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VOLUME CT the Key to a Superior Stroke Protocol

Over the last year, Kaleida Health Stroke Center at Millard Fillmore Gates Circle Hospital in Buffalo, N.Y., a national leader in stroke care, revised its stroke protocol with 320 detector row CT to better inform and accelerate clinical decision-making and optimize patient care. The goal is to individualize stroke care by carefully selecting patients for treatment. "Imaging is key," says Kenneth Snyder, MD, PhD, senior endovascular fellow.

The state-of-the-art foundation for the hospital's stroke protocol is the Aquilion ONE dynamic volume CT scanner from Toshiba America Medical Systems. The dynamic volume CT solution images the entire brain and shows real-time brain function with greater detail and in less time than conventional MR or 64-slice CT imaging systems.

"The ability to better inform and accelerate clinical decision-making is especially important in stroke patients," says Michael Miller, MD. "Time is brain. Saving even 15 minutes in the lead time to diagnosis can make a significant difference in clinical decision-making and guide patient treatment, which impacts outcomes." In addition, the dynamic volume solution provides a whole-brain perfusion map. The complete dataset helps physicians better select patients for treatment and removes artificial time constraints. The new protocol represents a giant step forward for the stroke center, which is one of a handful of centers nationwide to earn the Gold Seal of Approval and Disease-Specific Care Certification for Acute Stroke from the Joint Commission on Accreditation of Healthcare Organizations.

Aquilion ONE provides additional benefits as well. Image quality can surpass MRI and 64-slice CT in acute stroke patients, many of whom are confused, agitated and moving continuously. In addition, the volume acquisition mode allows sub-second routine brain imaging, which can minimize motion artifact on some sequences. Aquilion ONE whole-brain volume perfusion imaging allows evaluation of blood supply to the entire brain that is not possible on conventional helical scanners, in much less time and with fewer artifacts than MR perfusion.

Developing the new Aquilion ONE protocol required the commitment and collaboration of a multi-disciplinary team of radiologists, clinicians, technologists, nurses and IT personnel, backed by a strong partnership of Kaleida Health System, Toshiba and its workstation partner Vital Images. The end benefits—improved and accelerated decision-making and better informed treatment—demonstrate the value of the Aquilion ONE Neuro One acute stroke protocol.

The challenges of conventional stroke imaging

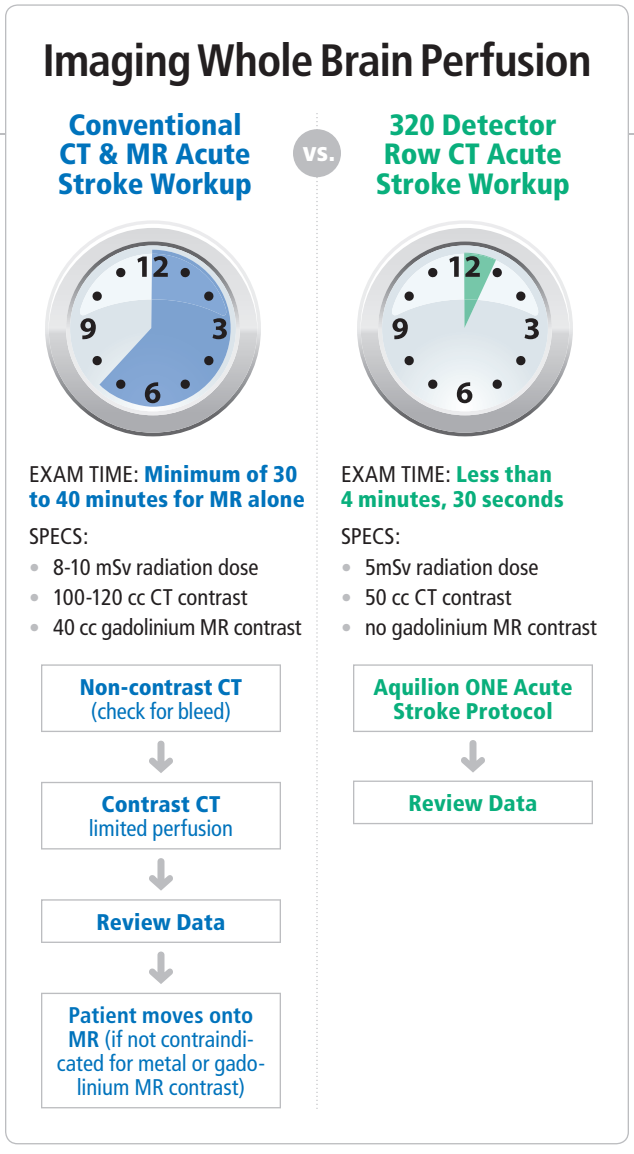
When Millard Fillmore Hospital opened the Kaleida Health Stroke Center, physicians relied on MRI, MRA and MRP to diagnose strokes. The first-generation acute stroke imaging protocol consisted of a limited brain MRI, MR perfusion and MR angiography of head and neck vessels, and it required gadolinium contrast agents. These techniques presented several challenges.

