The Alliance for Radiation Safety in Pediatric Imaging

Implementation Manual
Image Gently® Digital Radiography
Safety Checklist

Safety Steps to Do and Verify for Your Pediatric Patient

www.imagegently.org
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Introduction

The Image Gently campaign was launched in 2008 to promote radiation protection for children who undergo medical imaging examinations. The campaign was created by the Alliance for Radiation Safety in Pediatric Imaging, a group made up of more than 60 medical professional organizations. The mission of the Alliance is to create awareness, provide education and advocate for improved safety for the unique needs of children when undergoing necessary medical imaging.

Digital Radiography (DR) is a powerful diagnostic imaging technology that includes computed radiography and direct radiography. DR enables radiologists to diagnose medical conditions such as pneumonia, fractures or bowel obstruction. It has major advantages over film-screen techniques, such as image acquisition process, image distribution throughout the hospital and to remote geographic locations nearly instantly, and quick access to the patient’s medical information. The biggest advantage of the DR technology is perhaps image manipulation, allowing the viewer to adjust the image according to the anatomical structure of interest. There is a potential, however, to use more radiation than necessary when Digital Radiography is employed, a situation referred to as "dose creep".

In the past, when a film was overexposed, the diagnostic information was lost because the image was too dark. The radiologic technologist (RT) analyzing the film could immediately conclude that the patient was overexposed. With DR, the instant feedback on high doses can be lost, as the computer automatically adjusts the image to make it of diagnostic quality, even though the patient may have received more radiation than needed. Until recently, it has been difficult for DR users to have an indication of the radiation exposure to children due to lack of a standard exposure index across vendors.

In 2009, the American Association of Physicists in Medicine and the International Electrotechnical Commission agreed on a single standard set of values for the exposure index to characterize the radiation exposure to the image receptor.

The Image Gently campaign has partnered with the United States Food and Drug Administration (FDA) to create a safety checklist for the use of DR in children. The Image Gently Digital Radiography Safety Checklist was created to describe those critical steps of DR on children that, if omitted, could potentially result in harm to the patient. The checklist does not include all the steps necessary to image a child. It is hoped that this safety checklist, when used in conjunction with the quality improvement program included in these materials, will help reduce unnecessary radiation exposure when imaging children. The checklist was modeled after the airline industry’s safety practice of using checklists for every commercial airline flight, which has been demonstrated to decrease errors.

Why target DR for a safety checklist? The reason is simple. Radiography is the most common exam performed in the United States, representing 74% of all radiologic exams including both adults and children. According to the National Council on Radiation Protection and Measurements Report 160, there were an estimated 324 million general radiographic exams performed in the US in 2006, including 129 million chest radiographs and 56 million extremity films. Although DR is one of the lowest dose imaging tests, unnecessary radiation exposure is of particular concern for children because: 1) younger patients are more radiosensitive than adults (i.e. the cancer risk per unit dose of ionizing radiation is higher) and 2) use of protocols designed for an adult can result in excessive radiation exposure for a smaller patient. The second point is of concern because many pediatric imaging exams are performed in facilities lacking specialized expertise in pediatric imaging.

This safety checklist is intended to assist medical professionals performing DR in children and reinforce the safety practices already in use. This document is not meant as regulation or policy, but simply as an educational tool to improve radiation safety for children. At the end of the manual, medical facility
administrators are given suggestions on how to use the Image Gently Digital Radiography Checklist in their department as a quality improvement tool.
The Digital Radiography Safety Checklist

