SPECIAL REPORT

## Challenges and Solutions in Pediatric X-ray.

*"My littlest patients are very special to me – so I work hard to minimize the dose levels they receive."*

# gentle imaging

# *A Big Concern for Little Patients.*

Now more than ever, there is widespread focus on the level of radiation received by pediatric patients during imaging. And for good reason.

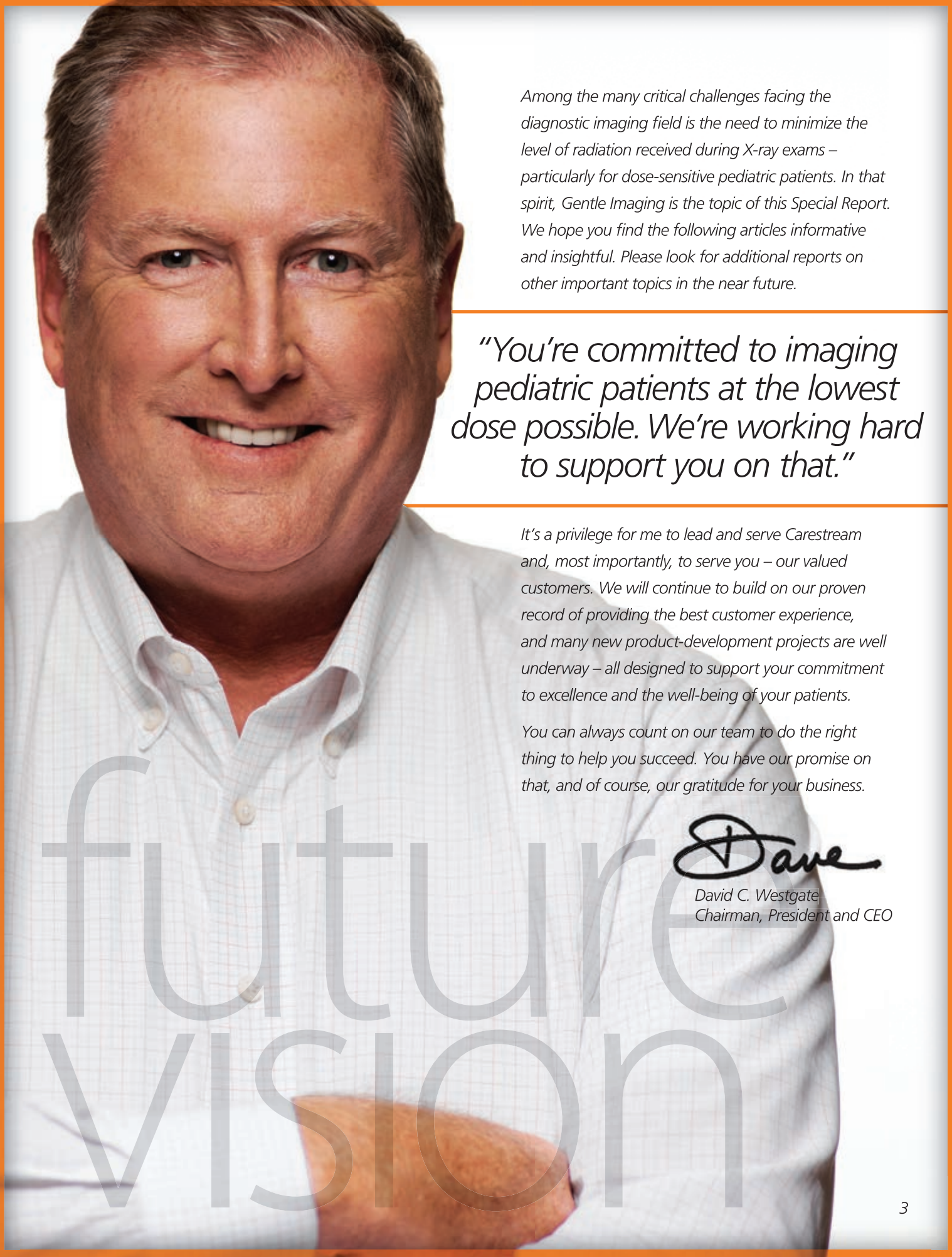
Diagnostic systems designed for adults, including General Radiography and Computed Tomography systems, can expose children to more radiation than what's needed for high-quality images. On top of this, children are more vulnerable to radiation-induced cancers. Young patients also have a longer span of years ahead in which malignancies could develop.

In response, government agencies and organizations worldwide – such as the Image Gently Alliance – have issued guidelines to help imaging facilities develop dose-safety pediatric protocols. Complying with these, without sacrificing image quality or speed, presents a serious challenge.