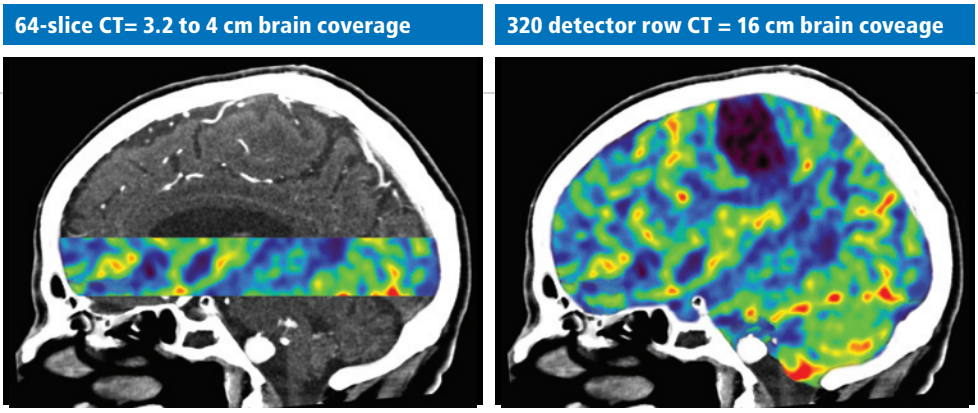
The first challenge was time. After months of tweaking, the optimized MR protocol required about 15 to 20 minutes to complete—after appropriate magnetic environment safety screening. "Patients must be screened prior to MR imaging for the presence of foreign bodies, aneurysm clips and pacemakers," explains Miller. Patients who could not provide an immediate history were subjected to a pre-MRI screening protocol that included x-rays of the skull, neck, chest, abdomen and pelvis to ensure a safe MR scan. Screening the typical stroke patient who presents to the ER confused, aphasic, comatose or otherwise unable to give a history is not only challenging but also adds time to the diagnostic process. "X-ray imaging and interpretation might add as much as 15 to 20 minutes to the process," shares Miller.

The second challenge also related to time. Individual MR series entail a fairly lengthy acquisition time. Consequently, studies are prone to motion artifacts that can degrade diagnostic value and accuracy. One way to reduce motion artifacts is to use conscious sedation in the MR suite for agitated patients, but conscious sedation adds time and risk to the imaging process.

The final MR challenge came on the patient safety side. The protocol required a cumulative gadolinium contrast load of approximately 40 ccs. In many cases, physicians could not determine patients' renal function prior to contrast injection, potentially putting patients at risk for nephrogenic systemic fibrosis (NSF).

The first-generation protocol was far from ideal. The image acquisition and review processes might take an hour or longer,





Left: 64-slice CT can cover only 3.2 to 4.0 cm per gantry rotation for limited brain perfusion studies with typically 8-10 mSv for the entire study. Right: 320 detector row CT can cover 16cm per gantry rotation to visualize whole brain perfusion with typically less than 5 mSv of radiation for the entire study. Note: The dark area that comprises compromised brain tissue that would have been missed on conventional MDCT.

delaying diagnosis and impacting treatment options. Tissue Plasminogen Activator (tPA), for example, should be administered within three hours of symptoms to reduce the effects of stroke and minimize permanent disability.

In 2007, the hospital invested in an Aquilion 64-slice CT scanner and revised its stroke protocols to leverage the new system. The stroke center partnered with Toshiba and Vital Images to develop the new protocol. The four-step protocol started with a non-contrast head CT to assess the patient for hemorrhage. Next, a dynamic CT perfusion study of the brain assessed 3.2 centimeters (cm) of tissue for perfusion defects. The final steps entailed dynamic helical CT angiography of the head and neck and a head CT with contrast. The shift from MR to CT imaging decreased scan time from 15 to 20 minutes to five to 10 minutes, and it eliminated the need for lengthy pre-MRI screening and x-ray imaging.