Safety Steps to Do and Verify for your pediatric patient

<table>
<thead>
<tr>
<th>Prior to Starting the Exam</th>
<th>Image Capture During the Exam</th>
<th>Image Critique</th>
<th>Following Completion of the Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ 1. Patient name selected from the worklist</td>
<td>□ 1. Beam body part image receptor aligned, SID checked, use of grid determined</td>
<td>□ 1. Cassette transported to and processed in reader, if applicable*</td>
<td>□ 1. Post-processing performed only if necessary</td>
</tr>
<tr>
<td>□ 2. Patient properly identified</td>
<td>□ 2. Patient positioned and body part measured, cassette positioned if applicable*</td>
<td>□ 2. Images displayed and reviewed, identification confirmed</td>
<td>□ 2. Exam verified and images archived to PACS for reporting</td>
</tr>
<tr>
<td>□ 4. Explained the exam to patient/parent</td>
<td>□ 4. Technical factors selected</td>
<td>□ 4. Exposure indicator/index checked, deviation index compared to target exposure index</td>
<td></td>
</tr>
<tr>
<td>□ 5. Verified LMP/pregnancy if appropriate</td>
<td>□ 5. Shielding and markers placed</td>
<td>□ 5. Image reprocessed or repeated as necessary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ 6. Final adjustment of tube and settings made</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ 7. Breathing instructions given</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ 8. Exposure taken</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*For Computed Radiography only*
Steps for Implementation and Assessment

This section of the manual outlines a strategy for implementing the Image Gently™ Digital Radiography Safety Checklist.

**PHASE ONE: INTRODUCE DIGITAL RADIOGRAPHY SAFETY CHECKLIST TO STAFF TECHNOLOGISTS.**
Communicate to staff the basic principles that lead to the development of the Digital Radiography Safety Checklist initiative. Introduce the Safety Checklist form for digital radiographic equipment. Review descriptions of each step on the checklist from the “How to run the checklist” section of this manual, pp. 5-10. Outline the steps for implementing the safety checklist and establish a date for data review and feedback to staff.

**PHASE TWO: PROCEDURE PREPARATION.**
This phase is designed to familiarize technologists with the items making up the Safety Checklist.

Post the Safety Checklist in a clearly visible location in the control booth area of diagnostic rooms and near the cassette reader, as applicable.

Identify a period of time in which technologists will consult/review the Safety Checklist prior to, during and following the completion of a diagnostic exam performed on pediatric patients.

**PHASE THREE: GOAL SETTING AND IMPLEMENTATION.**
Identify a period of time (example: 1 week) for technologists to fill out Safety Checklist forms for a minimum number (example: 10 exams) of pediatric examinations performed using digital equipment.

Strategies for filling out Safety Checklist may include:
- Self Assessment: Individual technologists use the Safety Checklist as they perform pediatric exams, checking off items to acknowledge actions taken/ tasks completed.
- Peer Assessment: Here a fellow technologist observes another performing a pediatric exam and checks off Safety Checklist items as they observe these action/tasks being completed. The observer would then review the Safety Checklist items with the technologist who performed the exam, focusing on steps that were not adequately completed.

**PHASE FOUR: DATA ASSESSMENT.**
Collect all Safety Checklists filled out during the trial implementation period. Transfer Safety Checklist data to the Digital Radiography Safety Checklist Datasheet and compare actual Checklist data to baseline forecasts, looking for individual and group items that either exceed or fall below expectation. Share this summary data with technologists with the goal of reaching consensus on strategies to improve performance on items that fell below expectation, celebrate items that exceeded expectation, and establish an approach for integrating Safety Checklists into daily practice. Establish a strategy for performing periodic Safety Checklist data collection (example: 1 week each quarter) as a commitment to maintain a focus on limiting/reducing radiation exposure to pediatric patients when using digital imaging equipment.
How to Run the Checklist: Prior to Starting the Exam

In a do-and-verify checklist, the radiographer carries out the normal workflow and then at a designated “pause point” reads a short list of critical actions and confirms they were all completed. If an action is missed, it can be completed at this time with no harm to the patient. The do-and-verify checklist is best suited for processes that are performed daily and are well practiced. For this checklist, the “pause points” are at logical points in the DR process for the patient: before and during the exam, image critique after the image has been taken, and finally, after the exam.

Prior to starting the radiographic exam there are several critical steps necessary to assure that the correct patient receives the correct exam. This section is necessary to prevent excess radiation exposure due to the performance of inappropriate procedures. The details for each step of the “Prior to Starting the Exam” section of the Digital Radiography Safety Checklist are below.