**In this Special Report on Challenges and Solutions in Pediatric X-ray,** we'll explore both the challenges and potential solutions in contemporary pediatric imaging. You'll read:

- *An article in which Shriners Hospital for Children* shares tips for keeping your pediatric patients calm and comfortable.
- *A white paper focused on technologies* that help maximize quality while minimizing dose.
- *Thoughts from a pediatric technologist* exploring the psychology of young patients during exams.
- *Recommendations and guidelines* for the use of Pediatric Dose Reference Levels (DRLs).

dose safety



*Among the many critical challenges facing the diagnostic imaging field is the need to minimize the level of radiation received during X-ray exams – particularly for dose-sensitive pediatric patients. In that spirit, Gentle Imaging is the topic of this Special Report. We hope you find the following articles informative and insightful. Please look for additional reports on other important topics in the near future.*

## *"You're committed to imaging pediatric patients at the lowest dose possible. We're working hard to support you on that."*

*It's a privilege for me to lead and serve Carestream and, most importantly, to serve you – our valued customers. We will continue to build on our proven record of providing the best customer experience, and many new product-development projects are well underway – all designed to support your commitment to excellence and the well-being of your patients.*

*You can always count on our team to do the right thing to help you succeed. You have our promise on that, and of course, our gratitude for your business.*

*David C. Westgate*
*Chairman, President and CEO*

# future vision

# Imaging Pediatric Patients Takes Flexibility and Creativity.

*In this article, the dedicated and caring radiology team at Shriners Hospital for Children shares tips and techniques for helping make pediatric exams comfortable for the patient and efficient for the technologist.*

Shriners Hospitals for Children®— Cincinnati

At Shriners Hospital for Children in Cincinnati, we give our pediatric patients the highest form of love and protection possible. When imaging pediatric patients, we make sure we use the lowest possible radiation dose, described as ALARA (As Low As Reasonably Achievable).

We care for children with pediatric burns, pediatric plastic surgery needs, and complex wound and skin conditions. Whether they are an infant or a teenager, we always make their experience as comfortable as possible.

Our radiological education gave us a great foundation, of course. But when working with children, flexibility and ingenuity are as important as our medical training. Often, we need to be as much of a creative photographer as a skilled technologist! Here are some of the techniques we've found helpful when imaging pediatric patients.

*"We always have someone lovingly hold the child in between views."*

loving care

**Techniques for imaging pediatric patients**

When doing a whole body X-ray of a young child, we start at their feet. This gives the child time to see the procedure and realize that X-rays do not hurt. This, in turn, reduces their anxiety when it is time to image more vulnerable areas, like their heads.

Distraction toys are helpful for younger patients. We let them hold and play with handheld toys if we are imaging their lower body. If we are imaging their hand or upper body, we have someone play with the toy within the child's line of sight. And we always have someone lovingly hold the child in between views.

For lengthy procedures, we always have two members of the radiology team in the room so we can complete the radiographs as quickly as possible. This is especially important because we never use restraints to hold our patients still. We need to work quickly in order to capture images during the limited time the patient can remain still.

With patients of all ages, we explain the process to them ahead of time. We let them see and touch our imaging machines and the controls, and operate them without exposure. Parents and guardians are invited into the room with the patient and are instructed to stand within where the pediatric patient can see them during the X-ray exposure.

Recently, we purchased a DRX-Revolution system that has several features that add to our reduced-stress atmosphere. We use the portable X-ray machine even when patients are brought to our imaging room. We prefer it because we can immediately see if the images are captured correctly without stepping out of the room to view them. Our constant presence helps reassure the child. Also, we can rotate the capture screen to show the images to the child, giving us another way to involve them and reduce their fear of the process. Also, the brightly decorated aquarium panel wrap is soothing and friendly for all involved in the imaging procedures.

*The Imaging Team at Shriners Hospital for Children – Cincinnati, from left, Lois Cone, Barb Blakeley, Frani Jackson, Cindy Murphy, Cindy Lee. (Not pictured, Howard Brodsky)*

Also, DR imaging is quicker than our previous CR radiography system. Many of our exams, like our Silverman Series, require multiple exposures. Instead of running film in between exposures, we move immediately to the next exposure using the same DR cassette. Less time and more physical contact help lessen the child's fears. The flexibility and patient-friendly features of the DRX-Revolution support our mission of "Love to the Rescue."

**Mobile X-ray unit brings imaging to point of care**

We love the easy mobility of our Revolution. The unit is self-propelled, and the collapsible column gives us good visibility to maneuver it through crowded areas and room to room.

We bring the portable to the ICU, and we bring it to post-op recovery and operating rooms. We use it to confirm proper placement of tubes and lines. The quality of the images is remarkable. Recently, we used it in the operating room to make a rapid determination that was appreciated by the surgeon and medical staff.

