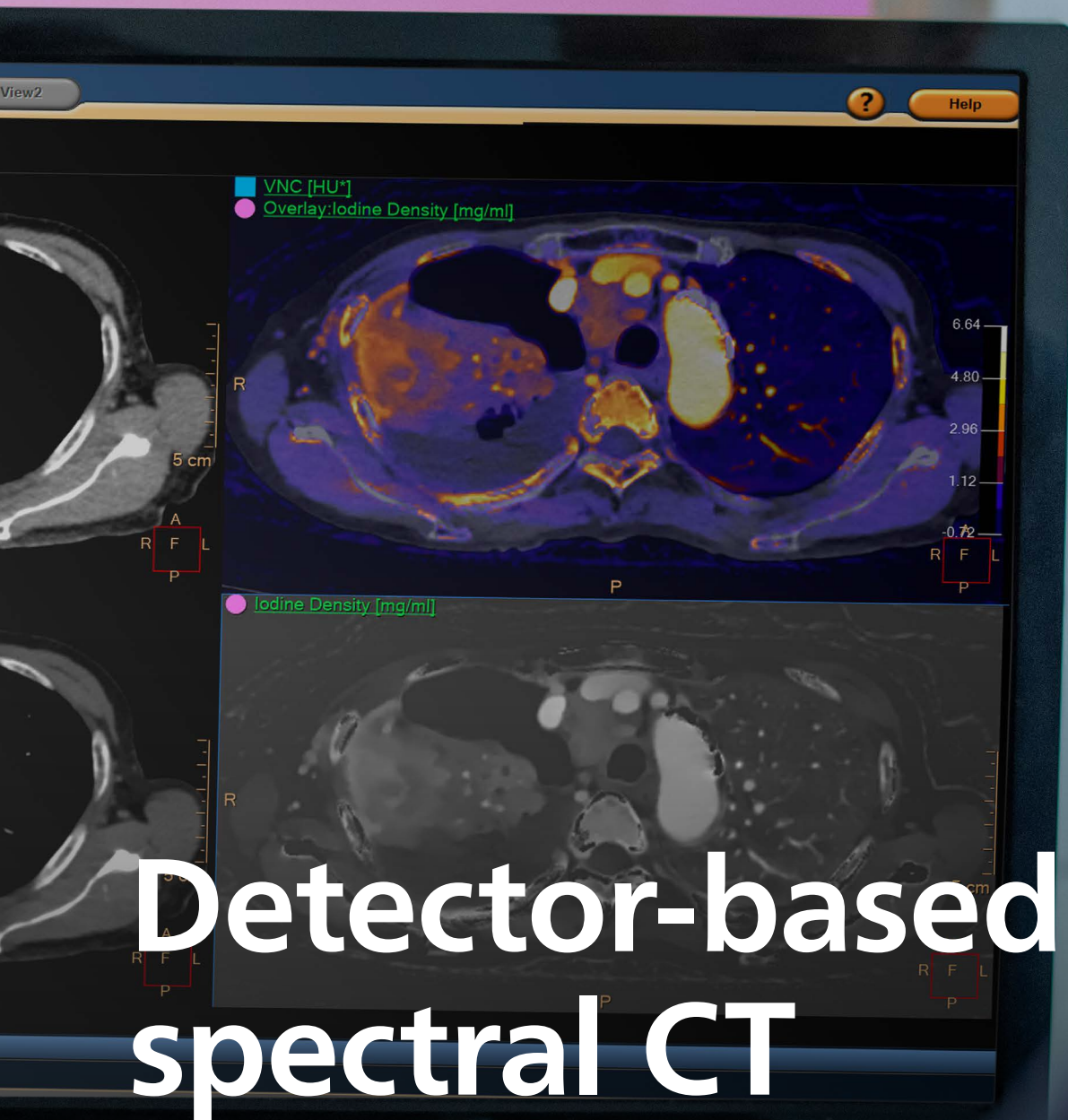# PHILIPS

Computed Tomography

Detector-based spectral CT
Clinical Publication Compendium

Summary Publication Review

Takes you back to **homepage**

Takes you to **publication page**

Takes you to **summary publication review**

Introduction

The Philips detector-based spectral CT scanners acquire spectral results within a single exposure for any clinical procedure and in a single, low-dose scan. Spectral detector computed tomography (SDCT) is a breakthrough dual-energy technology that uses two layers of detectors to simultaneously collect low- and high-energy data.

The spectral data is used to generate conventional polyenergetic images as well as dedicated spectral results, including virtual monoenergetic (monoE), iodine density, virtual non-contrast, calcium suppressed, effective atomic number and electron density. The "always on" detector-based spectral CT workflow makes it easy for clinicians to integrate spectral imaging into existing clinical workflows.

• The appropriate spectral result images are programmed into Exam Card protocols at the scanner and generated automatically for each exam and sent to PACS to be viewed in the clinician's desired hanging protocols

• Spectral results are also available on demand throughout the enterprise – anywhere, anytime: using the Philips Advanced Visualization Workstation (AVW), AVW access through PACS, or the Spectral Magic Glass on PACS visualization plugin.

This publication overview summarizes a subset of the more than 770+ peer-reviewed publications and white papers that have been published (as of July, 2024) describing the benefits of Philips spectral-detector technology. These publications are organized by clinical application and explore a wide range of detector-based spectral CT benefits, many of which are unique to spectral-detector technology and simply not possible with source-based multi-energy CT technologies.

Always on detector-based spectral CT workflow
Every detector-based spectral CT scan always provides a true conventional CT image as well as retrospective access to all detector-based spectral CT results, eliminating the need for patient selection, multiple scans, or special protocols. Spectral results are available when desired as pre-prescribed reconstructions, integrated with Philips Advanced Visualization Workspace, or with on-demand PACS viewing.

Increased diagnostic certainty
Improved tissue characterization and visualization, along with functional and quantitative information provides additional clinical information to aid in decision-making.

Reduced follow-up scans
Increased diagnostic certainty can reduce the need for additional imaging, speeding the time to diagnosis and reducing overall healthcare costs.

Address diverse patient populations
Capabilities such as full field of view spectral results, 100 kVp detector-based spectral CT, and low noise spectral results enable spectral CT usage from pediatric to bariatric patients.

CT dose
The ability to create a true conventional image and any spectral results from a single scan, with the use of iterative reconstruction and standard dose management tools, enable dose-neutral detector-based spectral CT.

Contrast agent management
By identifying and boosting the visualization of iodine, a lower dose of contrast agent is required to achieve diagnostic results. This can expand patient eligibility, salvage scans with suboptimal enhancement, and even save cost.

Artifact reduction
Detector-based spectral CT has been shown to reduce artifacts such as beam hardening, calcium blooming and metal artifacts.

Advanced clinical challenges
See beyond the limitations of conventional CT and begin to address advanced challenges in multiple clinical applications.

Oncology

Impact of spectral body imaging in patients suspected for occult cancer:

A prospective study of 503 patients

Objective

To investigate the diagnostic impact of spectral CT in the detection and characterization of cancer.

Method

- 503 patients with serious symptoms suspicious for cancer prospectively divided into two cohorts:
  1) Read with only conventional CT images
  2) Spectral CT images were also available
- The routine clinical pathway for general cancer workup was used
- 3 months later, the cases re-read as per the other cohort
- Diagnostic findings were compared with eventual known patient outcomes

Results

Compared to only conventional CT, spectral CT demonstrated:

- Higher sensitivity in cancer detection (89% vs. 77%)
- Higher diagnostic certainty in characterizing cysts (96% vs. 30%)
- Fewer follow-up procedures required for diagnostic certainty (0.25 vs. 0.81 / patient)
- Reading times nearly the same: +82 seconds with additional spectral interrogation

Conclusion

Spectral CT increases the confidence in characterization of lesions & minimizes the need for additional exams.

Translation to practice

Both clinical (cancer detection, cyst characterization) and operational (fewer follow-up exams, increased throughput) benefits of spectral CT were demonstrated.