1. PATIENT NAME SELECTED FROM THE WORKLIST
   The radiographer accesses information regarding the patient and the procedure to be performed from the electronic work list. It is critical that accurate information be obtained so that the appropriate procedure is performed on the correct patient.

2. PATIENT PROPERLY IDENTIFIED
   The radiographer identifies the patient following HIPAA guidelines and appropriate protocol for their institution. This typically involves confirming at least two patient identifiers (name, date of birth, etc.) in a private manner. Accurate identification assures that a patient has not responded to an incorrect name when called for a procedure in the waiting room. This often happens when a patient is anxious regarding their procedure.

3. APPROPRIATENESS OF REQUEST CHECKED
   The radiographer verifies the patient’s history as appropriate to the requested radiographic procedure. The radiographer asks the parent and/or patient questions related to the patient’s history to assure that the appropriate procedure and side of the patient’s body i.e. right versus left, where appropriate, have been ordered prior to starting the exam.

4. EXPLAINED THE EXAM TO PATIENT/PARENT
   The radiographer explains the type of procedure and the positioning that will be required. In addition, the radiographer explains how the parent or patient will be protected from radiation during the procedure (i.e. use of lead apron, shielding, etc.) The parent is given instructions for immobilization of the patient as needed. This communication helps to assure cooperation of the parent and the patient to decrease the probability of a repeat exposure due to motion.

5. VERIFIED LMP/PREGNANCY IF APPROPRIATE
   The radiographer checks the patient’s history for potential pregnancy. The radiographer asks patients of childbearing age (typically considered 12-55 years) if there is a possibility of pregnancy. If the patient waives, the radiographer asks the patient additional questions to clarify the potential for pregnancy. If the patient responds that they may be pregnant, the radiographer consults with the patient’s physician and/or the radiologist to determine if a pregnancy test or an alternative procedure is appropriate. The exact protocol for screening patients may be institution-specific. Many institutions require written documentation to verify patient pregnancy screening.
How to Run the Checklist: Image Capture During the Exam

During the image capture portion of the exam it is critical that the alignment of the equipment, alignment of the patient, selection of grid and technique factors, and use of safety equipment be as accurate as possible. This is necessary to reduce the potential for a repeat exposure and to assure the images are of the quality necessary for diagnosis. The details for each step of the “Image Capture During the Exam” section of the Digital Radiography Safety Checklist are below.

1. BEAM ➔ BODY PART ➔ IMAGE RECEPTOR ALIGNED, SID CHECKED, USE OF GRID DETERMINED
The radiographer selects the appropriate image receptor. The radiographer utilizes a grid when the part is thicker than 10 cm. The use of a grid is necessary for thicker parts to decrease the amount of scatter radiation reaching the image receptor to assure adequate image quality for diagnosis. Use of a grid for patient’s less than 10 cm thick will increase radiation dose unnecessarily. For procedures where the bucky tray is utilized in the table, the radiographer typically sets the appropriate tube angle (if applicable) and SID and then centers the beam to the image receptor. The movement of the table is then used to align the collimator light to the appropriate anatomical central ray location. For procedures performed table top, the body part is typically aligned to the image receptor and then the central ray is placed at the appropriate tube angle (if applicable) and SID. The tube is then positioned at the appropriate anatomical central ray location. For procedures done at the upright bucky a combination of these steps is utilized. Proper alignment is critical to assure that all essential anatomy is visible in the image, thus preventing a repeat exposure.

2. PATIENT POSITIONED AND PART MEASURED, CASSETTE POSITIONED, IF APPLICABLE
The radiographer accurately instructs and carefully and safely assists the patient into the appropriate position for the procedure. It is critical that the appropriate body position, alignment of the part and degree of obliquity (as applicable) are utilized to assure that a repeat will not be necessary. Immobilization of the patient may be used to prevent motion. The tube, body part, and image receptor are re-aligned. The body part is then measured with calipers to assure that an accurate technique is selected in conjunction with the use of a technique chart, if applicable. Use of calipers is the most accurate method for determining the correct technique based on size of the body part examined and ensuring the appropriate radiation dose to the patient.

