A Comparative Study of Dose Rates on
Positioning in Pediatric Chest X-rays

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Abstract

Radiological imaging is an important part of today’s overall healthcare practicum and chest x-rays are the number one exam performed. Imaging can begin as early as the first day of life but only recently have the effects of ionizing radiation on the pediatric population been brought to the forefront. Radiation effects are cumulative and children are more susceptible to cell damage therefore it is important to understand the need to reduce dose within the pediatric population. Non-gridded techniques verse gridded can greatly reduce dose and in most cases non-gridded techniques will reduce dose by half. Positioning children for non-gridded techniques can be challenging, however, for their benefit it is the preferred method when it comes to chest imaging in the pediatric patient.
A Comparative Study of Dose Rates on Positioning in Pediatric Chest X-rays

“It has been well established that diagnostic x-rays constitute the largest and most widely distributed source of man made radiation exposure to the general population” (Hintenlang, Williams, & Hintenlang, 2002, p. 771). “Medical doses account for approximately 50% of the total United States (US) population dose, and will likely continue to increase for the foreseeable future” (Huda, 2009, p. 335). “The frequency of diagnostic radiological examinations for all patients in the US has increased 10-fold since the 1950’s” (Furlow, 2011, p. 421) and “chest radiography is responsible for approximately 30 to 40% of all x-ray examinations performed, regardless of the level of health care delivery” (Schaefer-Prokop, Neitzel, Venema, Uffmann & Prokop, 2008, p. 1818) however in children chest radiography is the most common exam ordered (Freitas & Yoshimura, 2009).

According to an article written in The New York Times “a recent study found that by the age of 18, the average child will have already received more than seven radiological exams” (Bogdanich & Rubelo, 2011, February 27). Due to the nature of a child’s rapidly dividing cells children are 10 times more sensitive to the stochastic effects of ionizing radiation than adults, therefore, the risks of developing cancer over a lifetime is greater in children than in adults (Furlow, 2011). The longer an organism is exposed to ionizing radiation the greater the chances are that that organism could possibly develop a cancer. Compounding a child’s radiological sensitivity with an increase in exams over a lifetime; it is imperative to understand that minimizing dose during all radiological examinations in the pediatric patient is of the utmost importance (Maree, Irving & Hering, 2007).

Radiobiology
Animal studies and numerous epidemiologic studies, such as those of occupationally exposed populations and survivors of nuclear weapon detonation and the Chernobyl nuclear power plant meltdown, indicate the even relatively low doses of ionizing radiation may cause cancer, particularly leukemia and myeloma, as well as blood disorders such as aplastic anemia. Energy from ionizing radiation can directly disrupt the chemical bonds in DNA and protein and may indirectly disrupt these bonds by releasing free radical ions. The resulting tissue damage may be deterministic or stochastic (probabilistic). Short term tissue damage is deterministic and may include skin burns and hair loss. Long term stochastic damage is more probabilistic and may involve carcinogenesis when damage occurs to genes that control cell division (mitosis) or programmed cell death (apoptosis).

Stochastic effects are considered probabilistic because a given exposure may damage genes in a manner that triggers carcinogenesis or increase the risk that subsequent carcinogenic exposures will cause carcinogenesis. Not all radiation damage to DNA will result in cancer, and not all radiation exposures above a given threshold will result in carcinogenesis. Rapidly developing and growing organisms are undergoing rapid cellular division, and their DNA is more frequently uncoiled for replication and vulnerable to damage by ionizing radiation (Furlow, 2011, pp. 423-424).

**History**

In 1957 the National Council on Radiation Protection and Measurements (NCRP) adopted the no threshold concept for ionizing radiation meaning that no level of ionizing
radiation is considered safe. This no threshold concept reemphasized the NCRP’s long standing philosophy that radiation exposures from whatever sources should be kept as low as practical. Between 1975 and 1976 the Atomic Energy Commission (AEC) changed the term in 10 Code of Federal Regulations Part (CFR) 20.1(c) from “as far below the limits specified in this part as practicable” to “as low as reasonably achievable” thus coining the term (ALARA) or as low as reasonably achievable (HPS, 2011, Answer Section, ¶3). The ALARA principle is a principle that today all radiological workers must follow, however, only recently has the concept of reducing dose in pediatric patient been brought to the forefront.

