv). [Brody, 2007] The effective dose from a single pediatric CT scan may range from 5 mSv to 60 mSv. [NCI, 2008]. The natural background radiation effective dose is approximately 3 mSv/year. Furthermore, the evidence suggests that there is a lack of provider awareness about dose exposure and associated risks, [Frush, 2004a] with 75 percent of physicians surveyed underestimating the equivalent number of chest radiographs for a CT examination. [Lee, 2004; Frush, 2008; Huda, 2009; Linet, 2009]

The preventability of adverse events to children is directly related to the technique and procedural protocols used during the generation of the CT image. CT is a valuable diagnostic tool that may be the only study that can provide specific answers to a patient’s medical problem. CT studies should only be used when it is the best study for the clinical situation, as determined by the referring physician and radiologist. [Brody, 2007] Application of the concept of ALARA (as low
as reasonably achievable) can reduce radiation exposure. [ALARA, 2002] Dose-reduction techniques, such as automated exposure controls, have been shown to reduce radiation dose by 20 percent to 40 percent. [Frush, 2004b] A wide range of techniques with variable radiation exposure can be used in CT scans to produce very similar image quality. [Karmazyn, 2009] Recent survey data indicate that CT settings (tube current–mA–and peak kilovoltage–kVp) used by pediatric radiologists are significantly lower than was indicated by data obtained in 2001, implying that guidelines and education have had a substantial impact. [Arch, 2008] Without appropriate guidelines, errors in CT scanning in children (including unnecessary radiation exposure) can be frequent. [Frush, 2002b; Goske, 2008]

There are no additional costs incurred to implement practices of “child-sizing” a pediatric CT scan (using a lower kVp and mA): The cost of the exam is the same. Child-size CT protocols can be easily implemented at little to no additional cost by radiologists, technologists, and medical physicists through routine maintenance of equipment. In addition, with adherence to the principle of avoiding unnecessary CT exams, decreased utilization would positively affect rising healthcare costs. [Cohen, 2009]

**Safe Practice Statement**

When CT imaging studies are undertaken on children, “child-size” techniques should be used to reduce unnecessary exposure to ionizing radiation.

**Additional Specifications**

Organizations should establish a systematic approach to regularly updating protocols for computed tomography (CT) imaging of children.

Four simple steps should be undertaken by imaging team members to improve patient care in the everyday practice of radiology: [Goske, 2008]

- **Scan only when necessary.** This provides an opportunity to discuss the benefits of the CT exam as well as the potential risks with the child’s pediatrician or other healthcare provider, who has unique medical knowledge critical to the care of the patient. Commit to making a change in daily practice by working as a team with technologists, medical physicists, referring doctors, and parents to decrease the radiation dose.

- **Reduce or “child-size” the amount of radiation used.** This can be accomplished by contacting a medical physicist to determine the baseline radiation dose for an adult for CT equipment and comparing that dose with the maximum recommended by the American College of Radiology’s (ACR’s) CT Accreditation Program. If the doses are higher than those suggested, reduce the technique for adult patients. Use evidence-based protocols for children. Refer to the Image Gently™ website (www.imagegently.org), and view the protocols provided for children. [Strauss, 2009] These protocols are independent of equipment manufacturer, age of machine, or number of detectors. Although an institution or site may wish to lower scan technique even more, these protocols provide a starting point for making this important change. Work with radiologic technologists to implement the protocols. These professionals control the critical “last step” before a scan is obtained. [Singh, 2009]

- **Scan only the indicated area required to obtain the necessary information.** Protocols in children should be individualized. Be involved with patients. Ask the questions
required to ensure that the scan is “child-sized.” Decisions about shielding those radiosensitive areas (such as reproductive organs) outside of the scan range or those within the scan field (in-plane shielding) should be based on discussion with a qualified physicist and should incorporate local and national standards of practice.

- Scan once; single-phase scans are usually adequate in children. Pre- and postcontrast and delayed CT scans rarely add additional information in children, yet can double or triple the radiation dose to the child. Consider removing multiphase protocols from routine practice.

Applicable Clinical Care Settings

This practice is applicable to Centers for Medicare & Medicaid Services care settings, to include ambulatory, ambulatory surgical center, emergency room, inpatient service/hospital, and outpatient hospital.

Example Implementation Approaches

- Considerable work has been published in the literature on protocols to reduce the dose to children undergoing CT examinations. Many of these protocols are scanner specific and are not transferable to other CT units. The Image Gently™ website provides a simple, step-by-step procedure to assist imaging facilities and providers in either developing CT protocols for children or verifying that their current protocols are appropriate.

- An interpreting radiologist, in consultation with a medical physicist, must evaluate any changes to a practice’s techniques that reduce radiation dose so that the adequate diagnostic information is available. [Cohen, 2009] The radiologist should verify that CT technical factors do not deliver estimated radiation doses larger than those recommended by the American College of Radiologist’s (ACR’s) CT Accreditation Program. No universal CT technique can be used with all vendors CT equipment for the adult patient. Differences in CT scanner design make it impossible to estimate patient radiation dose based on technique factors alone. Thus, a qualified medical physicist (i.e., one who is board certified in diagnostic radiological physics) should measure the radiation output from CT scanners in order to estimate the dose and help establish appropriate techniques. Any qualified medical physicist who has assisted facilities in obtaining ACR accreditation of their CT scanners should be familiar with this test protocol.

- The supervising radiologist should work with CT technologists to familiarize them with techniques used for both adults and children.