3. BEAM COLLIMATED
The radiographer adjusts the area of the x-ray field to the smallest size that includes the essential anatomy. When using a cassette-based image receptor system, at least 1/3 of the image receptor should be covered by the x-ray field or an error may occur in image processing. Therefore selection of the appropriate image receptor size is important. This step is critical to reduce the amount of tissue irradiated and to improve image quality by decreasing the amount of scatter radiation reaching the image receptor. Beam collimation is one of the most important steps to decrease radiation dose to the child.

4. TECHNICAL FACTORS SELECTED
The radiographer utilizes automatic exposure control (AEC), anatomically programmed radiography (APR), and/or a technique chart to select appropriate exposure factors relative to the patient’s size and condition. The radiographer selects the optimal kVp to provide adequate penetration of the part. The lowest mAs that will provide adequate exposure to the image is then chosen. Higher kVp techniques with a corresponding reduction in mAs are utilized in digital imaging to reduce patient dose. The technique is compensated/increased to coincide with the use of a grid, as applicable. When AEC is used, the radiographer assures that the appropriate kVp, backup time, image receptor and detector(s) are selected. Accuracy of techniques selected through APR and the technique chart should be monitored.
for refinement of the technique system. The selection of technique factors directly controls the amount of dose received by the patient and therefore is an extremely critical step in radiation safety.

5. SHIELDING AND MARKERS PLACED
The radiographer places shielding so that it will protect the anatomical area and/or gonads near the exposure field but will not interfere with the diagnostic information required. Department protocols may be established to allow for the use of gonadal shielding on some projections when the anatomy around the gonads is equally well-demonstrated on another projection taken without the gonad shield. One example is the AP Pelvis taken with the bilateral frogleg lateral hip. Parents or caregivers assisting with the patient are provided with lead shielding and are properly instructed regarding radiation safety and immobilization. The lead marker is placed on the image receptor to coincide with the appropriate side of the patient where it will not interfere with the demonstration of the essential anatomy. The proper placement of the lead marker is critical to assure that the patient receives the appropriate diagnosis and treatment to the correct body part. It is especially critical in cases involving potential legal action such as child abuse.

6. FINAL ADJUSTMENT OF TUBE AND SETTINGS MADE
The radiographer checks the alignment of the tube and patient to assure that all equipment and the patient are properly placed. The technique settings are rechecked to assure proper exposure.

7. BREATHING INSTRUCTIONS GIVEN
The radiographer provides appropriate breathing instructions and then watches the patient to assure there is no motion. Prevention of motion is important to reduce blurring and the need for a repeat exposure.

8. EXPOSURE TAKEN
The exposure is taken when the radiographer is certain that the patient is still and the breathing instructions have been followed. The radiographer monitors the length of the exposure for appropriateness and makes note of the mAs readout if AEC is utilized. This is critical in the event that a repeat exposure is required due to the amount of exposure to the image receptor.
How to Run the Checklist: Image Critique

When critiquing the image all elements of image quality and indicators of exposure are taken into account. This requires the assessment of both the appearance of the image with regard to positioning, exposure, and legal requirements as well as the analysis of the exposure indicator. The need for a repeat is then determined as well as the corrective actions required. The details for each step of the “Image Critique” section of the Computed Radiography Safety Checklist are below.

1. CASSETTE TRANSPORTED TO AND PROCESSED IN READER, IF APPLICABLE
   The radiographer identifies the cassette to assure that the patient data, procedure, position, and orientation match that of the image receptor. The radiographer then places the cassette in the reader in the proper orientation to prevent jamming of the cassette. This step is critical to assure that the image is saved electronically in the record for the appropriate patient.

2. IMAGES DISPLAYED AND REVIEWED, IDENTIFICATION CONFIRMED
   The radiographer assures that the image is properly oriented. Electronic collimation should match collimation obtained during the exam. The radiologist is legally responsible for the medical information on the original image. While electronic collimation after the image has been obtained “cleans up” the image, the parts of the patient obscured by the electronic collimation have been radiated needlessly. The radiographer confirms that all necessary images have been acquired and that these images are correctly processed under the appropriate algorithm. In addition, the identification of the patient is confirmed. This step assures that the images will be archived in the information system with the appropriate connection to the patient’s information.