We believe that a body needs to be calm and relaxed before healing can take place. Some of us in the radiology department are certified Healing Touch practitioners, a therapy to calm nervous systems to give patients an optimal relaxation experience. We deliver the therapy in our old analog darkroom that we now consider as a special "light room." It is decorated with calming colors and we play soft music during sessions. ■

*Authors: The Imaging Team at Shriners Hospital for Children – Lois Cone, Barb Blakeley, Frani Jackson, Cindy Murphy, Cindy Lee, and Howard Brodsky.*

# Maximizing Dose Efficiency for Pediatric Patient Imaging.

*This white paper explores in detail the techniques and technologies that help ensure the best-possible image quality at the lowest-possible dose for pediatric X-ray.*

*"It's essential to use the appropriate acquisition protocols across the wide range of pediatric body habitus."*

**Introduction**

Radiographic imaging of pediatric patients presents a number of unique challenges compared to the imaging of adults. The increased radiation sensitivity of growing organs and bones, children's longer expected life spans and the large range of body habitus encompassed by this patient demographic all mean that it's not appropriate to use the same acquisition techniques and image-processing parameters used for adult imaging. The Image Gently campaign's "Back to Basics" initiative encourages the use of pediatric-specific imaging practices and is completely consistent with the guiding principles in Carestream's approach to addressing these important issues.[1 2 3]

To provide the highest-quality image with the most efficient use of the radiation exposure, it's important to address each step in the image-formation chain as part of a complete system. The image-formation process can be naturally divided into three distinct stages: image acquisition, image processing for display, and image review and assessment. These steps are represented in Figure 1. The process of image-quality assessment and its essential role in driving positive feedback into the acquisition and image-processing steps are also indicated in this figure.

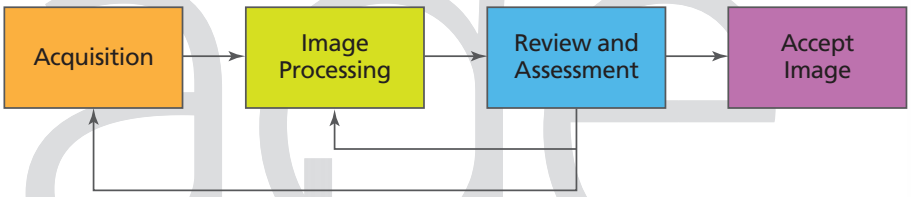



*Figure 1. Flow diagram for the image-formation process. Image review and assessment allow for feedback into the acquisition and image-processing steps, which can drive continued improvement.*

In keeping with the spirit of the Image Gently initiative, Carestream Heath has developed and implemented a number of product features specifically aimed at ensuring optimal image acquisition and display of diagnostic information across the full range of pediatric patients. The following sections outline some of these capabilities.

### Image Acquisition for Pediatrics

The first stage of image formation is the capture of the X-ray image by the image receptor. The introduction of Carestream's wireless DRX detector products has been a major step forward in the provision of a high-quality X-ray detector that fits seamlessly into the workflow of the NICU and pediatric ICU. In addition, the use of a CsI(Tl) X-ray absorption layer helps to ensure the highest possible image quality. The design virtually eliminates the problems that can be encountered with patient positioning in a busy clinical environment when a tethered system is used. The replaceable battery also guarantees that the detector is ready for use at a moment's notice.

In addition to a highly efficient detector, it's also essential to use the appropriate acquisition protocols (e.g. kVp, mAs and filtration) across the wide range of pediatric body habitus. The wide range of body sizes – from the smallest neonatal patient to the largest adolescent – requires acquisition techniques to be tailored to each patient's size and age. To help with this challenge, Carestream offers the ability to select the pediatric patient body size from a range of seven categories, based on the recent FDA recommendations.[4,5] This categorized selection allows the system to choose default acquisition parameters and image-processing configurations appropriate for the different types of patients as well as the different detector types (Pediatric Capture Image Optimization & Enhancement Software). This capability provides a more consistent acquisition and display of images for patients within a given body size and age range.

### Improved Acquisition Techniques for Pediatric Patients

Carestream is also engaged in research to develop improved acquisition techniques for pediatric patients. This work is based on the realization that the use of a digital receptor opens the possibility for targeting a specific signal-to-noise ratio in the image, versus maintaining a specific optical density within the final image. The inherent separation of the acquisition and display of an image in the digital environment provides new opportunities to develop task-specific tailoring for the amount and type of radiation used to create digital images.

To illustrate the opportunity for technique optimization, Figure 2 shows a normalized image-quality metric (detectability index per unit of effective absorbed dose) for a 5-10mm sized lung nodule, as a function of patient weight. The results indicate that for smaller patients, a lower kVp can provide improved image quality for a given patient dose, while higher kVps are more beneficial for larger patients. (The results are normalized to those for the 70kVp technique.)