First Time Right	Increased Throughput	Decreased Follow-Up Exams	IV Contrast Reduction
Cost Savings	Workflow Improvement / Simplicity		

Economic impact of spectral body imaging in diagnosis of patients suspected for occult cancer

Objective

To perform an economic analysis comparing the cost of downstream diagnostic procedures following spectral CT and conventional CT cancer diagnostic examinations.

Method

- 400 patients with serious illness suspected to be cancer received contrast enhanced C/A/P spectral CT scans
- Recommended follow-up procedures were defined separately for each patient: using only the conventional CT results and using the spectral CT results

Results

- A total of 573 follow-up procedures for the 400 patients were recommended when only the conventional CT results were evaluated compared to 370 follow-up procedures when the spectral CT results were available. This was a 36% (#203) reduction of follow-up procedures

- The cost of the unnecessary 203 procedures was calculated to be €52k using Danish reimbursement costs and $69k using United States reimbursement costs

Conclusion

- Spectral CT is an advanced imaging modality for suspected occult cancer
- A substantial number of follow up diagnostic procedures can be avoided because of the spectral results
- The reduction in follow up studies would result in significant cost savings for the health system

Translation to practice

In addition to reduced cost to the healthcare system, the reduction in follow-up procedures enabled by spectral CT could contribute to reducing the patient's time to diagnosis and reducing wait times for these procedures and increased departmental throughput with additional CT exam slots available.

First Time Right	Increased Throughput	Decreased Follow-Up Exams	IV Contrast Reduction
IV Contrast Reduction	Cost Savings	Workflow Improvement / Simplicity	Improved Image Quality

Double low-dose dual-energy liver CT in patients at high-risk of HCC:

A prospective, randomized, single-center study

Yoon JH et al. Investigative Radiology 2020

Objective

To investigate the clinical feasibility of simultaneous reduction in CT and contrast doses for Hepatocellular Carcinoma (HCC) patients.

Method

- 67 HCC patients were prospectively assigned to two groups:
- 32 patients received standard CT and contrast dose conventional CT scans
- 35 patients received "double low dose" (30% reduction in CT and contrast dose) spectral CT scans
- A qualitative & quantitative comparison of noise, contrast, contrast-to-noise ration (CNR), overall image quality, & lesion conspicuity was performed between the two groups

Results

Compared to full dose conventional CT images, 50 keV MonoE spectral CT results at 30% lower radiation and contrast media doses demonstrated:

- Better focal liver lesion conspicuity
- Significantly better subjective image noise & CNR
- Better noise, contrast, overall IQ, & lesion conspicuity performance

Conclusion

"Double low dose" 50 keV MonoE spectral CT results can provide better focal liver lesion conspicuity compared to full dose conventional CT images.

Translation to practice

The ability to simultaneously reduce radiation and contrast media doses, while improving image quality, is particularly beneficial for HCC patients where multiple multi-phase scans and renal dysfunction are common. Departmental cost savings may be recognized with the reduction in IV contrast dosage.

| First Time Right | IV Contrast Reduction | Cost Savings | Workflow Improvement / Simplicity |

| Quantitative DL Spectral CT | Improved Image Quality |

Dual-layer DECT for multiphasic hepatic CT with 50 percent iodine load:
A matched-pair comparison with a 120 kVp protocol

Objective

To evaluate the image quality and lesion conspicuity of MonoE spectral CT results for reduced contrast load multiphasic hepatic CT scans.

Method

- Two matched sets of 45 patients with known or suspected hepatic tumors each received multi-phase hepatic CT scans:
  - Patients with kidney dysfunction (low GFR) received spectral CT scans with 50% reduction in contrast dose. Multiple low MonoE results were created
  - A control group of similar patients received conventional CT scans with a normal contrast dose
- The follow parameters were compared: CT dose, CT attenuation, contrast-to-noise ratio (CNR), image quality, and lesion conspicuity

Results

Compared to conventional CT, the 50% contrast dose low MonoE spectral results demonstrated:

- Significantly lower CT dose

- Significantly better attenuation and tumor CNR

- Comparable or better image noise and tumor conspicuity

Conclusion

Low MonoE spectral results at 50% reduction in iodine load and lower CT dose provide equivalent or better image quality and lesion conspicuity compared to conventional CT for multi-phasic hepatic scans.

Translation to practice

Spectral CT can help with the challenging balance of contrast load in patients with kidney dysfunction (low GFR), CT dose, and image noise for multi-phase hepatic CT scans.

First Time Right	Decreased Follow-Up Exams	IV Contrast Reduction	Cost Savings

Improved Image Quality

Head and neck squamous cell carcinoma:
Evaluation of iodine overlay maps and low-energy virtual mono-energetic images acquired with spectral detector CT

Zopfs D et al. Clinical Radiology 2022

Objective

To evaluate the diagnostic value of spectral CT in the assessment of head & neck cancer prior to therapy selection.

Method

- 56 patients with confirmed squamous cell carcinoma were imaged with spectral CT for staging purposes
- Quantitative and qualitative image quality were evaluated for conventional CT, and spectral results using multiple MonoE levels, and Iodine overlays

Results

- Attenuation, tumor Contrast-to-Noise and Signal-to-Noise ratios were significantly higher for 40keV MonoE spectral CT results compared to conventional CT
- Subjective image quality assessment determined that tumor conspicuity and delineation were significantly higher (vs. conventional CT) for both 40kev MonoE and Iodine overlay spectral CT results

Conclusion

40 keV MonoE spectral results had the best performance across the quantitative and qualitative evaluation categories.

Translation to practice

- Squamous cell carcinoma accounts for >90% of head & neck cancers
- Imaging is critical in selecting the best treatment strategy and this work demonstrates the added value of spectral CT

First Time Right   **Quantitative DL Spectral CT**   **Improved Image Quality**

Value of spectral detector computed tomography for assessment of pancreatic lesions

Objective

To investigate the qualitative & quantitative benefits of spectral CT in the assessment of pancreatic lesions.

Method

- 61 patients were identified with known pancreatic lesions detected during portal-venous spectral CT scans
- Spectral CT and conventional CT performance was compared via qualitative scoring and quantitative analysis

Results

Compared to conventional CT alone, spectral CT results demonstrated:

- Significantly better lesion conspicuity and reader confidence
- Significantly higher lesion-to-parenchyma ratios (CNR)

Conclusion

Spectral CT provides significant added clinical value for the imaging of pancreatic lesions.

Translation to practice

- Pancreatic lesion detection and characterization is of critical clinical importance given late-stage mortality rates. But pancreatic lesions are difficult to visualize on CT, particularly on a portal-venous contrast scans
- Spectral CT provides significant incremental diagnostic value for what may often be an incidental or unintended finding that was not originally indicated in the prescription for the CT scan

First Time Right | Decreased Follow-Up Exams | Workflow Improvement / Simplicity | Improved Image Quality

Dual-energy CT-derived iodine maps:
Use in assessing pleural carcinomatosis

Objective

To evaluate spectral CT for differentiation between noncalcified benign pleural lesions (BPL) & pleural carcinomatosis (PC).

Method

- 84 patients with known BPLs (40) or PC (44) received contrast enhanced late venous scans with spectral CT
- A qualitative & quantitative comparison between conventional CT and conventional + spectral CT was performed
- A training dataset (57 patients, 100 lesions) used to determine and optimal Iodine Concentration threshold for differentiating PC vs. PBL. This threshold was applied to a test dataset (27 patients, 40 lesions)

Results

- Compared to conventional CT alone, spectral CT demonstrated better lesion conspicuity & diagnostic confidence
- Spectral CT improved sensitivity and specificity, especially for inexperienced readers (75% to 93% sensitivity for inexperienced, 90% to 98% for experienced)
- The iodine concentration threshold (1.3 mg/ml) was found superior to a conventional HU threshold

Conclusion

Spectral CT improved both the quantitative and qualitative determination of PC vs. BPL.

Translation to practice

- Spectral CT not only increased overall diagnostic accuracy, but brought the diagnostic accuracy of inexperienced readers almost to the level of experienced readers.
- A BPL vs. PC diagnosis can be challenging, requiring additional PET/CT or biopsy if CT if inconclusive

First Time Right	Increased Throughput	Multimodality Comparison	Quantitative DL Spectral CT
Improved Image Quality			

Comparison of contrast-enhanced CT, dual-layer detector spectral CT, and whole-body MRI in suspected metastatic breast cancer:

A prospective diagnostic accuracy study

Objective

To compare the diagnostic accuracy of spectral CT vs. conventional CT vs. whole-body MRI (WB-MRI) for diagnosing metastatic breast cancer.

