

The Impact of 320 Detector Rows: Aquilion ONE in the Pediatric Setting

The 320-detector CT scanner, recently implemented at Arkansas Children's Hospital, has minimized dose requirements, reduced the need for sedation, and opened the door for future research **By Cat Vasko**

Dose is a central consideration in the CT suite for the pediatric patient, and finding a scanner that minimized dose to a level as low as technically achievable was the primary consideration for Arkansas Children's Hospital (ACH), Little Rock, when it replaced its legacy 16-slice scanner. As it turned out, in reducing dose, the hospital's new scanner also delivered uncommon speed, reducing the need for sedation and resulting in significant workflow advantages.

ACH was operating 64-detector and 16-detector CT scanners, when it issued a request for proposal (RFP) for a new, state-of-the-art CT system. As the only freestanding pediatric hospital in Arkansas (and a statewide tertiary burn center), ACH faced a unique set of challenges when imaging its patient population. Due to the clinical complexity of patients and their variable age range, ACH's CT suites were accommodating an average of one to two patients an hour.

While the radiology department took every opportunity to use dose at a rate as low as reasonably achievable, or ALARA, during scan protocols to minimize exposure for its patients, newer and faster scanners were coming onto the market, promising further dose reductions, faster scan times, and, therefore, the potential to minimize or even eliminate sedation.

The dose-reduction capabilities of the 320-detector CT system caught the attention of ACH's radiology staff. The ability to scan a body part in a single rotation, dramatically reducing radiation exposure and minimizing the need for sedation, spoke volumes to a pediatric imaging service. "Our radiologists were very interested in that technology," Karen Craig, director of radiology, recalls.



Figure 1. Technologists at Arkansas Children's Hospital appear with their state-of-the-art 320-detector Aquilion ONE CT scanner, customized with jungle decals and featuring a monitor and voice prompts delivered by a child.

Though it entered into a formal RFP process and reviewed proposals from multiple vendors, in the end, ACH chose the Aquilion ONE 320-detector CT system from Toshiba America Medical Systems (TAMS), Tustin, California, above a competitor's multislice CT scanner. Toshiba had also supplied the hospital's 16- and 64-slice scanners. Craig adds that the ability of the Aquilion to do volume imaging on small body parts with a single rotation was also a key decision point. "There was widespread support from physicians across the hospital to get this scanner," Cynthia Holland, vice president of ancillary services, affirms.

Optimized for Pediatric Care

In March 2009, ACH replaced its 16-detector CT scanner with the Aquilion ONE system (Figure 1). When it comes to the primary reason that ACH selected the scanner—dose reduction—the system has not disappointed. Preliminary internal reviews at ACH show that, in a comparison of noncardiac gated angiograms on children three years or younger, the 320-detector scanner offers a 70% reduction in dose over helical acquisition on the 64-detector unit. In gated cardiac studies, the dose reduction has been around 50%. Donna Hoover, imaging manager, notes that although the

Aquilion ONE has become the scanner of choice for most studies. "In the case of cardiac studies, we would only use the 320-detector CT now," she says.

Though radiation exposure from imaging represents a concern for all age groups, the team at ACH has good reason to be particularly focused on dose reduction.^{1,4} "Our radiologists will do anything they can to minimize the dosage, the drugs, and the trauma that a child experiences," Holland says. "This system has been great at addressing all three of those issues."

Hoover reports that the features of the Aquilion ONE have simplified the creation of accurate pediatric-imaging protocols. In addition to providing options for reducing dose, the unit automatically estimates the radiation dose for each exam, giving radiologists and technologists the opportunity to work together to adjust scan protocols until the dose is at the lowest possible level that still results in good image quality. "We've always built multiple protocols into our scanners," Hoover notes, "but with the Aquilion ONE, there are more options, and the dose estimate is very helpful when it comes to determining whether to scan in volume or helical mode."

One of the Aquilion ONE's most patient-popular features is a 12-inch flat-screen LCD monitor (mounted on the scanner) called iStation, which uses animation

and voice prompts to ensure patient compliance during scanning. ACH uses the iStation to guide patients through the exam.

"The child in the animation tells patients when to raise their arms, when to hold their breath, and so on," Hoover explains. "That really helps: They are child-friendly instructions, coming from a child." Hoover and her team worked with an outside vendor to decorate the scanner with jungle-themed stickers that match the backdrop displayed in the animation, delighting the young patient population. "The main things, though, in terms of comfort, are the speed of the scan and the distraction of the screen. The kids love it," she says.