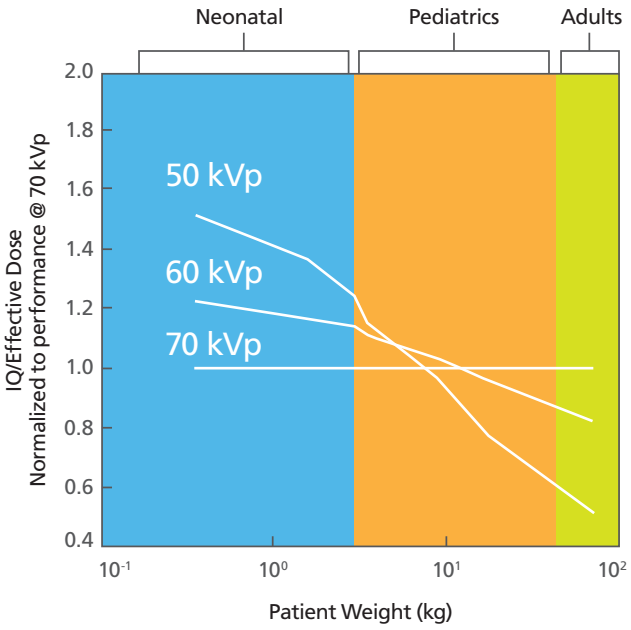



*Figure 2. Normalized image quality (nodule detectability index) per unit absorbed effective dose for different kVps as a function of patient weight for a 5-10mm lung nodule. The data is normalized to the image quality result for the 70Vp case.*

In certain procedures, such as scoliosis exams, it may be possible to reduce the exposure levels used for the follow-up images. Exposure reduction works if the imaging task can be satisfactorily achieved with an image that is noisier than the high-quality primary exam but still provides sufficient delineation of the spinal processes to allow accurate clinical investigating dose-reduction strategies. Carestream Health has also implemented a long-length imaging capability that minimizes the amount of overlap between consecutive images. This reduces patient exposure and ensures maximal coverage of the anatomical field of view.

Once an image has been acquired, the rapid display of the preview image allows the radiographer to quickly decide whether the patient's anatomy was correctly captured or if the image needs to be retaken. This improves the speed and efficiency involved in completing exams, which is particularly important for young patients. To help, Carestream has implemented the new IEC Exposure Index (EI) standard for quick assessment of the amount of radiation used to create the image.[6,7] The associated Deviation Index (DI) allows an immediate evaluation of the acquisition technique compared to the institutional target of exposure for the given exam. This immediate feedback, coupled with the other developments in technique selection described above, helps the radiographer provide more consistent image quality from the detector to the next step in the imaging chain, the image processing.

**Infant Image Processing and Display**

Once a high-quality image has been acquired at the lowest-possible patient exposure, it's essential to perform appropriate image processing that presents the diagnostic information clearly and most efficiently to the radiologist. Carestream's EVP Plus Software can be tailored to adjust the image-processing parameters to an individual site's preference. With information about the patient's size and age, the IP parameters can also be adapted to display the features of the clinical information in a more informative way compared to using adult image-processing configurations.

The eight-band frequency decomposition, multi-frequency noise reduction and controlled edge-restoration capabilities mean that the available clinical content of the bony structures in the smallest NICU patients can be appreciated as well as the trabecular detail of older, more developed patients, as one example. The fine detail and lower contrast of the smallest NICU patient's anatomy requires accentuation of different frequency components than the features of the larger adolescents. Figures 3 and 4 illustrate these differences and show the improved visualization provided by careful selection of the appropriate image-processing parameters.

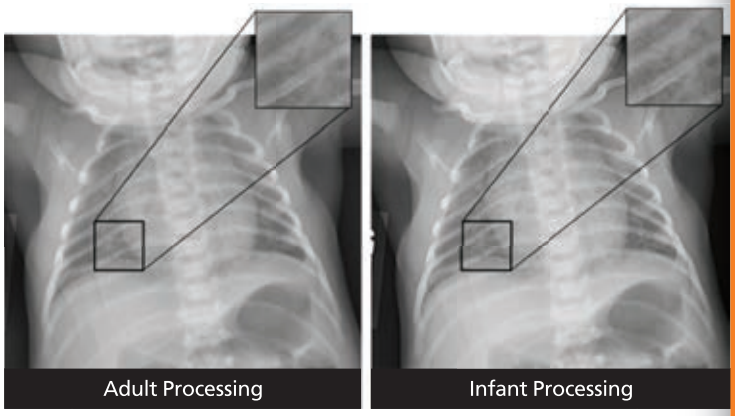



*Figure 3. An infant chest image processed with both adult (left) and infant (right) image processing. Note that many infant chest details are not apparent when using adult processing.*