Method

- 182 breast cancer patients with suspicion of metastatic disease were prospectively imaged on the same day with spectral CT and WB-MRI (T1 & T2 Dixon and DWI images)
- Diagnostic results were compared with the eventual confirmed diagnosis

Results

- On a per-lesion basis:
  - Spectral CT: Sensitivity = 75%, Specificity = 95%
  - Conventional CT: Sensitivity = 66%, Specificity = 94%
  - WB-MRI: Sensitivity = 65%, Specificity = 98%
- On a per-patient basis: spectral CT and WB-MRI had significantly better diagnostic performance vs. conventional CT. Spectral CT was not significantly different than WB-MRI

Conclusion

Compared to conventional CT and WB-MRI, spectral CT had the highest diagnostic performance for diagnosing metastasis on a per-lesion basis.

Translation to practice

- Breast cancer is the most frequent cancer in women and its 5-year survival rate is strongly correlated to the presence of metastatic disease
- Spectral CT was shown to improve the diagnostic performance in the detection of metastatic breast cancer

First Time Right	Multimodality Comparison	Quantitative DL Spectral CT	Improved Image Quality

Value of spectral detector CT for pretherapeutic, locoregional assessment of esophageal cancer

Objective

To Investigate the value of spectral CT for pre-therapeutic assessment of esophageal cancer.

Method

- 74 adult patients were identified with biopsy-proven esophageal cancer who underwent pre-therapeutic portal-venous phase staging spectral CT scans of the chest and abdomen
- A qualitative and quantitative performance comparison was made between conventional CT and spectral CT, using criteria important for pre-surgical assessment

Results

- Spectral MonoE (40-60 kEV) showed higher attenuation, signal-to-noise ration (SNR), and contrast-to-noise ration (CNR) were significantly better than conventional CT
- Spectral CT results were significantly better in assessment of all qualitative categories evaluated: primary tumor, lymph nodes, tumor infiltration, & celiac trunk

Conclusion

Spectral CT MonoE results & Iodine overlays improve the assessment of esophageal cancer prior to treatment.

Translation to practice

- Esophageal cancer is a challenging disease with a high mortality rate. Therapy (surgery) can be risky, so pre-treatment staging is critically important
- Conventional CT has known limitations in staging due to limited soft tissue contrast. This work demonstrated that spectral CT improves clinical performance in this application

First Time Right | Decreased Follow-Up Exams | Improved Image Quality

Adrenal adenomas versus metastases:
Diagnostic performance of dual-energy spectral CT virtual noncontrast imaging and iIodine maps

Nagayama Y et al. Radiology 2020

Objective

To determine whether virtual noncontrast (VNC) and iodine density spectral CT results allow reliable differentiation between adrenal adenomas and metastases.

Method

- 149 adult patients with adrenal lesions underwent unenhanced and portal venous enhanced spectral CT scans
- Diagnostic accuracy was compared between enhanced, unenhanced, VNC, Iodine Density, & Iodine/VNC ratio

Results

Ratio of iodine density to VNC attenuation yielded 95% sensitivity (compared to 85% for true unenhanced images) with comparable specificity.

Conclusion

Combined VNC and iodine density spectral CT results enabled accurate discrimination of adrenal adenomas from metastases.

Translation to practice

- Adrenal lesions are a common finding in CT scans, with most being benign adenomas, but differentiation is a common diagnostic challenge
- Many incidental lesions are found on enhanced scans that are not optimized for adrenal imaging (i.e. multiphase), requiring additional imaging and/or biopsy for diagnosis
- The VNC / Iodine Density ratio effectively combines the two standard conventional CT imaging characteristics (HU value on unenhanced image and washout rate on multiphase adrenal scan), demonstrates excellent diagnostic performance, and avoids a dedicated delayed phase adrenal scan

First Time Right	Increased Throughput	Decreased Follow-Up Exams	IV Contrast Reduction
Cost Savings	Workflow Improvement / Simplicity		

Application value of double-layer spectral detector CT in differentiating central lung cancer from atelectasis

Objective

To evaluate the value of spectral CT in differentiating central lung cancer from atelectasis.

Method

- 51 patients with confirmed central lung cancer + atelectasis were imaged with spectral CT
- The differentiation of cancer vs. atelectasis was retrospectively analyzed by comparing conventional CT with 40 keV MonoE and iodine density spectral CT results

Results

The correct differentiation rate (lung cancer vs. atelectasis) using spectral CT was significantly better than conventional CT (69% – 76% vs. 33%).

Conclusion

- Venous-phase spectral CT can be used to differentiate most central lung cancers from atelectasis and the max diameter measurement of the tumor is consistent
- Spectral CT can accurately identify the borderlines of most central lung cancers without the need for additional imaging modalities

Translation to practice

- The differentiation of central lung cancer from atelectasis is a common clinical challenge during tumor staging, efficacy evaluation, and radiotherapy planning in which conventional CT is often not effective
- Spectral CT may reduce the need more expensive imaging modalities such as MRI or PET/CT

First Time Right   **Decreased Follow-Up Exams**   **CT Dose Reduction**   **Multimodality Comparison**

Dual-layer spectral detector CT in comparison with FDG-PET/CT for the assessment of lymphoma activity

Objective

To explore the potential of spectral CT iodine concentration as an alternate biomarker (to PET/CT) for assessing lymphoma disease.

Method

- 60 lesions in 25 patients analyzed
- The correlation of multiple spectral CT results to PET/CT SUV-max was assessed

Results

In malignant lymphomas, there is a significant correlation between metabolic activity as assessed by FDG PET/CT and spectral CT iodine concentration.

Conclusion

Spectral CT iodine concentration shows promising diagnostic performance for detecting lymphoma activity and may represent a potential new type of imaging biomarker.

Translation to practice

While FDG PET is the gold standard for lymphoma staging and therapy response assessment, spectral CT represents an interesting alternative when there are cost or access barriers to PET/CT.

First Time Right	Decreased Follow-Up Exams	Multimodality Comparison	Improved Image Quality

The value of dual-layer spectral detector CT in preoperative T staging of laryngeal and hypopharyngeal squamous cell carcinoma

Objective

To evaluate the performance of spectral CT MonoE results in visualizing laryngeal and hypopharyngeal squamous cell carcinoma (LHSCC) and its diagnostic performance for preoperative T staging of LHSCC.

Method

- 67 LHSCC patients were imaged with spectral CT
- Spectral MonoE and conventional CT images were evaluated quantitatively and qualitatively
- The optimal spectral MonoE result was compared to conventional CT for T staging accuracy using clinical T staging as the reference standard

Results

- The contrast between the tumor and sternocleidomastoid muscle, SNR, CNR and subjective image quality scores of LHSCC on 40–50 keV MonoE results were significantly higher than those on conventional CT images
- The image noise of 40–100 keV MonoE results were significantly lower than those of the conventional CT images
- The accuracy rates of the 40 keV MonoE and conventional CT images for T staging of LHSCC were 0.86 and 0.63 (P < 0.001), respectively

Conclusion

Compared to conventional CT:

- The image quality of 40–50 keV MonoE results is higher
- The diagnostic accuracy of 40 keV MonoE is better
- 40 keV Mono is most suitable for preoperative T staging of LHSCC

Translation to practice

- Spectral CT can provide superior T staging performance compared to conventional CT
- Accurate preoperative imaging staging provides important reference information for LHSCC treatment selection and planning

First Time Right **Quantitative DL Spectral CT** **Improved Image Quality**

Performance of four dual-energy CT platforms for abdominal imaging: a task-based image quality assessment based on phantom data

Comparison of virtual monoenergetic imaging between a rapid kilovoltage switching dual-energy computed tomography with deep-learning and four dual-energy CTs with iterative reconstruction

Objective

To assess the detection of contrast-enhanced phantom lesions with various virtual monoenergetic image (VMI) energies and compare the spectral performance of dual-energy CT (DECT) platforms using a task-based image quality assessment.

