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Computed tomography

White paper

Economic impact of IQon for patients with renal insufficiency

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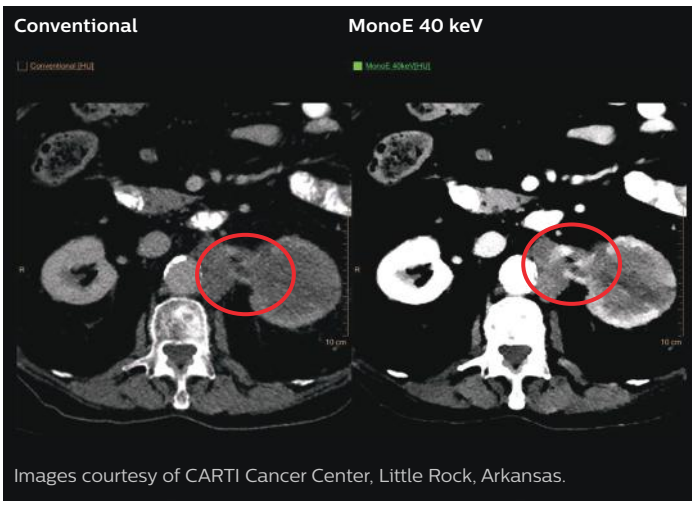
The evolution of multi-detector computed tomography (MDCT) throughout the past decade has established its position as the workhorse of radiology. MDCT is used in routine examinations, such as thoracic, abdominal, pelvic, brain, neck, and spine. About 50% of examinations on MDCT are performed with the injection of iodinated contrast. Iodinated contrast highlights the blood vessels and enhances the structure of organs such as liver, kidney, brain, etc. In oncology patients, use of iodinated contrast can enhance the lesions, facilitating easier detection and boundary delineation.

With health care in United States moving more towards value-based care, it is essential for hospitals to improve clinical efficiency and reduce duplication of services to make it easier for people to get the care they need. In value-based models, doctors and hospitals are accountable for treating and improving the health of those who have chronic conditions in a cost-effective way. Today, accountable care organizations are transforming care delivery by paying health systems and doctors based on their success at improving overall quality, cost, and patient satisfaction with their health care experience. Physicians and hospitals are continuously looking for tools and technologies to help treat the patients in the most cost-effective way.

IQon SDCT

Dual-energy CT scanners have been in clinical use for a few years. However, all the dual-energy scanners are source-based (KVp switching or dual source), requiring the user to make a decision *a priori* whether a patient needs to be scanned in dual-energy mode. Also, source-based dual-energy scanners are limited in terms of dose modulation capabilities. The latest innovation in CT detector technology is the IQon spectral detector CT (SDCT), which has been introduced for spectral scanning. This scanner has a single X-ray source and a two-layer detector. The top layer selectively absorbs low-energy photons and the bottom layer absorbs high-energy photons, thus providing two distinct energy data sets.[1] In addition to the conventional images that are obtained by utilizing combined data from both detector layers, additional spectral analysis can be obtained by decomposition of the low- and high-energy data. A unique feature of this technology is that there is no need to prospectively screen and select patients for dual-energy mode since all the patients scanned on this scanner will have spectral information available on demand, even patients for whom there would have been no specific clinical indication for a dual-energy acquisition. Hence, there is no need to change the existing clinical protocol or workflow. Other advantages of the scanner include spatial and temporal alignment, low artifacts, availability of all dose tools, and no field-of-view limitations or cross-scatter effects. Spectral CT imaging can add different spectral image types and clinical value to the conventional data.



Images courtesy of CARTI Cancer Center, Little Rock, Arkansas.

Low MonoE allows improved visualization of the vascular structures on this delayed CT.

Contrast-induced nephropathy (CIN)

The amount of contrast media delivered to a patient during a CT scan is of utmost concern due to the risk of complications, particularly contrast-induced nephropathy (CIN). Contrast-induced nephropathy is defined as acute renal failure occurring within 48 hours of exposure to intravascular radiographic contrast material that is not attributable to other causes, and it is the third most common cause of hospital-acquired acute renal failure. Prevention of CIN has been the subject of many discussions; however, due to non-standardized implementation of contrast management techniques, there has been limited success with varying results across different sites. It is well-known that visualization in CT scans benefits from the use of iodinated contrast media. The injection technique – including volumes, concentrations, and injection rates –depends on the patient size and individual clinical sites. However, the risk of CIN increases with increased contrast volume. Efforts to reduce contrast volume per patient study may reduce the risk of CIN and provide institutions with an overall clinical and economic benefit.