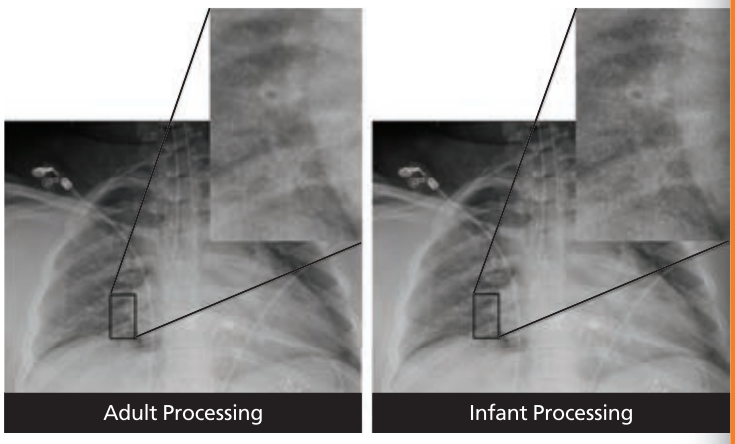



*Figure 4. A teenage chest image processed with both adult (left) and infant (right) image processing. Note that fine details of the teen chest are overemphasized when using infant processing.*

## Quality Acceptance and Control

Once an imaging system has been installed and tailored to a site's preferences for patient exposure and image "look," it's important to have an ongoing quality control (QC) program in place that ensures the continued high quality of the images delivered to the reading radiologist. There are multiple aspects to this type of QC program and Carestream Health has implemented a number of system capabilities that enable a site to easily track many of the important parameters.

At the front end, the DR Total Quality Tool (DR TQT) package allows for efficient evaluation of the digital X-ray detector's current performance level. In addition, the IEC EI allows quick evaluation of the exposure levels used to acquire the images. On a departmental level, the Administrative Reporting and Analysis Software allows the QC technician or physicist to query all the Carestream systems across the institutional network from a single, central location. This can quickly highlight anomalous exposure levels, high repeat rates or other image-quality issues that can develop, and allows for more proactive steps to solve potential problems. Together, these system capabilities can help technologists maintain their high level of image quality and consistency.

## Conclusion

The unique demands of pediatric imaging require a system-wide approach to guarantee high-quality imaging at the lowest-possible patient exposure. Carestream Health offers a range of features and functionality that ensure our systems can provide the best and safest-possible X-ray imaging across the full clinical range of exams for all pediatric patients. ■


[1] Bulas DI, et al. AJR Am J Roentgenol. 2009 May; 192(5): 1176-8. Image Gently: Why We Should Talk to Parents about CT in Children.

[2] AJR Am J Roentgenol. 2009 May;192(5):1169-75. Image Gently Vendor Summit: Working Together for Better Estimates of Pediatric Radiation Dose from CT. Strauss KJ, et al.

[3] Image Gently®: The Alliance for Radiation Safety in Pediatric Imaging. http://www.pedrad.org/associations/5364/ig/ (Accessed September 27th 2012)

[4] FDA guidance entitled "Premarket Assessment of Pediatric Medical Devices," May 14, 2004, http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM089742.pdf

[5] FDA draft guidance entitled "Draft Guidance for Industry and Food and Drug Administration Staff: Pediatric Information for X-ray Imaging Device Premarket Notifications," May 10, 2012, http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM302938.pdf

[6] International Standard IEC 62494-1 (2008) Medical electrical equipment—exposure index of digital X-ray imaging systems—Part 1: definitions and requirements for general radiography. International Electrotechnical Commission, ISBN 2-8318-9944-3

[7] Seibert J.A., Morin R.L.,"The standardized exposure index for digital radiography; an opportunity for optimization of radiation dose to the pediatric population," Pediatric. Radiol. 41(5), (2011), 573-581

# Pediatric Radiography Techniques.

*A veteran radiology technologist shares his insights regarding pediatric imaging. He focuses primarily on the psychology of young patients, helping us understand that children, with their unique attitudes and anxieties, need a special approach to keep them calm and reassured.*

Radiology technologists interact with people who are sick and frightened every day. However, pediatric radiography requires heightened sensitivity to our patients.

We professionals are much like a brush saturated with fresh paint. We leave our texture and our color on everyone we touch – and even more so on children. Have you ever wondered what kind of artwork you have produced some days?

Whether you are a novice or a veteran at imaging pediatric patients, it is worthwhile to review techniques for imaging our youngest patients. My insights are based on my 41 years of experience as a radiology technologist.