Method

- Two CT phantoms were scanned on four DECT platforms:
  - Fast kV-switching CT (KVSCT)
  - Split filter CT (SFCT)
  - Dual-source CT (DSCT)
  - Dual-layer CT (DLSCT)
- Filtered Back Projection (2021 study) and Iterative or ML recon algorithms (2022 study) were utilized
- Noise power spectrum and task-based transfer function were evaluated over a range of 40 to 140 keV for the VMI images
- Detectability index was computed to model the detection task of two contrast-enhanced lesions

Results

- In both studies the detectability of each simulated contrast enhanced lesion was highest for spectral detector CT at low MonoE
- Spectral detector CT had significantly lower noise magnitude at 40 keV compared to the source-based platforms

Conclusion

Spectral detector CT outperformed various source-based DECT platforms in a task-based image quality assessment.

Translation to practice

- A task-based detectability index is a sophisticated image quality evaluation technique used to assess the detectability of lesions against a background
- The performance of Philips spectral detector CT relative to source-based platforms gives insight into clinical detectability performance
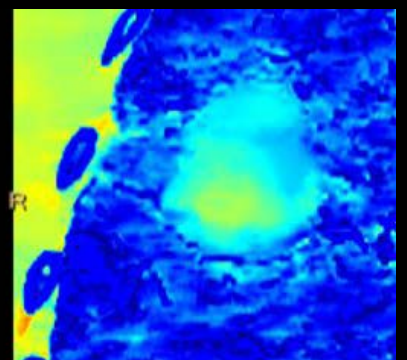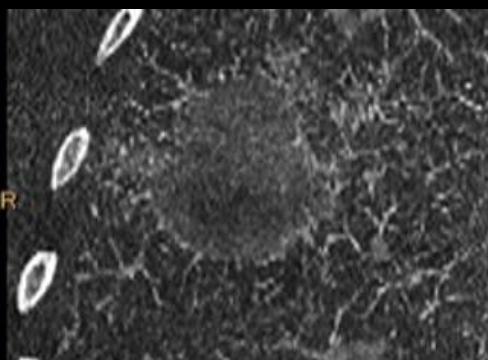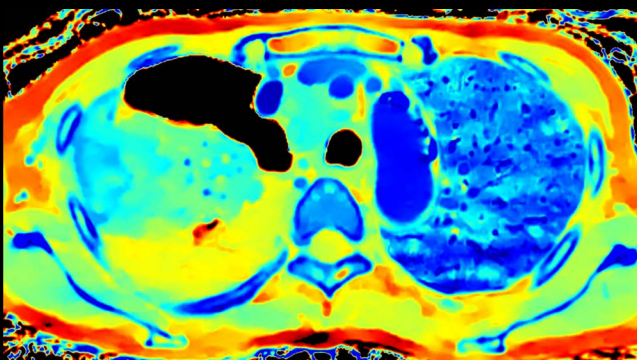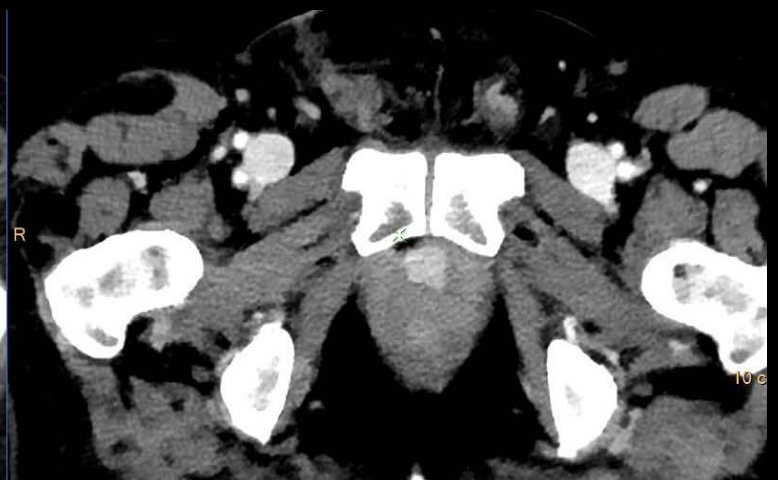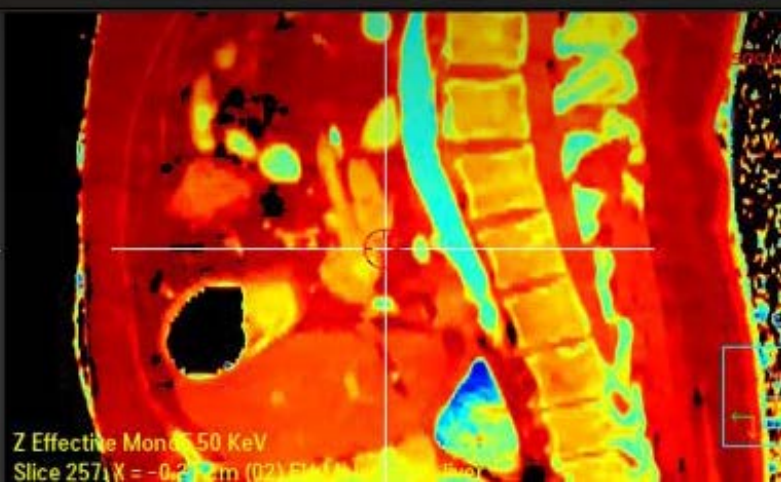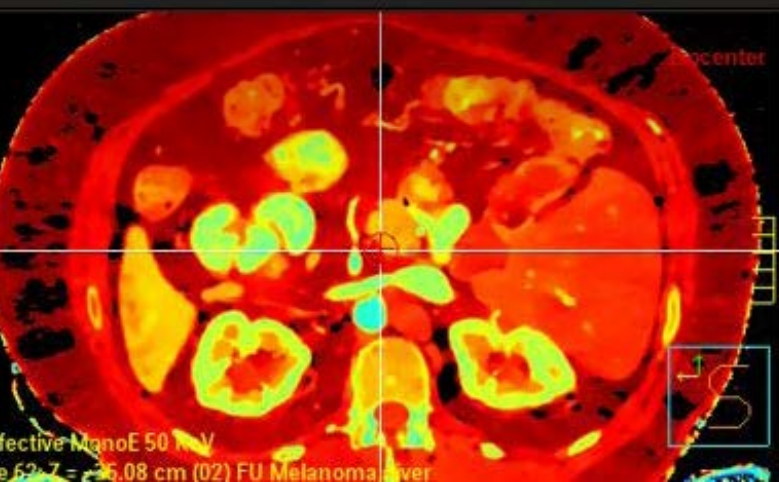
| First Time Right | Increased Throughput | Dual Layer Spectral Technology | Quantitative DL Spectral CT |

| Improved Image Quality |

Radiation Oncology

Improving radiation physics, tumor visualization, and treatment quantification in radiotherapy with spectral or dual-energy CT

Objective

To provide an overview of the current state of spectral CT and explore opportunities for applications in radiotherapysquamous cell carcinoma (LHSCC) and its diagnostic performance for preoperative T staging of LHSCC.

Method

A review of peer-reviewed literature was performed and findings analyzed.

Results

The literature review illuminated three groups of benefits for spectral CT in radiotherapy applications, relative to conventional CT:

- Improved visibility of tumors and organs at risk
- More information about the physical properties of the patient body, which can lead to improved treatment dose calculation
- The availability of quantitative physiological information which can be used to personalize and quantify treatment

Conclusion

- Spectral CT has gained relevancy in radiology applications, particularly in oncologic imaging
- It's use in radiotherapy remains limited, but clear areas of clinical value have been identified

Translation to practice

The Philips Spectral CT 7500 is well positioned to deliver incremental clinical value, relative to conventional CT, in the three groupings of radiotherapy applications discussed in this publication.

First Time Right

Workflow Improvement / Simplicity

Radiation Oncology

Quantitative DL Spectral CT

Improved Image Quality

Accuracy of electron density, effective atomic number, and iodine concentration determination with a dual-layer dual-energy computed tomography system

Objective

To assess the accuracy of spectral CT electron density (ED), Effective Atomic Number (Z_{eff}), and Iodine Concentration results for radiation therapy planning applications.