"Surgeons embraced the new protocol, reporting that the Aquilion 64 provided excellent anatomic information combined with the physiologic datasets needed to detect perfusion defects that might require endovascular intervention," explains Miller.

The 64-slice system, however, did leave some room for improvement. The primary limitation of the 64-slice system is coverage; physicians select a 3.2 to 4 cm section of brain rather than the entire brain to create the perfusion map. To cover an entire brain, physicians need the ability to acquire a 12-to-16 cm volume. Consequently, clinical understanding of a patient's brain perfusion is incomplete with 64-slice CT imaging.

The next step in stroke care

In June 2008, Millard Fillmore Hospital joined other leading-edge hospitals around the country and added an Aquilion ONE dynamic volume CT system to its imaging infrastructure with plans to leverage the new solution for acute stroke imaging.

Millard Fillmore physicians worked with research pioneers at Johns Hopkins Hospital in Baltimore, Md., to revise its stroke protocol for whole-brain volume imaging. The Aquilion ONE stroke protocol has allowed the hospital to launch a state-of-the-art stroke treatment program that is faster, safer and more accurate. Clinical decisions are more informed and accelerated, physicians agree.

Dynamic volume CT transcends the limitations of 64-slice CT because it has 320 detector rows and can cover up to a 16 cm volume. This gives physicians the ability to create a perfusion map of the whole brain in less than one minute and with less than 5 mSv of radiation dose.

"With Aquilion ONE, we can use CT perfusion imaging to better guide stroke decision-making and care," states Snyder. The dynamic volume solution offers whole-brain perfusion mapping capabilities that assess the full brain vasculature. More complete data about perfusion helps physicians locate viable tissue, providing the data necessary to treat patients up to 24 to 36 hours after a stroke. If the perfusion map shows viable tissue, the time window is extended and the patient is treated. "Within five minutes of the scan, we can put the patient on the endovascular table to remove the clot. We've been able to treat many patients eight hours after a stroke and send them home the next day," says Snyder. Conversely, if the map shows the tissue is not viable, physicians obtain definitive news faster, giving them the ability to eliminate additional, unnecessary procedures.

In addition to improving and better defining the pool of patients eligible for endovascular treatment, the Aquilion ONE delivers dramatic improvements in image quality and patient safety, says Miller.

"Aquilion ONE delivers high-quality information in a fraction of the time of the MR protocol. In many ways, CT datasets are superior to MR datasets. Overall, the anatomic angiographic assessment is better with CT than MR. MR-angiography is prone to artifacts, but with CT, techs obtain a diagnostic quality study in almost every case. In addition, resolution of whole-brain perfusion CT images is better than MR perfusion images," states Miller.

The list of improvements continues. Radiologists instantly reconstruct images in any plane to provide neurosurgeons with a better view of any anatomic abnormalities, which better guides surgical intervention. Dynamic volume CT produces volume datasets that are well-suited to motion correction, further improving image quality. What's more, the Aquilion ONE protocol includes CT angiography from the aortic arch to vertex, which provides an additional look at the Circle of Willis in high spatial and contrast resolution.

In fact, one of the most important benefits of dynamic volume CT over 64-slice systems is extended coverage. Scanners with less than 320 detector row are limited to thin 3.2-to-4.0 cm sections, resulting in blind spots during the perfusion study. Dynamic volume CT extends the perfusion range up to 16 cm coverage from skull base to vertex, allowing radiologists to assess the patient for acute stroke and ischemia in areas that remain masked during 64-slice scans. Perfusion imaging is a key component of the protocol. "The strength of perfusion imaging is that it tells us which

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areas of the entire brain are abnormal, gives an idea of relative cerebral blood flow and volume and directs the reader's attention to the vascular anatomy that needs to be interrogated. We can zero in on abnormalities rather than trying to assess the entire cerebral circulatory system at once. Frequently, we see abnormalities on Aquilion ONE studies that we would not be able to visualize on conventional CT systems," reports Miller. Dynamic volume CT makes it possible for radiologists to pinpoint the exact location of a lesion to direct surgeons to the abnormality.

Dynamic volume CT also offers a new level of flexibility, allowing radiologists to optimize resolution. Prior to Aquilion ONE, the stroke protocol called for identical techniques for every partition, which is not ideal for clinical needs. After physicians indicated that improved spatial resolution of small vessels during the mid-arterial phase could benefit decision-making, Miller and his colleagues implemented Toshiba's built-in technique boost feature to increase resolution mid-way through the acquisition. "It increases resolution for those partitions and provides a rapid review of cerebral circulation as soon as the cerebral perfusion and 4D CT digital subtraction angiography data (CT DSA) is processed," explains Miller.