Spectral results

Spectral results derived from IQon SDCT include iodine-based results, virtual non-contrast (VNC), virtual mono-energetic images (from 40- 200 keV), effective atomic number, and uric acid, and assist in clinical decision making. A brief description of these spectral results are listed below.

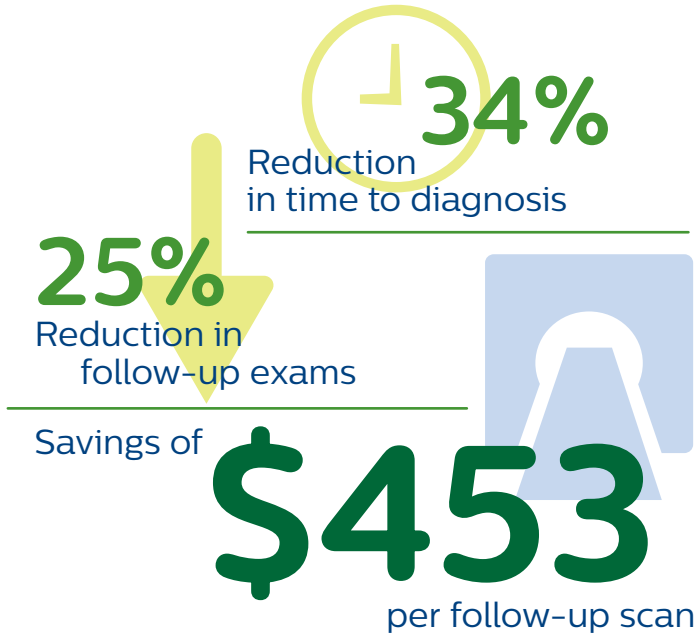
- **Iodine-based results** – Material density image that shows materials that behave like iodine and not like water. The results are useful in identifying iodine uptake in images and also quantifying iodine.
- **Virtual non-contrast image** – Shows image as if iodine component is removed but data shows attenuation as if no iodine was present, useful for simulating a non-contrast scan.
- **Mono-energetic image (MonoE)** – Image shows attenuation as if a single monochromatic energy (keV) were used to scan. This result would be useful in boosting the iodine signal, improving contrast-to-noise ratio at low keVs and reducing artifacts (metal and beam hardening) at high keVs.

*http://www.nejm.org/doi/full/10.1056/NEJMra072149

- **Effective Z** (effective atomic number) – Shows effective atomic number value at every pixel which is derived from the photo and scatter values computed from the low- and high-energy signals. This results are useful in material and tissue differentiation.
- **Uric acid** – Generated by computing and the identifying pixels where uric acid is present. The HU values are same as MonoE 75 keV for uric acid pixels. This results provide assistance in detection of uric acid stones, detection of uric acid deposits due to gout, and tendon visualization.

In the current article we will focus on low MonoE results, which boost iodine signal in the CT image allowing the user to manage the amount of iodinated contrast delivered to the patient. These results are those that are most pertinent to this study, conducted by CARTI Cancer Center who performed head,neck, chest, and abdomen pelvis scans in patients with a high risk of CIN (due to low eGFR) with limited amount of iodinated contrast. These patients originally would not have been candidates for contrast-enhanced CT scans. They would have received non-contrast CTs, and depending on the findings, they would have received follow-up scans on another imaging modality such as MRI or ultrasound. The ability to scan these patients with low volumes of contrast helps with the clinical diagnosis and also reduces the overall imaging costs for these patients by reducing follow-up scans on other modalities.

CARTI Cancer Center is a leading outpatient imaging center in Little Rock, Arkansas. Most of their patients are referred for oncology based investigations and follow-up. The IQon Spectral Detector CT was installed in August of 2016. Patients are routinely referred for follow-up CT examinations. CARTI would refer all the patients with a high risk of CIN (reduced eGFR) to non-contrast CT scans since these patients would be able to tolerate the volume of contrast that CARTI uses for the contrast-enhanced CT scans (CECT) for oncology evaluations. Their typical dose for a CECT exam for oncology evaluation was 80-130 cc. After the installation of IQon, physicians at CARTI realized the benefits of MonoE results on IQon and started scanning patients with reduced kidney function (reduced eGFR) using 50-80 cc of contrast and using low MonoE spectral results to boost contrast enhancement in the study. This allowed them to get the full benefits of contrast-enhanced exams without using the full volume of contrast.