Method

- Spectral CT was used to perform measurements with two phantoms comprised of different tissue-equivalent inserts and iodine and calcium inserts of various concentrations
- Accuracy was determined by comparing spectral CT quantitative results to chemical compositions provided by the phantom vendors
- Scan and reconstruction parameters were varied

Results

- ED: ~+/- 1% accuracy for soft tissue and bone-equivalent materials
- Z_{eff}: ~+/- 2% accuracy for soft tissue and bone-equivalent materials
- Iodine: <0.1 mg/mL median error (2-20 mg/mL concentrations)
- Even at the lowest concentrations (2mg/mL iodine, 50mg/mL calcium), iodine and calcium are well separated
- Overall effects of scan parameters were small on ED and Z_{eff} quantitative accuracy

Conclusion

- The quantitative accuracy of ED, Z_{eff}, and iodine quantification was demonstrated
- The accuracies are not sensitive to scan and reconstruction parameters

Translation to practice

Although the accuracy of quantitative spectral CT results is important for many applications, it is a critical driver for the use of ED and Z_{eff} to improve the accuracy of the stopping power estimate used in proton therapy treatments.

Radiation Oncology

Dual Layer Spectral Technology

Potential of a second-generation dual-layer spectral CT for dose calculation in particle therapy treatment planning

Objective

To evaluate spectral CT as an alternative to conventional CT for patient-specific stopping-power ratio (SPR) prediction and its impact on treatment dose distribution.

Method

- A variety of tissue-equivalent and non-tissue implant materials were imaged with the Spectral CT 7500 system
- SPR values were calculated from both conventional CT images and spectral CT results and compared to measured SPR values
- An end-to-end analysis of spectral CT-based treatment planning workflow was conducted with anthropomorphic head and pelvic phantoms

Results

- SPR mean deviation (error) was reduced to 0.7% when using spectral CT to calculate SPR, compared to 1.6% for conventional CT
- Dose distributions of spectral CT treatment plans showed greater agreement with ionization chamber measured dose distributions than dose distributions of conventional CT treatment plans
- End to end treatment planning workflow demonstrated for spectral CT based images

Conclusion

The use of the Spectral CT 7500 in particle therapy treatment planning may lead to better agreement between planned and delivered dose compared to current clinical conventional CT systems.

Translation to practice

- Improving patient-specific SPR prediction is essential for accurate dose calculation in proton and particle therapy treatment planning
- Using spectral CT results to calculate SPR was shown to improve accuracy relative to conventional CT

Radiation Oncology

Dual Layer Spectral Technology

Feasibility of using post-contrast dual-energy CT for pediatric radiation treatment planning and dose calculation

Ates O et al.
British Journal of Radiology
2020

Objective

To validate the hypothesis that post-contrast spectral CT images are sufficient for accurate photon and proton radiotherapy dose calculation, eliminating the need for a separate non-contrast CT (NCCT).

Method

- 10 pediatric patients with abdominal tumors received spectral CT radiotherapy planning scans before and after the administration of iodinated contrast
- Photon and proton therapy treatment dose distributions derived from spectral CT results were compared to those using the conventional method of calculation from conventional CT Hounsfield Units (HU)

Results

- Iodine affects the HUs used with conventional CT treatment planning more than the electron density spectral CT result
- Using electron density results directly for treatment planning instead of the HUs from conventional CT images reduces the dosimetric error caused by the presence of the contrast media
- There was no statistically significant difference between the treatment plans using true NCCT scans and those using spectral CT results

Conclusion

- Conventional CT with iodine contrast resulted in a large dosimetric error for proton therapy, compared to true NCCT plans, but the error was less for photon therapy
- These errors can be greatly reduced in the case of the proton plans if spectral CT is used, raising the possibility of using only a single post-contrast CT for radiotherapy dose calculation, thus reducing the time and imaging dose required

Translation to practice

The feasibility of direct use of electron density spectral CT results in radiotherapy treatment planning was demonstrated with advantages in workflow, imaging dose, and planning accuracy.

CT Dose Reduction | Workflow Improvement / Simplicity | Radiation Oncology | Pediatric Imaging

Dual-energy CT parameters in correlation to MRI-based apparent diffusion coefficient:

Evaluation in rectal cancer after radiochemotherapy

Sauter AP et al. Acta Radiologica 2020

Objective

To compare spectral CT to MRI as a non-invasive response assessment tool for post radiochemotherapy (RCT) rectal cancer (RC).

Method

- 11 RC patients were identified that had received spectral CT and MRI scans before and after RCT
- Changes in MRI apparent diffusion coefficient and spectral CT iodine concentration, effective atomic number, and Hounsfield Units (HU) within the tumor were analyzed

Results

- An excellent correlation between MRI ADC and spectral CT iodine concentration was found
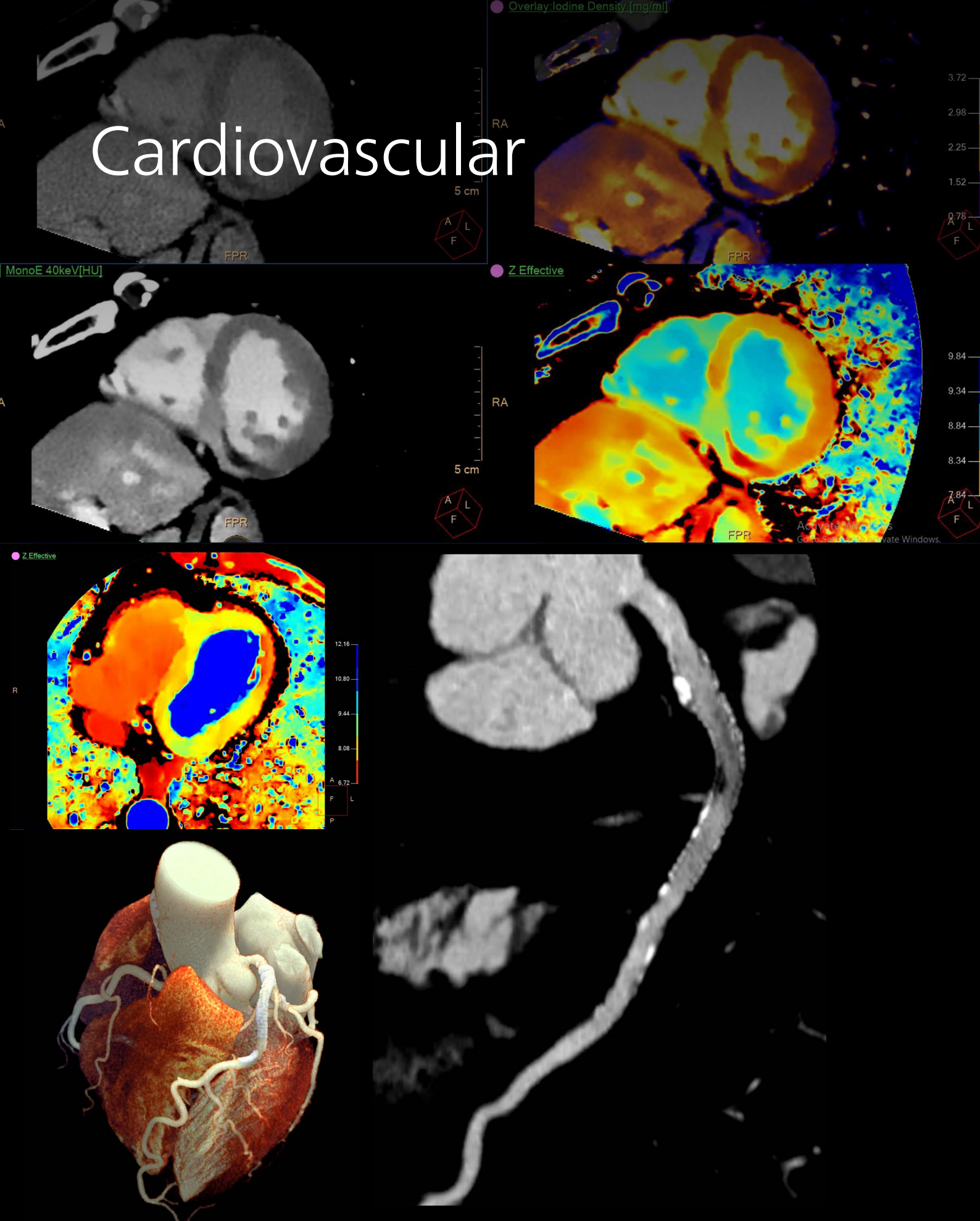
Conclusion

- Response evaluation of RC after RCT could be possible with a quantitative iodine concentration measurement from spectral CT
- Spectral CT could be the imaging modality of choice for evaluation of RC when MRI is contraindicated or not available

Translation to practice

The feasibility of direct use of electron density spectral CT results in radiotherapy treatment planning was demonstrated with advantages in workflow, imaging dose, and planning accuracy.