First and foremost, remember that children are not little adults. Do not expect adult reactions. Also keep in mind that:

- Your behavior with pediatric patients will influence their perception of and mood for all future radiology examinations.
- Technologists are rarely trained in Pediatric Psychiatry. However, we can go about the task of imaging young children with good common sense, and extra patience and compassion.
- The personality and psyche of children vary dramatically with age and to some extent with gender.
- The more sensitive and adaptable we are in dealing with a child will in turn make them more cooperative and also ease the anxiety of their hovering parents. Unfortunately, the inverse also is true.
- Children, like most patients, are likely to be confused, frightened, and feeling ill.

**Inside the mind of the pediatric patient**

There are several factors that influence a child's behavior more than adult patients. These generalities are perhaps obvious to many of you. However, it is easy to forget them in the midst of a busy day.

**Degree of anxiety:** Often patients have fear of the possible primary illness. But children have less context

and rationale than adults to corral their fears. Also, some children might think their injury is a punishment for having been "bad."

**Family attitude toward the medical profession:** The effect of a negative, critical attitude of parents toward doctors is no less damaging than an unrealistic attitude toward teachers or law enforcement. Parents might threaten a child's bad behavior with "Do that again and I'll have the doctor give you a shot."

**Developmental level:** A chest radiograph for a 12-year-old female is an embarrassing ordeal. In contrast, most 12-year-old males have little modesty about their chests. However, all children are modest to some degree about having their genitals or backsides exposed after ages 4 to 5. This is partly due to modesty, but also due to fear.

**Reaction to the procedure:** Patient response is greatly influenced by existing emotional problems. For example, a fearful child will be more fearful. A pediatric patient who kicks and screams might be extremely scared or disoriented. Don't misinterpret their actions as those of a "mean little kid," or "spoiled brat."

**Separation anxiety:** The move to a hospital is especially traumatic for the under 5 years-of-age group. They don't understand why they are no longer at home. They left the security of their home for a strange place where everything – the mattress, room, smells, noises, and people – are foreign to them.

**Stranger anxiety:** At age 5 months, even when mother is nearby, the child has a sobering reaction when approached by a stranger. At eight to nine months, the child will react to separation from mother, even though some stranger (perhaps you) offers "goodies."

These are factors that the pediatric patient brings with them to the hospital. Now let's consider what is happening in the hospital environment.

**Impact of the hospital environment on pediatric patients**

For radiology technologists, the hospital is an integral part of our lives. It is so familiar to us that we might forget that for others, it is a foreign, noisy, and possibly frightening place. This is especially likely at general hospitals where it is not routine to image infants and children.

Based on my experience, here are some of the more significant factors within the hospital in general and some specific to radiology that can trigger a strong reaction from a child.

**The mood of the hospital personnel:** Sick patients might lie still with their eyes closed, but they are listening – and probably more acutely than usual. Everything you do, even your mood, leaves an impression on them. No matter how personal you make the radiology exam, you are only one of many interactions that the pediatric patient will have with hospital personnel. It is also likely that the child will have a different technologist on a repeat visit. A well-executed visit with you can set the tone for the child's future imaging exams and interactions with other hospital personnel.

**Large machines:** Children are fascinated but usually not scared of cement mixers or bulldozers although they are large and unfamiliar. However, an unfamiliar and large X-ray unit can be terrifying. Why? Because

it is suspended directly overhead while the child is in a highly vulnerable position. He or she is immobilized on a hard, impersonal table and they aren't holding mom or dad's hand.

**Noise:** Noise can be the catalyst that converts inner tension with an outward varnish of calm into unmanageable, convulsive fright. In addition to being utilitarian, the X-ray table is a perfectly constructed sound box. Are you driving the Bucky tray "home" with a good bang? Do you slam cassettes on the tables?

Here's something to try on yourself. Lie on an X-ray table on your side with your ear glued to it and ask a colleague to slam a cassette down. Better yet, repeat the procedure someday when you have a fever of 102, a headache, and every muscle is throbbing.

*"First and foremost, remember that children are not little adults. Do not expect adult reactions."*

**Odor:** Odors are capable of generating all sorts of emotions. You've probably never given a thought to the insults of your early morning coffee breath or stale cigarette odors.

**Temperature:** Cold hands, frigid tables, icy cassettes, and refrigerated cleansing solutions applied to any body's bare skin is unwelcome. For a sick child, it can be intolerable.

**Movement:** X-ray table movement is very important! Take time to explain to the patient what you are doing before you begin tilting an X-ray table in either direction. Pause the table half way down to give them time to orient themselves. Even better, make it a game with youngsters: Science fiction? Astronauts? Magic? I realize that in certain instances it is imperative to move quickly, but this should be explained before and during the examination.