3. IMAGE QUALITY REVIEWED
   The radiographer conducts an initial review to assure that all essential anatomy has been included on the image and that collimation is appropriate. The image is also reviewed to identify motion, the presence or absence of adequate legal documentation (lead markers), and artifacts. The radiographer then critiques the image for appropriate positioning in relation to the national standard and the patient’s condition. The radiographer accurately determines where specific positioning errors have occurred, noting the alignment of anatomical structures. The radiographer also reviews the appearance of the image to identify under or overexposure. Underexposure appears as noise. Significant overexposure appears as a graying of the image and extreme overexposure appears as saturation of the anatomical structures. The radiographer determines if the image is of adequate diagnostic quality and consults with the radiologist if necessary.

4. EXPOSURE INDICATOR/INDEX CHECKED, DEVIATION INDEX COMPARED TO TARGET EXPOSURE INDEX
   The image is reviewed to determine if any factors affected the accuracy of the exposure indicator and the subsequent image processing. These factors may include excess or inadequate field size, inclusion of unnecessary anatomy due to improper centering, pathology, and medical implants or devices. The radiographer checks the exposure indicator in relation to the acceptable range. The radiographer determines if the exposure is adequate. If outside the acceptable range, the radiographer determines the magnitude of underexposure or overexposure represented by the numerical value.

5. IMAGE REPROCESSED OR REPEATED AS NECESSARY
   When the image is not of diagnostic quality due to image processing errors, the radiographer reprocesses the image utilizing settings for an alternative procedure in an attempt to avoid additional exposure to the patient. Repeating the image should be performed only as a last resort. If the image is
inadequate due to positioning or exposure, the radiographer repeats the image using corrective actions determined during the review of image quality and the exposure indicator value.
How to Run the Checklist: Following Completion of the Exam

Following completion of the exam it is critical that the image be appropriately directed to the image archive system. The details for each step of the “Following Completion of the Exam” section of the Digital Radiography Safety Checklist are below.

1. POST-PROCESSING PERFORMED IF NECESSARY
The radiographer adjusts the window level and width only if necessary to present the image as diagnostic quality. Excess post-processing may not allow the image to be fully manipulated by the radiologist. Also, excess post-processing may cause loss in certain information, e.g., noise reduction filter may blur out small low contrast objects.

2. EXAM VERIFIED AND IMAGES ARCHIVED TO PACS FOR REPORTING
The radiographer assures the image is complete and sends the image to PACS for archiving. This assures appropriate access to the image and the long term retention of the image.
MODIFYING THE CHECKLIST
The safety checklist was designed to include the primary factors that may significantly affect the radiation dose received by a patient during a radiographic procedure. It focuses on points in the imaging process where potential errors can cause an increase in a patient’s dose. While the safety checklist may be modified to adapt to a specific institution, it is recommended that safety steps not be removed simply because they are inconvenient. Facilities and individual radiographers should aspire to implement all the safety steps as part of their quality improvement program.

INTRODUCING THE CHECKLIST
The safety checklist is appropriate for posting in critical areas where patient care is affected. These critical areas include the CR workstation, x-ray control panel, and additional areas where patient information is accessed or imaging steps occur. The checklist is designed to include information to serve as reminders of best practices for radiation protection and patient care. The information included should be reviewed and discussed for appropriate usage prior to posting. With proper attention and planning, the safety checklist can be easily utilized and can make a significant improvement in the practice of radiographers with regard to radiation safety.