Radiation Oncology   **Multimodality Comparison**

Cardiovascular

MonoE 40keV[HU]

Spectral detector CT for cardiovascular applications

Objective

To provide an overview of spectral CT technology and examine the utility of spectral CT in cardiovascular imaging from an initial experience of over 200 patients.

Method

- Detector-based spectral CT technology and spectral results are reviewed
- Spectral CT Cardiovascular clinical applications and uses are identified and the impact on radiation and contrast dose is explored
- Representative clinical results are reviewed

Results

- Clinical applications for spectral CT include: evaluation of aortic disease, imaging before transcatheter aortic valve implantation, evaluation of pulmonary veins pre- and post-pulmonary radiofrequency ablation, evaluation of coronary artery lumen, assessment of myocardial perfusion, detection of pulmonary embolism, and characterization of incidental findings
- Spectral CT provides the opportunity for reducing iodinated contrast load
- Spectral CT may enable salvaging sub-optimal scans such as those with poor contrast enhancement or beam hardening artifacts

Conclusion

Spectral CT has multiple applications in Cardiovascular imaging, with the unique benefit of providing spectral data with every scan – without the need for a special acquisition protocol or prospective selection.

Translation to practice

Conventional CT has an increasingly prominent role in cardiovascular imaging per recent guidelines. The incremental value of spectral CT may add additional clinical benefits.

First Time Right	IV Contrast Reduction	Workflow Improvement / Simplicity	Enterprise Results On-Demand

Reduced-iodine-dose dual-energy coronary CT angiography:

Qualitative and quantitative comparison between virtual monochromatic and polychromatic CT images

Rotzinger DC et al. European Radiology 2021

Objective

To evaluate the quantitative impact of spectral CT MonoE results on reduced iodine dose CCTA compared with conventional full dose CT (phantom) and to evaluate image quality of reduced iodine results (patient studies).

Method

- A high precision vessel lumen phantom in the center of an anthropomorphic chest phantom simulating normal (70 kg) and overweight (120 kg) patients was imaged with both normal and reduced (40% reduction) contrast doses. Lumen diameter was assessed and compared to known actuals
- 203 patients prospectively divided into two groups and received CCTA scans. Quantitative and qualitative image quality was assessed:
  - 103 patients received a full contrast dose (50-90 mL, 5 mL/s)
  - 100 patients received a reduced contrast dose (30-40 mL, 2.5 mL/s)

Results

Compared to normal contrast dose conventional CT, spectral CT 55 keV MonoE results with a reduced contrast dose demonstrated:

- Phantom: Superior lumen segmentation accuracy and precision
- Patients: Non-inferior quantitative and qualitative results, with significantly better performance in some scenarios

Conclusion

- In vitro, low-keV MonoE improves vessel area segmentation
- In vivo, low-keV MonoE allows for a 40% iodine dose and 50% injection rate reduction while maintaining diagnostic image quality and improves the CNR between lumen versus fat and muscle

Translation to practice

Spectral CT can enable improved vessel lumen segmentation accuracy and provide non-inferior image quality when used with reduced doses of iodinated contrast.

| First Time Right | IV Contrast Reduction | Cost Savings |

Spectral imaging with dual-layer spectral detector computed tomography for the detection of perfusion defects in acute coronary syndrome

Mochizuki J et al. Heart and Vessels 2022

Objective

To evaluate the feasibility of spectral CT imaging for the diagnosis of acute coronary syndrome (ACS).

Method

- 30 patients were identified with ACS as confirmed by invasive coronary angiography
- MonoE, Iodine Density & Effective Atomic Number spectral CT results were qualitatively and quantitatively compared to conventional CT for the ability to visualize the area of myocardial hypo-perfusion
- Contrast and contrast-to-noise ratio (CNR) between normal and hypo-perfused regions of the myocardium were analyzed

Results

- Compared to conventional CT, 40 keV MonoE results were significantly better at differentiating normal vs. hypo-perfused myocardial regions in quantitative & qualitative comparisons
- Iodine Density and Effective Atomic Number results showed measurable differences in normal vs. hypo-perfused regions of the myocardium

Conclusion

Spectral CT is a feasible technique to detect hypo-perfused myocardial regions in ACS patients.

Translation to practice

- Conventional CCTA is effective at detecting and quantifying coronary artery stenosis, but is only moderately effective at assessing decreased myocardial blood flow
- Spectral CT was shown to improve the visualization and quantification of hypo-perfused regions of the myocardium

First Time Right

Quantitative DL Spectral CT

Relationship between coronary iodine concentration

Determined using spectral CT and the outcome of percutaneous coronary intervention in patients with chronic total occlusion

Objective

To evaluate the feasibility of spectral CT coronary iodine concentration in assessing outcomes of percutaneous coronary intervention (PCI) for chronic total occlusion (CTO) patients.

Method

- 50 consecutive patients underwent preprocedural spectral CCTA prior to PCI for CTO
- Depending on the outcome of PCI, all CTO lesions were divided into two groups: successful PCI (68%) and failed PCI (32%)
- The concentration of iodine at the entry of the CTO lesion was measured with Iodine No Water spectral CT result
- The iodine concentration was correlated with outcome and a cutoff value was calculated for predicting PCI outcome

Results

2.5 mg/ml of iodine concentration was determined to be the best threshold for predicting patients that would likely not benefit from PCI treatment, with strong statistical significance: 87% sensitivity, 79% specificity.

Conclusion

Iodine based spectral CT results may serve as an independent predictor of the outcome of PCI in patients with CTO.

Translation to practice

- Contrast enhancement within at the entry of the CTO can be associated with microvessel recanalization of the lumen, which is associated with PCI success rate.
- Spectral CT was shown to be valuable in providing a quantitative assessment of this parameter, which could aid in patient management.

First Time Right   **Quantitative DL Spectral CT**   **Improved Image Quality**

Incremental improvement of diagnostic performance of coronary CT angiography for the assessment of coronary stenosis in the presence of calcium using a dual-layer spectral detector CT:

Validation by invasive coronary angiography

Objective

To investigate the value of spectral CT for the quantification of coronary artery stenosis in the presence of calcified or partially calcified plaques.

Method

- 72 patients were identified with calcified or partially calcified plaques (122 total coronary lesions) and for whom invasive coronary angiography (ICA) results existed
- Conventional CT and spectral CT results were reviewed separately, without knowledge of the ICA results
- Diagnostic performance (% stenosis correlation with ICA) was evaluated for conventional CT, Iodine No Water, Effective Atomic Number, and 8 MonoE energy levels (70 – 140 keV)

Results

Positive Predictive Value (PPV) / Negative Predictive Value (NPV):

- Conventional CT: 70/73% (≥50% stenois), 53/91% (≥70% stenosis)
- 100 keV MonoE 80/76% (≥50% stenosis), 93/91% (≥70% stenosis)
- 100 keV + Effective Atomic Number (serial): 85/74% (≥50% stenosis), 93/88% (≥70% stenosis)

Conclusion

- Spectral CT MonoE results had a higher correlation to ICA compared to conventional CT, with 100 keV scoring the highest
- Effective Atomic number results used with 100 keV MonoE resulted in further improvements to diagnostic accuracy. This was particularly true for patients with Agatston score >1000 where combining Effective Atomic Number results further reduced false positives by more than half

Translation to practice

- Coronary CTA exams in the presence of calcified plaque is a known challenge
- Spectral CT demonstrated superior diagnostic performance in this situation, relative to conventional CT. This was primarily by reducing false positives, which could avoid unnecessary interventional procedures

First Time Right | Multimodality Comparison | Quantitative DL Spectral CT | Improved Image Quality

The optimal monoenergetic spectral image level of coronary computed tomography (CT) angiography on a dual-layer spectral detector CT with half-dose contrast media

Huang X et al. Quantitative Imaging in Medicine and Surgery 2020

Objective

To investigate image quality and optimal MonoE level in coronary CTA using spectral CT while reducing iodinated contrast media.