Study design

The study included a total of 60 patients. These patients were divided into two groups. Group 1 consisted of 30 patients with reduced renal function (based eGFR values) scanned without contrast on a Philips iCT scanner. Patients were scanned with a collimation of 128*0.625, slice thickness of 3 mm, slice increment of 3 mm, pitch of 0.984, at 120 KVp. Group 2 consisted of patients with reduced renal function scanned with 50-80 cc of contrast scanned on a Philips IQon SDCT. Scanning protocol for patients in Group 2 was the same as Group 1. Both groups had CT scans that were obtained for head and neck; or chest, abdomen, and pelvis; or head and neck combined with chest, abdomen, and pelvis. Most of these patients were scanned for an oncology evaluation. They were either initial diagnostic scans or therapy follow-up exams.

A retrospective data review on PACS and electronic management of records (EMR) was also performed to evaluate the number of follow-up scans received by patients in Group 1 and Group 2 over a period of three months following the initial non-contrast CT or low-contrast volume CT. EMR and PACs records were reviewed for every patient to collect information on the follow-up scans received on other imaging modalities such as magnetic resonance imaging (MRI) and ultrasound (US). The dates of the original and follow-up scans on other modalities were recorded to calculate the time to final diagnosis. Time to diagnosis was calculated using the dates of the original CT exam and the follow-up exams.

Results

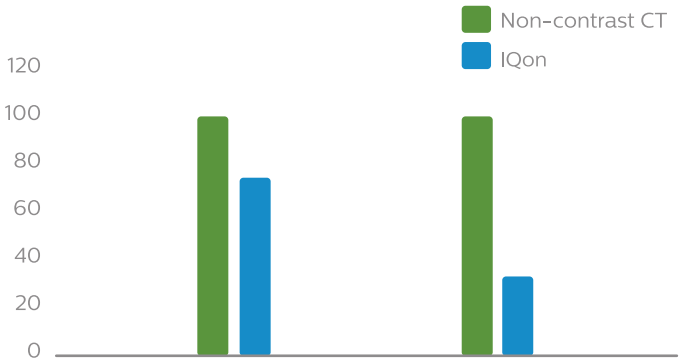
The retrospective data review of the 60 patients within the two groups was conducted. The analysis revealed that the 30 patients that received a non-contrast CT would need additional diagnostic tests. They would need an additional follow-up MRI and two ultrasound scans within a period of three months.

Required follow-up exams to come to a diagnosis

	Non-contrast		IQon		Follow-up reduction
	#	%	#	%	%
MRI	4	13%	3	3%	25%
Ultrasound	3	10%	1	10%	67%

This would result in additional average cost of $453 per follow-up scan (based on the average cost of **MRI = $1109.43** and **ultrasound = $124.89**, from Medicare reimbursement costs) in patients using non-contrast CT as compared to IQon in this group of patients.* Also, the need for additional follow-up scanning to would add additional time to diagnosis. Use of contrast-enhanced scans on IQon SDCT reduced the time to diagnosis of those patients from 100 days to 66 days. This is a **34% reduction in time to diagnosis**.

% Reduction in follow-up exams



*Based on CMS.gov, Coding and Revenue Resource Center, MediRegs.

We can take the clinical and economic impact that we have seen at CARTI Cancer Center – an outpatient imaging center – and apply it to a large health system. A large health system or IDN (integrated diagnostic network) usually performs an average of 400,000 total CT scans annually. If 5% of those scans were patients with reduced renal function, that would be about 20,000 scans. Applying the methodology mentioned earlier, significant economic benefits can be realized at an IDN level, based on the **average savings of $453 per follow-up scan**.

Conclusion

The use of IQon spectral detector CT allows scanning of patients with high risk for CIN by using iodinated contrast. The ability of MonoE results to boost iodine signal at low keVs allow for improved visualization of structures at low volumes of iodinated contrast. This enables CECT scanning of patients that would have received a non-contrast CT scan. The use of contrast on these patients improves the clinician's ability to identify and delineate lesions and structures in solid organs such as liver, kidney, pancreas, neck, brain, etc., thereby reducing the need for follow-up exams.

Collectively, IQon allows scanning on an expanded patient population and enables contrast-enhanced scanning on a patient population that would not have been eligible to receive contrast. This reduces the time to diagnosis by 34% and also reduces the need for additional follow-up scans for this sub-group of patient population.

Results from case studies are not predictive of results in other cases. Results in other cases may vary.

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