USING THE CHECKLIST AS A QUALITY ASSURANCE TOOL
The safety checklist can be used as a tool to monitor radiation safety practices. In a total quality management system, goals for safe practice can be set and reviewed to identify areas of weakness. The identification of problem areas can then provide the basis for improvement planning. The institution can set a benchmark percentage or number of safety steps followed per procedure during a specific monitoring timeframe. The data can be collected by an objective informed observer for the best accuracy or can be self-reported by the radiographer. A system such as this is best implemented where there is a consistent and uniform understanding of the safety checklist. Spreadsheet and report templates are provided in Appendix A. These forms allow for compilation of data for the purpose of quality assurance monitoring. See the Steps for Implementation and Assessment section of the manual for details.
Appendix A

We have provided a downloadable Excel spreadsheet (www.imagegently.org under radiologic technologists section) that can be used at your institution for a practice quality improvement project (see attached Excel file). Below is an example Digital Radiography Safety Checklist Data Report that is populated from the Excel spreadsheet.

Digital Radiography Safety Checklist Data Report

The following data represents a summary of Digital Radiography Safety Checklists completed for the period of (insert start date) through (insert end date).

Total number of records for the reporting period: (insert number)

Number of technologists involved in the study: (insert number)

The following chart is a comparison of benchmark targets to the average of recorded values.

<table>
<thead>
<tr>
<th>Category</th>
<th>Benchmark Targets</th>
<th>Average Score</th>
<th>Possible Checkmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to Exam</td>
<td>4.5</td>
<td>4.0</td>
<td>5</td>
</tr>
<tr>
<td>During Exam</td>
<td>7.0</td>
<td>7.0</td>
<td>8</td>
</tr>
<tr>
<td>Image Critique</td>
<td>4.5</td>
<td>4.5</td>
<td>5</td>
</tr>
<tr>
<td>Following Exam</td>
<td>2.0</td>
<td>1.5</td>
<td>2</td>
</tr>
</tbody>
</table>

Overall Average: 18

Average Score: 17.0

Possible Checkmarks: 20
The following is a summary of the average values recorded for each Safety Checklist item and average for each of the four checklist categories.

<table>
<thead>
<tr>
<th>Prior to Exam (5)</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient name selected from the worklist.</td>
<td>0.50</td>
</tr>
<tr>
<td>Patient properly identified.</td>
<td>1.00</td>
</tr>
<tr>
<td>Appropriateness of request checked.</td>
<td>1.00</td>
</tr>
<tr>
<td>Explanation of the exam to patient/parents.</td>
<td>1.00</td>
</tr>
<tr>
<td>Verify LMP/pregnancy if appropriate.</td>
<td>0.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Image Capture During the Exam (8)</th>
<th>7.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam to part to image receptor aligned, SID checked.</td>
<td>1.00</td>
</tr>
<tr>
<td>Use of grid determined.</td>
<td></td>
</tr>
<tr>
<td>Beam collimated.</td>
<td>1.00</td>
</tr>
<tr>
<td>Patient positioned, part measured, and cassette positioning if applicable.</td>
<td>1.00</td>
</tr>
<tr>
<td>Technical factors selected.</td>
<td>1.00</td>
</tr>
<tr>
<td>Shielding and markers placed.</td>
<td>1.00</td>
</tr>
<tr>
<td>Final adjustment of tube and settings made.</td>
<td>0.50</td>
</tr>
<tr>
<td>Breathing instructions given.</td>
<td>0.50</td>
</tr>
<tr>
<td>Exposure taken.</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Image Critique (5)</th>
<th>4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassette transported to and processed reader, if applicable.</td>
<td>1.00</td>
</tr>
<tr>
<td>Image displayed and reviewed, identification confirmed.</td>
<td>1.00</td>
</tr>
<tr>
<td>Image quality reviewed.</td>
<td>1.00</td>
</tr>
<tr>
<td>Exposure indicator checked, deviation index compared to target exposure index.</td>
<td>0.50</td>
</tr>
<tr>
<td>Image reprocessed or repeated as necessary.</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Following Completion of the Exam (3)</th>
<th>1.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-processing performed if necessary.</td>
<td>1.00</td>
</tr>
<tr>
<td>Exam verified and images archived to PACS for reporting.</td>
<td>0.50</td>
</tr>
</tbody>
</table>
REFERENCES