Method

- 200 patients with suspected coronary artery disease (CAD) received prospectively gated spectral CT coronary CTA scans:
  - 50% of the patients were given a normal dose of iodinated contrast (patient weight x 0.8 mL/kg)
  - 50% of the patients received 50% contrast dose (diluted with saline so the same injection rate was used)
  - Other imaging parameters, including radiation dose, were equivalent between the two groups
- Three MonoE energy levels were evaluated (45, 50, and 55 keV) for the 50% contrast dose images
- A subjective and objective evaluation of image quality was performed

Results

- Compared to conventional CT, the half dose 50 keV MonoE images had significantly higher mean CT values, SNR, CNR, & subjective contrast
- There was no significant difference between the conventional CT and the half dose 50 keV images for sharpness, subjective noise, and acceptability

Conclusion

Compared to conventional CCTA with a routine contrast dose, half dose 50 keV spectral MonoE images provide equivalent or improved image quality.

Translation to practice

- Lower doses of iodinated contrast are desirable for CCTA scans to minimize the risk of adverse patient reaction and to potentially reduce cost
- Spectral CT demonstrated the ability to reduce contrast dose by 50% while maintaining or improving image quality

| IV Contrast Reduction | Workflow Improvement / Simplicity | Improved Image Quality |

Low dose contrast CT for transcatheter aortic valve replacement assessment:

Results from the prospective SPECTACULAR study (spectral CT assessment prior to TAVR)

Objective

To investigate the feasibility of a low dose iodinated contrast protocol, utilizing spectral CT MonoE 40 keV reconstruction for CTA in patients undergoing transcatheter aortic valve replacement (TAVR) planning.

Method

- 116 consecutive TAVR patients received a gated chest and non-gated spectral CTA of the abdomen and pelvis
- 25 ml of iodinated contrast agent was administered
- Proximal aorta and access vessels were scored for image quality

Results

Compared with conventional CT, 40 keV MonoE results demonstrated:

- Significantly higher proximal aortic image quality as assessed by signal to noise (SNR) and contrast to noise ratio (CNR)
- Comparable aortic root dimensions
- Significantly higher SNR and CNR in all access vessel segments

Conclusion

TAVR pre-procedural scans are feasible using very low contrast volumes (25ml) by utilizing spectral CT MonoE results.

Translation to practice

- Reducing iodine contrast dose for pre-TAVR planning scans is a recognized clinical desire, because many patients are frail with impaired renal function and are at increased risk for acute kidney failure from contrast material administration.
- Spectral CT demonstrated the feasibility of using very low contrast volumes.

First Time Right	IV Contrast Reduction	Cost Savings	Workflow Improvement / Simplicity

Coronary plaque characterization assessed by delayed enhancement dual-layer spectral CT angiography and optical coherence tomography

Objective

To evaluate the ability of delayed iodine enhancement spectral CT to improve coronary plaque characterization.

Method

- 72 patients with known or suspected coronary artery disease (CAD) received prospectively gated spectral CCTA
- 17 of the patients with significant CAD (>50% stenosis) also underwent invasive coronary angiography (ICA) including optical coherence tomography (OCT)

Results

- The minimum iodine concentration using a cut-off of 2.25 mg/ml allowed an estimation of high-risk coronary plaques as identified by OCT with a sensitivity of 77% and a specificity of 56%
- Conventional CT plaque characterization was not able to distinguish plaque entities nor to discriminate high risk from low-risk plaques as identified by OCT

Conclusion

- Spectral CCTA with delayed enhancement is able to quantify delayed iodine enhancement within coronary artery plaques
- This approach may be helpful to improve differentiation of high- vs. low-risk plaque morphologies beyond conventional CT

Translation to practice

- Plaque characterization (high vs. low risk) is critical information in selecting the best care path for CAD patients
- By incorporating physiological elements such as neovascularization, spectral CT may provide a less invasive alternative to the gold standard of ICT + OCT

First Time Right   Multimodality Comparison   Quantitative DL Spectral CT

Detection of cardioembolic sources with nongated cardiac computed tomography angiography in acute Stroke:
Results from the ENCLOSE study

**Kauw F et al.
Stroke 2023**

Objective

- The primary objective is to investigate the yield of a non-gated CTA scan as a part of the admission stroke imaging protocol in detecting cardioembolic sources
- The secondary objective is to investigate diagnostic certainty of cardiac thrombus with spectral CT

Method

271 patients prospectively imaged with spectral CT (IQon and Spectral CT 7500) as a part of a non-gated CTA protocol.

Results

- Primary: a cardiac thrombi was detected in 12% of the patients with transient ischemic attack (TIA) or acute ischemic strokes with an admission non-gated head-to-heart CTA
- Secondary: The diagnostic certainty for left atrial appendage thrombus (vs. slow flow) was significantly higher for spectral CT iodine maps compared with the conventional CTA

Conclusion

- Incorporating non-gated spectral CT of the heart and aorta into the admission stroke imaging protocol is a promising alternative to echocardiography
- The use of spectral CT to assess LAA thrombus vs. slow flow is a promising approach

Translation to practice

- Certainty of a cardioembolic source during the admission stroke imaging protocol is valuable information in informing the secondary prevention strategy
- The ability of spectral CT to assess LAA thrombus vs. slow flow presents a promising alternative to echocardiography, which can be time consuming and invasive

| First Time Right | Multimodality Comparison | Quantitative DL Spectral CT | Improved Image Quality |

Feasibility of low-dose contrast media in run-off CT angiography on dual-layer spectral detector CT

Objective

To assess the feasibility of low dose contrast media with spectral CT MonoE results in run-off CTA studies.

Method

- 40 patients with suspected peripheral artery disease received spectral CT run-off CT scans:
    - 20 patients were given a normal (90 mL) contrast dose and only conventional CT results were analyzed
    - 20 patients were given a half volume contrast dose (45 mL) and (40-120 keV) MonoE results were generated in addition to conventional CT

- A quantitative comparison between the two cohorts was performed at multiple vascular locations: vascular attenuation, noise, signal-to-noise ratio (SNR), contrast-to-noise ration (CNR), & CT dose

- A qualitative comparison (MD scoring) was performed between the two cohorts: noise, artifacts, contrast, & sharpness

Results

Compared to normal contrast dose conventional CT, low MonoE results with 50% the contrast dose demonstrated:
- sufficient vascular contrast
- similar or lower noise
- comparable or higher SNR and CNR
- comparable subjective IQ scores

Conclusion

- It is feasible to perform run-off CTA scans using low contrast doses with low MonoE spectral CT results
- 40–50 keV MonoE energy levels were the optimal choice and did not compromise image quality

Translation to practice

Spectral CT low MonoE (40-50 keV) images can enable half-dose contrast dose run-off CTA procedures, which are a procedure that requires a large volume of contrast.

IV Contrast Reduction   **CT Dose Reduction**   **Quantitative DL Spectral CT**   **Improved Image Quality**

Computed tomography coronary angiography on a detector-based spectral computed tomography platform:

Evaluation of patients with coronary artery disease reporting and data system score of 3 and higher

Objective

To compare the ability of spectral CT to assess the severity of coronary artery stenosis with that of conventional CT in patients with an original CAD-RADS score of 3 or higher.

Method

- 41 coronary artery segments from 32 patients were read twice: first with only conventional CT images and then six weeks later with spectral CT results
- The CT CAD-RADS scores were compared with the cardiac stress (pharmacologic or exercise) test and/or cardiac catheterization results used for final characterization of stenosis.