In 2007 a group of medical professionals got together and formed the Alliance for Radiation Safety in Pediatric Imaging. These professionals formed this organization based on findings that many pediatric patients were receiving “adult” sized doses during many radiological examinations; mostly computed tomography (CT). The Alliance began the Image Gently campaign in 2008 building on past efforts of such organizations as the Society for Pediatric Radiology (SPR) who sponsored ALARA conferences based on pediatric dose rates. The Image Gently campaign was designed to bring awareness to reducing or “child-sizing” the amount of radiation used when obtaining (CT) scans in children, however, the campaign has expanded to include all types of pediatric imaging (Goske et al., 2008).

Discussion

According to Freitas (2008) chest radiography is the most commonly performed pediatric radiologic exam. Keeping this in mind it is important to understand the difference in dose rates of chest radiographs performed with and without the use of grids. When an adult chest radiograph is performed typically it is done with a grid in order to reduce scatter and produce a clear image of the lung fields. However, when it comes to imaging children there is little benefit
on image quality when using a grid therefore techniques that involve a tabletop non-gridded technique are preferred.

Additionally, imaging pediatric patients can be a challenge especially when it comes to chest radiography. According to the American Academy of Pediatrics (AAP) “pediatric” refers to patients between the ages of one day to 15 years of age. Because children grow at different rates a “one size fits all technique” can not be used when imaging the lung fields of children (AAP, 2011). Part thickness must be taken into consideration when performing any radiological exam therefore it makes perfect sense to use this ideology on pediatric chest radiography performed table top.

**Technical Factors**

A study performed in 2001 by Hintenlang et al. on radiation dose in pediatric chest radiography shows the differences of effective dose between exams done with and without a grid. Ten hospitals and clinics within the state of Florida were chosen to participate in the study. Seven of those 10 facilities used a grid to reduce scatter in 1 year old pediatric chest radiography while 3 of the 10 did not. Lateral chest examination techniques on average for the 7 facilities using a grid were respectively 80 kilovoltage peak (kVp) and 10 milliamperage per second (mAs) while those without were 70 kVp and 3 mAs. Posterior anterior (PA) chest examination techniques, on average, for 7 of the 10 facilities using a grid were respectively 75 kVp and 6 mAs while those without were 65 kVp and 2 mAs. (See tables 1. & 2.)

### Table 1. Tube potential (kVp) selected for a 1 year old for each of the examinations performed at the surveyed facilities

<table>
<thead>
<tr>
<th>Examination facility ID</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral chest</td>
<td>74</td>
<td>85</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>70</td>
<td>84</td>
<td>90</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>PA chest</td>
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<td>68</td>
<td>75</td>
<td>67</td>
<td>58</td>
<td>70</td>
<td>68</td>
<td>80</td>
<td>90</td>
</tr>
</tbody>
</table>

### Table 2. Tube current (mAs) selected for a 1 year old for each of the examinations performed at the surveyed facilities

<table>
<thead>
<tr>
<th>Examination facility ID</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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</thead>
</table>
Table 3. Comparison of effective doses for male and female 1 year olds among facilities for chest examinations

<table>
<thead>
<tr>
<th>Facility ID</th>
<th>PA chest Effective dose (mSv)</th>
<th>Lateral chest Effective dose (mSv)</th>
</tr>
</thead>
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<tr>
<td>1</td>
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</tr>
<tr>
<td>2</td>
<td>0.004</td>
<td>0.011</td>
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<td>0.013</td>
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<tr>
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<tr>
<td>8</td>
<td>0.005</td>
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<td>9</td>
<td>0.007</td>
<td>0.062</td>
</tr>
<tr>
<td>10</td>
<td>0.013</td>
<td>0.031</td>
</tr>
</tbody>
</table>

According to Hintenlang et al. (2002) and the International Council of Radiation Protection (ICRP) “effective dose is currently considered to be the best measure of radiation damage; effective dose is the sum of the products of absorbed organ dose and the ICRP’s tissue weighting factor for each specified organ” (p. 772). As you can envision from the aforementioned techniques, effective dose rates for exams performed with a grid verses those without correlate directly to the amount of kVp and mAs used. (See table 3.) In this study, facilities 2, 5, and 6 did not use a grid and were forced to use manual techniques based on patient part thickness therefore doses rates were on average .0059 mSv. The other 7 facilities that did used a grid and an automatic exposure control (AEC) technique had dose rates that were on average .0304 mSv; or five times higher than those rates without a grid.