**Helplessness:** Being powerless creates a very anxious state. The young pediatric patient is helpless and exposed in the presence of a stranger who – in their small minds – could be a potential enemy.

**Immobilization:** We ask children to lay still, thus stifling the very tactics they use to cope with anxiety. They are unable to fidget, suck their thumb, or stroke their hair to calm themselves down.

I hope you found these insights into pediatric imaging helpful. If nothing else, remember to treat pediatric patients as though they were your own children. For the brief time you are performing your exam… they are! ■

*Read the study on Pediatric Fracture Detection.*

*Author: Terry Ferguson is currently the Training Development Manager at Carestream Health. He is an Air Force trained Registered Radiologic Technologist with a BS in IT Management. He has been a Staff Technologist and Chief Technologist at St. Louis University Hospital and the Radiology Director at Cardinal Glennon Children's Hospital. Terry has held positions of Sales Manager, Product Specialist, Training Development Manager, and Sales Development Manager in the commercial arena.*

# Recommendations and Guidelines for the use of Paediatric DRLs.

*An understanding of Diagnostic Reference Levels and how to apply them can be essential in the initiative to minimize dose levels when imaging children. Here, author Raija Seuri, a paediatric radiologist and expert in Radiation Safety, presents clear and practical guidelines for optimal use of DRLs. Although she draws on references in the European Union, her insights can be applied to pediatric imaging worldwide.*

*Editor's note: the spelling of 'paediatric' used in this blog is the correct spelling in the European community.*

Diagnostic Reference Levels (DRLs) are a useful tool for dose optimization – including in paediatric imaging. However, the relatively small number of paediatric patients in many institutions is a challenge for optimization of imaging parameters for children of different sizes. Optimization requires both time and expertise, which are not always easy to find in daily practice.

Fortunately, the focus on paediatric DRLs has increased during recent years. Recently (in 2017), the European Commission (EC) published European DRLs for the most common paediatric examinations for all modalities.

Based on my experience in this area, I have compiled those guidelines for DRLs for paediatric imaging that I believe are the most useful. I also explain when and how to apply national, European, and local DRLs.

**DRLs – What are they?**

Diagnostic Reference Levels are a tool for optimization. Optimization means keeping the dose "As Low As Reasonably Achievable" (ALARA) for the required image quality to obtain the desired diagnostic information. The International Commission on Radiological Protection (ICRP) states, "the objective of a diagnostic reference level is to help avoid excessive radiation dose to the patient that does not contribute additional clinical information to the medical imaging task." Several countries have begun to establish indication-based reference levels, but most are for adult procedures.

DRLs are not a dose constraint, nor a limit. They are not intended to classify "good" or "bad" practices. Rather, they are markers to help professionals identify abnormally high (or low) dose levels for the indication, and to make the optimization process easier. The dose should always be considered together with the indication of imaging and image quality needed.

**DRLs for pediatric imaging – Where to find guidance?**

Many international, national, and local authorities have published guidance for the use of DRLs. Following are the references for paediatric imaging that I believe are the most useful. I chose these because they are the most authoritative, are recently published, and give practical guidance for how to use DRLs for paediatric imaging.

International Atomic Energy Agency (IAEA) – I recommend this resource for everyone who has a role in paediatric imaging. The information is easy to find and in a compact form. Their Frequently Asked Questions (FAQs) section provides short and practical answers.

European Diagnostic Reference Levels for Paediatric Imaging (PiDRL) – This EC Publication includes European DRLs for the most common paediatric procedures on all modalities, and how to use them in everyday clinical practice. It also includes guidelines for collecting and comparing dose values to DRLs, and recommendations for collecting and processing data to establish national DRLs.
I recommend the report to anyone interested in or responsible for pediatric imaging and paediatric dose. You can find them in Radiation Protection publication 185.

The International Commission on Radiological Protection (ICRP) Publication 135 (2017) – This is the most authoritative and thorough resource on DRLs in general. This will be of special interest for those responsible for radiation protection in their unit. The most recent publication – ICRP Publication 135 (2017) – includes a special chapter on paediatric procedures with detailed recommendations, including:

- Detailed and practical guidance on both the establishment and use of paediatric DRLs in clinical practice
- Recommendations on conducting surveys to establish DRLs
- Recommended quantities for DRLs for *each modality*
- All modalities including nuclear and hybrid imaging

*"An important change in DRLs is the recommendation to use grouping by weight rather than age."*

**National, European and Local DRLs – Which ones to use?**

When radiologists and other medical imaging professionals talk about DRLs, they are usually referring to national reference levels. However, European and local DRLs also can be used.

National DRLs (NDRL) – This will be the dominant reference – if one exists for your country. They are based on national dose surveys and are set by national authoritative bodies.