ACH is the first dedicated children's hospital in the world to install the Aquilion ONE. As with any product that is new to the market, there have been features that needed to be optimized. The vendor has been responsive to the hospital's feedback and is working in partnership with ACH continually to improve applications, including advances in reconstruction speed, image quality, and lower-dose pediatric protocols.

Enhanced Workflow

Though the Aquilion ONE has been in use only since March 2009, it has rapidly become the department's scanner of choice. "It is the preferred scanner for most patients, throughout the day," Hoover explains. "Our staff uses the scanner exten-

sively during the day, and it is the scanner used on nights and weekends."

TAMS contends that the demand for the scanner is made more manageable by the enhanced workflow that it facilitates. It is the position of TAMS that the Aquilion ONE can cut exam time by two-thirds (Figure 2). "The Aquilion ONE's faster acquisition times and the ability to do the single-rotation volume scan have improved throughput," Hoover says. "Where we used to scan one or two patients per hour, now we can get in a third patient per hour, and we're able to work in more last-minute, same-day add-on exams."

Another challenge in pediatric imaging is the need to sedate patients along a continuum that runs from minimal, moderate, and deep sedation to anesthesia. Prior to implementation of the Aquilion ONE, approximately 10% of ACH's pediatric CT patients required sedation, meaning that food and drink had to be withheld, an anesthesiologist had to be available, the CT suite was tied up for an hour, and (last, but not least) the patient was exposed to additional risk.

In 2000, a multidisciplinary conference took a close look at the variability in pediatric sedation policies and characterized such policies as positioned close to the safety fault lines of health care.⁵ As CT technology hit 320 detectors, the potential to decrease acquisition speed dramatically (with volume cover-

A New Research Tool

Arkansas Children's Hospital (ACH), Little Rock, is an academic center, with physicians involved in clinical care, research, and education on the local, state, and international levels. "We do quite a bit of on-site research, and we try to translate as much of that to the clinical-care arena as we can," Cynthia Holland, vice president of ancillary services, explains. ACH is currently participating in pediatric clinical trials of a miniature heart pump, the Berlin Heart; in the past, it has helped test a cooling cap that has since gained FDA approval for use to reduce potential brain injury in full-term newborns.

The radiology team at ACH has participated in a number of studies on the potential applications of imaging in pediatrics. Past areas of research include:

- the use of a gadolinium-based contrast agent (MultiHance; Bracco Diagnostics Inc, Princeton, New Jersey) in the pediatric population;
- silent infarct transfusion (via participation in the Silent Infarct Transfusion Study);

- the use of intraoperative transesophageal ultrasonography for measurement of renal blood flow;
- the effect of a soy-milk diet on metabolism, body composition, and brain function in infants and children;
- functional MRI (fMRI) evaluation of the neonatal diet's effect on language and neurocognitive-function development in children; and
- an fMRI study of neurocognitive activation for adolescents with spina bifida.

In addition, ACH recently reviewed CT imaging to study the effects of all-terrain vehicle (ATV) accident trauma on children. Holland explains, "Arkansas is a rural state. We have a lot of people who use ATVs, and we're seeing significant injuries in children. We're going to use the data from the study to raise the recognition level and get some laws passed stating that you have to be a certain age to operate an ATV."

One of ACH's radiologists, Chetan Shah, MD, published the findings of the retrospective study¹ in

the July 2009 issue of *Pediatric Radiology*. Shah et al found that head injuries occurred in 48% of the children studied and played a role in five of six deaths from ATV accidents, concluding that "head and extremity injuries are the two most common injuries in children suffering ATV injuries and are associated with long-term disability. ATV use by children is dangerous and is a significant threat to child safety."

In the coming months, the ACH team hopes to use the Aquilion ONE CT system (Toshiba America Medical Systems, Tustin, California) for further research. "It's too early to share any of the information, but we have several possible research opportunities in the future," Holland says.

Reference

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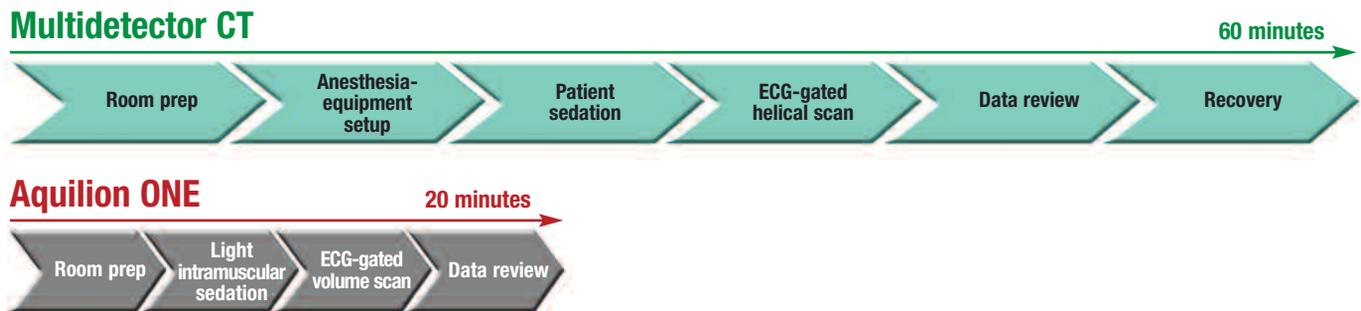