According to AAP dose rates for a single view pediatric chest radiograph should not exceed .01 mSv (AAP, 2011). Within this study the 7 facilities that were using a grid are shown to be well over the AAP’s recommended effective dose amount. Studies done in Austria (Billinger, Nowotny & Homolka, 2010), Brazil (Feitas & Yoshimura, 2009), and Sudan (Bushra,
Sulieman & Osman, 2010) have also concluded approximately the same outcomes on effective dose rates of the pediatric chest exam performed with a grid and without.

**Positioning**

Children in general do not tend to hold still very well when it comes to performing a pediatric chest exam. A blog spot titled *Topics in Radiography* (2007) does a great job of discussing the options available when it comes to positioning the pediatric patient for chest radiography utilizing tabletop manual techniques.

The first option discussed on the blog is the table top method. (See Fig. 1)

With the table-top method the patient is placed at the end of the table with the parent sitting in front of that patient for the PA exam. The parent dons a lead apron for protection and holds the imaging cassette and child in place. The tube is lowered down to rest on top of the table-top; collimate accordingly so as to only image the patient’s chest, and place a leaded glove or thyroid shield behind the patient’s gonadal area to protect them from scatter. Based on patient thickness set a manual technique accordingly and shoot. For the lateral exam rotate patient’s legs to the left 90 degrees and increase mAs up one step from PA.

The second option discussed is the pigg-o-stat method. (See Fig. 2)

This method involves an immobilization device called the pigg-o-stat. This device in general is used
only for children under the age of 12 to 18 months since many are unable to sit up and hold still on their own. Line up your tube and the imaging cassette before placing the patient in the device to save time. Because many children do not like the idea of being restrained you need to be quick therefore careful planning in advance can save a lot of heartache. For many parents this device looks like a dark-age’s torture device so one must explain the device and its use whenever necessary. For the PA place the pigg-o-stat roughly 72 inches away from your tube, set a manual technique and shoot. For the lateral rotate pigg-o-stat 90° and increase mAs up one step from PA.

The third option discussed is the Pediaposer immobilization chair method. (See Fig. 3)

It works much along the same lines as the pigg-o-stat but because it looks much like a high chair it does not seem to scare children and parents as much as the pigg-o-stat. The imaging cassette is inserted into the back of the chair. With this device the exam must be performed AP which increases patient’s breast and thyroid dose, however, a manual technique is still utilized reducing overall dose to the patient.

And, the fourth option discussed is the supine method. (See Fig. 4)

This method is mainly for babies who are unable to sit up on their own. Since this exam is not done erect the
image may not display correct air fluid levels. Place the imaging cassette on the table-top and align the tube with cassette; collimate approximately. Lay the child down AP on the cassette and have the parent don a lead apron so that they may hold the child securely with their arms above their head and their legs outstretched. Place a thyroid shield or lead glove over the gonadal area and collimate accordingly. Set a manual technique based on patient thickness and shoot. For the lateral roll baby to the left and follow the same positioning procedure increasing mAs up one step from the AP. This method can also be preformed with a radiolucent immobilizer instead of using the parent for immobilization. (See Fig. 5)

![Radiolucent Immobilizer](http://google.com/imgres?q=pediatric+xrays+restraints)

### Conclusion

Chest radiographs are the most commonly performed pediatric radiological exam. Because of this it is imperative to understand the effects of dose rates on the pediatric patient when using a non-gridded manual technique verses a gridded technique with AEC. Pediatric patients in general are more sensitive to the effects of ionizing radiation due to the nature of their rapidly dividing cells and with radiological exams on the rise it is important to understand that the effects of ionizing radiation are cumulative. In order to help reduce the effects of ionizing radiation within the pediatric population we need to utilize manual techniques that do not involve the use of a grid. Positioning the pediatric patient for the utilization of a manual technique during chest radiography can be quite challenging; however, careful planning when it comes to
positioning, along with proper collimation, and shielding can yield an ALARA principle exam that any technologist would be proud to have performed.

References