Strategies of Progressive Organizations

- National public and private quality and research organizations are encouraging all stakeholders to recognize that pediatric CT dose-reduction strategies should be considered, efforts should work towards optimal utilization, and existing devices not specifically designed with children in mind should meet pediatric-specific safety considerations. Radiology professional associations are advocating that the CT dose-reduction strategies embodied in this practice be considered as a template for performance improvement programs for both adult and pediatric radiology. [Denham, 2005; Kuettner, 2009]
Opportunities for Patient and Family Involvement

- Consider including families of patients with children who have received a pediatric imaging event to serve on appropriate patient safety or performance improvement committees.
- Educate family members about pediatric imaging risks and benefits. [Bulas, 2009]
- Empower family members to request the results of imaging studies within an appropriate time frame.

Outcome, Process, Structure, and Patient-Centered Measures

These performance measures are suggested for consideration to support internal healthcare organization quality improvement efforts and may not necessarily address all external reporting needs.

- **Outcome Measures:** The carcinogenic effects of ionizing radiation manifest many years after exposure; however, outcome measures might include increased rates of cancer and other radiation-related conditions in children who frequently undergo imaging evaluation (e.g., children with cystic fibrosis, oncology, central nervous system abnormalities such as shunt malfunction, primary or acquired immune disorders). Ample sources indicate the potential risk of carcinogenesis and low-level (such as CT) radiation, including the BEIR VII report and the UNSCEAR report. [Linet, 2009] Through available healthcare practice assessment organizations (e.g., Arlington Medical Resources), the number of pediatric CT scans performed annually can be tracked to assess for change in practice patterns. [UNSCEAR, 2000]

- **Process Measures:** Compliance with use of child-sized CT protocols and frequency of updates might be used as process measures. This can be assessed through a CT accreditation process and periodic surveys of CT practices.

- **Structure Measures:** The existence of formal structures ensures that pediatric CT protocols are updated on a regular basis as evidenced by documentation. The ACR has an established program for CT accreditation, and the Image Gently Campaign website can be used for documentation through data gathering, such as annual surveys for adherence to pediatric CT protocols and data tracking of the campaign website “hits” when updates in CT protocols are made available.

- **Patient-Centered Measures:** Patient families might be polled about their comfort related to the efforts a healthcare organization takes to ensure that the CT scanning process is as safe for their children as possible. Moreover, as progress is made in proposals for tracking CT, or any radiation dose in patients, [Birnbaum, 2008] this type of record may promote informed discussions with families and may facilitate such surveys.

Settings of Care Considerations

- **Rural Healthcare Settings:** This practice applies in rural settings.

- **Children’s Healthcare Settings:** This practice applies to children’s healthcare settings.

- **Specialty Healthcare Settings:** Specialty healthcare settings are expected to implement this safe practice.
New Horizons and Areas for Research

New horizons include cooperative efforts in technology assessment and development directed at dose reduction and the preservation of image quality, including automatic exposure control, and newer investigations such as iterative reconstruction, improving image quality for a given dose (under development), and making improvements in current technology, consisting of improved estimates for pediatric CT dose (CTDI) and dose displays. [Strauss, 2009] This is also ongoing and requires efforts through the scientific community, manufacturers, and regulatory agencies. In addition, simulation CT is a potentially powerful new tool for assessing radiation dose reduction and image quality without unethical investigational exposure of children to additional radiation. [Frush, 2002b; Frush, 2002a; Li, 2008] Results for this research have direct clinical applications. [Paulson, 2008] Evidence-based pediatric CT should be cultivated, and periodic surveys of utilization and techniques will be helpful in assessing the impact of safe practices. [Broder, 2007; Arch, 2008] Tracking CT dose of the cumulative imaging radiation exposure as part of the evolving electronic healthcare record should also be pursued.

Other Relevant Safe Practices

Refer to Safe Practice 4: Identification and Mitigation of Risks and Hazards and Safe Practice 30: Contrast Media-Induced Renal Failure Prevention.

Notes


Feb. 16, 2011

Dear Healthcare Leader:

We are delighted to announce that the National Quality Forum has graciously given us permission to distribute copies of the NQF Safe Practices for Better Healthcare – 2010 Update. This copy has been provided to you in the interest of helping you implement, and/or educate others to adopt the suggestions and implementation examples into your safe practices.

The National Quality Forum is dedicated to providing evidence-based practices as ready-to-use tools to improve safety. The practices in the NQF Safe Practices for Better Healthcare – 2010 Update have been evaluated, assessed and endorsed to guide large and small healthcare systems in providing the safest care in every area of patient safety. We give our highest recommendation for them as a valuable resource toward patient safety from hospital bedside to boardroom. It is in the fulfillment of this mission that NQF makes the gift of this to you in your pursuit of your quality journey.

We hope that you will recommend that others purchase the report from NQF. The homepage of the National Quality Forum can be accessed at the following link: http://www.qualityforum.org/ and an abridged report of the NQF Safe Practices for Better Healthcare—2010 Update can be downloaded free online at: http://www.qualityforum.org/Publications/2010/04/Safe_Practices_for_Better_Healthcare___2010_Update.aspx. To obtain the full report for a cost of $29.99, please contact NQF by phone during business hours at 202-783-1300 or via e-mail at info@qualityforum.org and their staff will contact you for payment details.

If you want to have a free copy of the entire set of practices, you may receive one if you fill out a web-based survey that may be filled out at http://www.safetyleaders.org/2010nqfResearchStudy/index.jsp.

We want to acknowledge you and your institution for your current efforts in patient safety. We hope you enjoy this important information and find it useful in your future work.

Sincerely,

Charles R. Denham, M.D.
Chairman