Figure 2. Infant cardiac-scan workflow. Source: Toshiba America Medical Systems. Experience may vary from facility to facility.

age of up to 16 cm)—and, therefore, to reduce the number of pediatric patients requiring sedation—was extremely attractive.

Preliminary numbers indicate that ACH has been able to reduce the percentage of its patients requiring sedation since implementing the Aquilion ONE. Toshiba America Medical Systems believes the Aquilion ONE can dramatically reduce the number of pediatric patients requiring sedation (Figure 3). “Obviously, doing fewer sedations helps you use more efficiently your resources, staffing, and the amount of time the scan takes,” Holland says.

Holland adds that case-time decreases are not the only reason that a reduced need for sedation is so valuable; lowering the number of studies that require an anesthesiologist in attendance is another benefit. “That’s a big deal for us because anesthesia is involved in so much at this hospital. Our anesthesiologists are a precious, valuable resource, and we have to coordinate extensively between the operating room and radiology to make sure we’re maximizing the use of their time,” she says.

ACH technologists have also embraced the system’s ease of use. “The Aquilion ONE has been very well received by our technologists,” Hoover says. “New technology can be a struggle in a department. Sometimes, what the radiologists want and what the technologists can do functionally differs. The technologists, however, have been very pleased, from a user’s perspective, and the radiologists have been very pleased with the images produced.”

Shifting Clinical Patterns

Holland describes the implementation of the Aquilion ONE as a culture change for ACH radiologists and referring physicians. As the unit becomes the preferred scanner

for most pediatric studies, the radiology department continues to discover exams for which it is particularly useful, and to explore clinical scenarios where it could even replace other modalities, in time.

“We have to work together to determine what will give the best diagnostic capability for our patients,” Holland says. Though ACH’s 64-detector scanner is still valuable, the 320-detector unit is particularly favored when it comes to cardiac, pulmonary-embolism, CT-angiography (CTA), temporal-bone, skull-anomaly, and trauma exams (Figure 4). “The functional [dynamic] aspect of the scanner’s cardiac imaging has enabled some patients who could not have an MRI, for one reason or another, to have functional cardiac CT exams

that will provide some of the same information,” Hoover notes. “For skull fractures and CTA of the brain and neck, it’s a real improvement over previous scanning methods when we are able to obtain the images in volume-scanning mode.”

The Aquilion ONE’s 4D imaging capability has opened up a number of new uses for CT imaging within the hospital. “We’ve done one study, so far, using volume dynamic imaging, where you can see the mobility of the patient’s joints,” Hoover says. “We’ve also done several lung-function studies, which can detect air trapping and quantify right- and left-lung function. We want to do more of those in the future.”

The system is also favored for cardiac

Bringing Dose Front and Center

The Image Gently campaign, launched last year by the ACR and the Society for Pediatric Radiology, has brought renewed focus to the issue of effective dose for children versus effective dose for adults. The campaign aims to educate radiologists, referring physicians, and the public on the importance of child sizing radiation dose. According to the US National Cancer Institute,¹ the risk of developing a radiation-related cancer is several times as high for a young child as it is for an adult undergoing an identical CT exam.

At Arkansas Children’s Hospital, Little Rock, finding the appropriate dose for pediatric patients has always been a priority. Each morning, radiologists and technologists work together to tailor each of the day’s exams to the individual patient, basing scan protocols on the patient’s weight and size and on the reason for the exam.

“We’ve always worked hard to reduce our dose, and we have built-in protocols based on patient weight: 0 to 5 kg, 5 to 10 kg, 10 to 15 kg, and so on,” Donna Hoover, imaging manager, explains. “In the morning, the radiologists work

with the technologists to go over all the exams that will be done that day. They also worked together when we built weight-, size-, age-, and diagnosis-based protocols.”

The Aquilion ONE CT system (Toshiba America Medical Systems, Tustin, California) offers an estimated dose for each exam protocol prior to scanning. “That’s a feature the 320-detector has that the 64-detector doesn’t have,” Hoover notes. “There are more possibilities for dose adjustment with the Aquilion ONE because you can choose among volume, helical, and axial imaging, according to what you need for that patient and clinical application.”