**European DRLs (EDRLs)** – EDRLs could play an important role in harmonizing the practises in the European countries by providing guidance for optimization until NDRLs are established. These DRLs should be considered when your country does not have national DRLs for paediatric patients, or if the NDRLs are higher than EDRLs or otherwise outdated. They are based on national DRLs of the European countries. EDRLs can be found in the PiDRL Report.

**Local DRL (LDRLs)** – LDRLs can provide guidance on the institutional level for a hospital or a group of hospitals. Consider applying them if you feel the NDRLs are high for your local practice; or if your NDRLs are outdated or non-existent. In that case, your local DRLs can be the first step to establishing national DRLs in your country!

**DRLs – How to use them for pediatric X-rays?**
When planning a dose survey, choose a procedure that is common in your institution. The recommended dose quantities are found in the guidelines, and should be easily available in the equipment console.

A recent and important change for many countries in DRLs for paediatric imaging is the recommendation to use grouping by weight rather than age. There can be a huge variation of sizes of paediatric patients within an age group, which might distort the results of dose collection, especially with small sample sizes. The recommendation is to collect at least 10 patients for each weight group. In Finland, the national practice is to use a continuous DRL-curve, with which you only need 10 patients to compare your dose levels.

The calculated median dose of your collected sample is then compared to the DRL-value. If your value is higher than the DRL-value, you should have a closer look at your practices. Is there a problem in equipment function or optimization of parameters? Are you using the right protocol? Could there be a problem in staff performance (collimation, protocol/ parameter selection)?

**DRLs – When to use them?**
Regular checks of dose levels should be part of your QC. Also, review dose levels when you:

- have changed your protocols;
- have a change in practice;
- purchase new equipment;
- or update existing equipment.

Also, remember to perform regular calibration or checks to ensure that you get accurate values of the dosimetric quantity from your console.

Dose always should be considered together with image quality. Good image quality in digital imaging is a result of multiple factors, and many of them do not relate to the dose parameters. To be able to know the dose used, you have to look at the dose indicators. With all PACS systems, it should be possible to get the dose indicators shown in the image display. The only way to know your dose levels is to collect actual patient doses. Comparison to existing DRLs shows where you stand with your dose levels, and where you should put your focus in quality improvement: dose optimization or image quality.

Remember that dose surveys are not only for comparison, but also to improve your practice. ■

Learn about *Carestream's Exposure Indicators.*

*Author: Raija Seuri is a Paediatric Radiologist at HUS Medical Imaging, Children's Hospital. She is also a clinical consultant for the Radiation and Nuclear Safety Authority STUK, Helsinki Finland. Radiation protection of patients and optimization of imaging practices in paediatric imaging are her special interests.*

# Carestream's Solutions for Pediatric Imaging.

*To address concerns about dose in pediatric X-ray, you need a holistic, focused solution. That's why Carestream developed our family of pediatric X-ray solutions – integrated hardware systems and software options tailored to the singular demands of pediatric imaging. These solutions deliver all the efficiency and quality you require, while helping you meet the recommendations of government agencies, such as the Image Gently Alliance for Radiation Safety in Pediatric Imaging, and the safety principles of As Low As Reasonably Achievable (ALARA).*

## DRX Detectors

Our CARESTREAM DRX Plus 2530C Detector is custom-engineered and approved for pediatric applications. Light-weight and wireless, its small, compact design fits easily into a neonatal incubator X-ray tray, and its cesium iodide (CsI) scintillator is excellent for dose-sensitive pediatric patients. Our standard-size DRX Detectors are available with Cesium Scintillators as well.

## Image Processing Software

Powered by our Eclipse Image-Processing Engine, the Pediatric Image Optimization and Enhancement option utilizes multi-frequency processing for improved noise suppression and detail enhancement of pediatric exams. It provides default acquisition techniques and image processing parameters optimized specifically for the pediatric patient population. Image-review allows measurement and tracking of dose levels. IEC Exposure Index assesses the degree of radiation used, while Dose Reporting sends the data to the RIS.

## Mobile Systems

The CARESTREAM DRX-Revolution Mobile X-ray System and CARESTREAM DRX-Revolution Nano Mobile are ideal for pediatric and NICUs. The Nano System's small footprint allows easy maneuvering, while the articulating arm and small tube simplify positioning. Its unique Softgrid provides high image quality, with reduced dose and lighter weight. Both systems are available with whimsical, child-friendly graphics.

## X-ray Rooms

The CARESTREAM DRX-Evolution Plus and CARESTREAM DRX-Ascend Rooms offer removable grids and motorized, low-absorption tables that can be adjusted to a height that accommodates small children. Filter wheels in the tube head provide additional X-ray filtration. Long-Length Imaging solutions help support fast exams of longer anatomical regions.

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