On the patient safety side, Aquilion ONE, like Aquilion 64, eliminates safety concerns and ferromagnetic contraindications. In addition, the ultra-brief scan time and comfort level of CT compared to MR translates into a hefty drop in the number of patients who require conscious sedation prior to stroke imaging.

Optimizing the investment: Workflow and IT infrastructure updates

The primary benefits of dynamic volume CT also bring new challenges. Although the system produces essential images for acute stroke management, the data output from the 320-detector row volume CT requires some adjustments—particularly in IT infrastructure and workflow patterns. "The datasets are large," confirms Miller, "It's a struggle to manage, process, and interpret all of the data. The CTP [CT perfusion] sequence generates more than 6,000 images in less than a minute, which are then processed on the Vital Images Vitrea fX workstation for review. The typical completed acute stoke protocol averages between 1,200 and 1,400 images (0.6 to 0.7 GB) on PACS."

When Millard Fillmore Hospital initially deployed the new system, it took about 10 minutes to transfer and process the data acquired during the less than one minute CTP scan. "Neurosurgeons told us the time frame was unacceptable," recalls Miller. Radiologists and IT staff collaborated closely with Toshiba and Vital Images to slash the time to transfer and process datasets to less than four and a half minutes. This more than 50 percent improvement impressed the staff and is now state of the art for acute stroke neuro imaging workflow. This improvement included the latest enhanced DICOM workflow, dedicated high-speed connections between the scanner and Vitrea fX workstation, revised processing algorithms and changes in the order of background processing.

There are image management challenges, too. "Our neurosurgeons, who are invested in stroke research, beseeched us not to dispose of the source data acquired during the perfusion scan," says Miller. The request is reasonable; perfusion datasets can be useful for research and comparison purposes. In practice, however, the request represented a tremendous challenge. Complete neuro CT studies have grown from about 0.5 GB with the 64-slice CT to 3 to 6 GB with the Aquilion ONE. The Toshiba solution is a parallel image management system; a dedicated image cache managing CT datasets that can be accessed later for research or comparison.

Another challenge comes on the radiologist workflow front. "Aquilion ONE produces datasets faster than we can handle," confirms Miller. At Millard Fillmore Hospital, the scanner is used for 10 to 15 stroke studies and 10 to 15 head CT scans every day. This study volume forces radiologists to work better and faster, says Miller. Nearly one year since deployment, radiologists have adapted, in part by using system features that automate workflow.

Tools like Toshiba SURESubtraction technology provide valuable assistance to clinicians. The feature is predicated on basic subtraction similar to bone subtraction techniques used in digital subtraction angiography. The application automatically subtracts bone from the pre- and post- contrast neuro CT images to save time and provide a clearer view of anatomical structure. These subtracted volumes can be automatically transferred and archived as their own DICOM dataset. "It allows rapid assessment of cerebral circulation," sums Miller. Other features automate contrast injection timing, auto-transfer, post-processing to boost technologist efficiency. Prior to automated post-processing tools, technologists could spend 20 to 30 minutes on each case. With automation, the time technologists spend post-processing drops to a few minutes per study.

Anatomy of the state-of-the-art stroke protocol

Current, conventional diagnostic stroke imaging is not optimal. The MRI process requires a minimum of 30 to 40 minutes, which may impact a patient's treatment options. Although 64-slice CT offers improvements over MR imaging, it is not an ideal solution. That's because it does not provide a complete picture of brain vasculature, so physicians can not ascertain if brain tissue is viable prior to clot removal or treatment. Dynamic volume CT now fills the gaps to provide a superior platform for state-of-the-art stroke diagnosis and treatment. In addition to delivering superior image quality, the dynamic volume system creates a perfusion map of the entire brain to better inform clinical decision-making. Specifically, physicians can determine whether or not brain tissue is viable. Aquilion ONE provides detailed diagnostic data within minutes, which enables physicians to determine optimal treatment for patients. The system images the entire brain vasculature within one minute to provide physicians the essential data needed to accurately identify which patients will benefit from treatment regardless of how much time has elapsed since the stroke. "Aquilion ONE provides the imaging data needed to individualize stroke care," sums Snyder. H&I