Resources to aid imaging providers in establishing safe scan protocols for children are available online at imagegently.org.

Reference

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Aquilion ONE

- Light sedation (or none at all) may be used.
- Scanning is so rapid that sedation, if needed, can be a light intramuscular sedative used just to calm the patient.
- Room preparation is quickly finished for a short scan with ECG triggering.
- This is a 20-minute procedure.

Multidetector CT

- Heavier sedation, with a cardiac anesthesiologist present, may be needed.
- One must keep the patient still and control his or her breathing.
- Room preparation is extensive and includes anesthesiology equipment.
- Postsedation monitoring is needed.
- This is a 60-minute (or longer) procedure.

Figure 3. Sedation comparison for an infant cardiac case. Source: Toshiba America Medical Systems. Experience may vary from facility to facility.

gated and nongated exams; routine neurological imaging for patients less than 2 years old, as well as CTA of the brain and neck (when done in volume-scanning mode); routine orthopedic imaging; and routine pulmonary imaging and multiphase pulmonary studies for infants with respiratory problems.

In the future, ACH radiologists hope to validate the use of the 320-detector Aquilion ONE scanner in place of more risky invasive exams. "Our radiologists and physicians love it," Holland confirms. "They want to do everything on it that they can."

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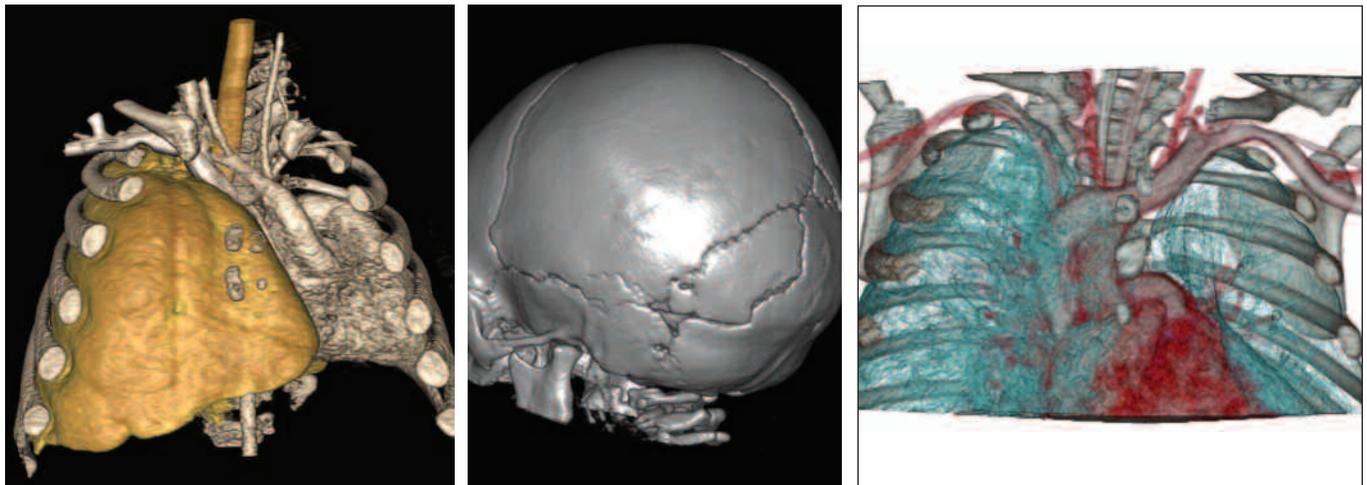


Figure 4. *Left:* A 21-day-old male infant from the neonatal ICU was scanned using Aquilion ONE. CT angiography (CTA) of the chest was performed using a volume-scan mode that allows the entire chest to be scanned in a single rotation; a low-dose scan technique was employed for this study, giving an effective dose of just 0.4 mSv. The 3DVR CTA shows that the superior vena cava is on the right, and a right aortic arch that has a mirror-image branching pattern is present.

Center: In the case of this three-month-old infant, the linear lucency seen on the axial images was initially thought to be a fracture. A fracture was ruled out using this 3DVR view of the skull, which shows an accessory occipital suture (a normal variant that sometimes occurs in children). A low-dose scan of 0.79 mSv was performed in just 0.5 seconds, without the need for sedation.

Right: This 3-month-old-patient has congenital absence of the left lung. The effective dose was just 1.2 mSv. A single volume scan, obtained during free breathing and crying and without sedation, used just one rotation in 0.35 seconds.