Results

- The spectral CT results more closely approximated the qualitative and quantitative hemodynamically significant findings from nuclear medicine stress tests and cardiac catheterizations in most patients when compared with conventional CT
- Spectral CT results led to the reassignment of CAD-RADS scores in 39% of the segments evaluated

Conclusion

Spectral CT can improve diagnostic confidence of coronary artery assessment compared to conventional CT in patients with an original CAD-RADS score of 3 and higher.

Translation to practice

- Although considered the standard of care for patients with stable chest pain and low-to-intermediate pretest probability of obstructive CAD, conventional CT has limitations in accurately quantifying stenosis due to artifacts, particularly in patients with a higher pre-test probably of CAD. This can lead to over-estimation of stenosis in the presence of calcified plaques
- Spectral CT can improve confidence in diagnostic evaluation compared to conventional CT for patients with a CAD-RADS score of 3 or higher
- The Spectral CT results more closely approximated the qualitative and quantitative hemodynamically significant findings from multiple modalities

| First Time Right | Multimodality Comparison | Quantitative DL Spectral CT | Improved Image Quality |

Iodine-based extracellular volume for evaluating myocardial status in patients undergoing percutaneous coronary intervention for acute myocardial infarction by using dual-layer spectral detector computed tomography:

A comparison study with magnetic resonance

Objective

To evaluate the use iodine-based of extracellular volume (ECV) assessment of the myocardium with spectral CT compared to cardiac MR (CMR) in patients undergoing percutaneous coronary intervention (PCI).

Method

- 19 patients received both a spectral CT and CMR evaluation after PCI
- ECV was quantified using CCTA and late iodine enhancement (LIE) spectral CT and T1-weighted CMR
- Image quality was subjectively evaluated and the correlation between spectral CT and CMR ECV results was analyzed

Results

- The mean IQ scores for spectral CT and CMR images were 3.81±0.40 and 3.25±0.58, respectively
- The mean ECV values were 35.93%±9.73% for spectral CT and 33.89%±7.51% for CMR, with good correlation (r=0.79, P<0.001)

Conclusion

Iodine-based ECV obtained by spectral CT is highly correlated with ECV obtained from CMR imaging and could serve as a biomarker for myocardial evaluation.

Translation to practice

In combination with CCTA, spectral CT could be used for one-step cardiac follow-up examination in patients after PCI.

| First Time Right | Decreased Follow-Up Exams | Multimodality Comparison | Quantitative DL Spectral CT |

Identifying fragile calcifications of the aortic valve in transcatheter aortic valve replacement:

Iodine concentration of aortic valvular calcification by spectral CT

Objective

To demonstrate the relationship between spectral CT iodine concentration and strength of aortic valvular calcification (AVC) in patients with aortic valve stenosis (AVS).

Method

- 94 AVCs were analyzed from 22 patients who underwent transcatheter aortic valve replacement (TAVR) for AVS
- These patients receive spectral CT scans pre and post-procedure
- Post-procedural CT data were used to calculate the volume reduction percentage (VRP) of AVC
- AVC volume and iodine concentrations were analyzed pre-procedure

Results

- The mean AVC volume reduction (pre vs. post-procedure) was 18.5%
- Iodine concentration was found to be significantly correlated to AVC volume reduction. A higher iodine concentration was indicative of a more fragile AVC (volume reduction > 18.5%)

Conclusion

When using spectral CT to prepare for TAVR, the iodine concentration of the AVC may be useful to assess the probability of AVC deformity after TAVR.

Translation to practice

- An AVC with loose composition is associated with deformity (and complications) after TAVR
- Measuring the iodine concentration in an AVC with spectral CT has the potential to assess the probability of AVC deformity and associated outcomes and complications

First Time Right   **Multimodality Comparison**   **Quantitative DL Spectral CT**

Virtual versus true non-contrast dual-energy CT imaging for the diagnosis of aortic intramural hematoma

Objective

To assess whether spectral CT virtual non-contrast (VNC) results could replace true non-contrast (TNC) images for aortic intramural hematoma (IMH) diagnosis in acute aortic syndrome imaging.

Method

- Spectral CT images from 21 patients with surgery confirmed IMH were analyzed objectively and subjectively
- A custom IMH phantom was built from animal tissue and blood was used to directly compare VNC and TNC objective and subjective performance under a variety of imaging parameters and patient sizes

Results

- In both phantom and clinical studies, the contrast to noise ratio (CNR) between hematoma and lumen was similar between VNC and TNC images
- Both methods allowed differentiating the hyper-attenuation within the hematoma from the blood
- Equivalent high diagnostic confidence was achieved with both VNC and TNC images

Conclusion

Spectral CT VNC offers similar IMH diagnostic performance as TNC images, without compromise in diagnostic image quality.

Translation to practice

- Traditionally, separate contrast-enhanced and TNC scans are required to diagnose IMH due to the masking effect of iodine
- Spectral CT offers similar diagnostic performance without the TNC scan and associated radiation dose (which was 40% in this study)

First Time Right	Increased Throughput	Decreased Follow-Up Exams	CT Dose Reduction
Workflow Improvement / Simplicity	Improved Image Quality		

CTPA with a conventional CT at 100 kVp vs. a spectral-detector CT at 120 kVp:

Comparison of radiation exposure, diagnostic performance and image quality

Objective

To compare performance of spectral CT MonoE results with conventional CT for CT Pulmonary Angiographies (CTPA).

Method

- 60 clinical cases with the same mean CT dose index and at least one confirmed pulmonary embolism (PE) were analyzed. 30 were scanned with spectral CT and 30 were scanned with conventional CT. The scan protocol was the same for all patients except that the spectral CT images were acquired at 120 kVp and the conventional CT images at 100 kVp
- A semi-anthropomorphic thorax phantom with rods of various iodine density was also analyzed

Results

- The highest subjective image quality was found with 60 and 70 keV MonoE results, with significantly higher image quality compared to conventional CT
- The highest diagnostic accuracy scores were found for 60 and 70 keV MonoE results
- CNR in the phantom study was significantly higher for 40 keV MonoE images compared to conventional CT
- A review of 2110 scans for suspected PE showed a significantly lower mean CTDIvol was being used with spectral CT scans compared to conventional CT

Conclusion

Higher levels of diagnostic performance and image quality were achieved with spectral CT MonoE results compared to conventional CT.

Translation to practice

Each comparison between C-CT and SD-CT (all/non-obese/obese patients) showed a significantly lower radiation exposure with SD-CT spectral CT showed superior performance with 100 kVp scans, which may also apply to a wider patient population.

| First Time Right | Decreased Follow-Up Exams | CT Dose Reduction | Improved Image Quality |

The influence of motion-compensated reconstruction on coronary artery analysis for a dual-layer detector CT system:

A dynamic phantom study

Objective

To assess the impact of Precise Cardiac (motion-compensated reconstruction) on coronary CTA motion artifacts at various heart rates (HR).

Method

- A 5mm diameter tube simulating a coronary artery filled with iodinated contrast agent was positioned inside an anthropomorphic chest phantom and imaged on the Spectral CT 7500 at various constant velocities
- For each velocity, five CCTA scans were repeated using a clinical protocol
- Images were reconstructed with & without Precise Cardiac. Motion artifacts were quantified and analyzed

Results

- Precise Cardiac was shown to reduce motion artifacts, producing an image that is not significantly different than one with zero motion
- Precise Cardiac reduced coronary motion artifacts across a wide range of velocities commonly encountered in clinical practice
- An 11x reduction in motion artifacts was demonstrated on the Philips Spectral CT 7500 system

Conclusion

Precise Cardiac may improve CCTA assessment by reducing coronary motion artifacts, especially in patients with elevated HR or who have contraindications to beta blockers and do not attain the targeted HR.

Translation to practice

Despite improvements in patient management, native scanner temporal resolution and conventional reconstruction techniques, coronary artery motion artifacts remain a clinical challenge, and their occurrence is difficult to predict.Precise Cardiac may provide diagnostic results where motion artifacts would have rendered the study undiagnostic.
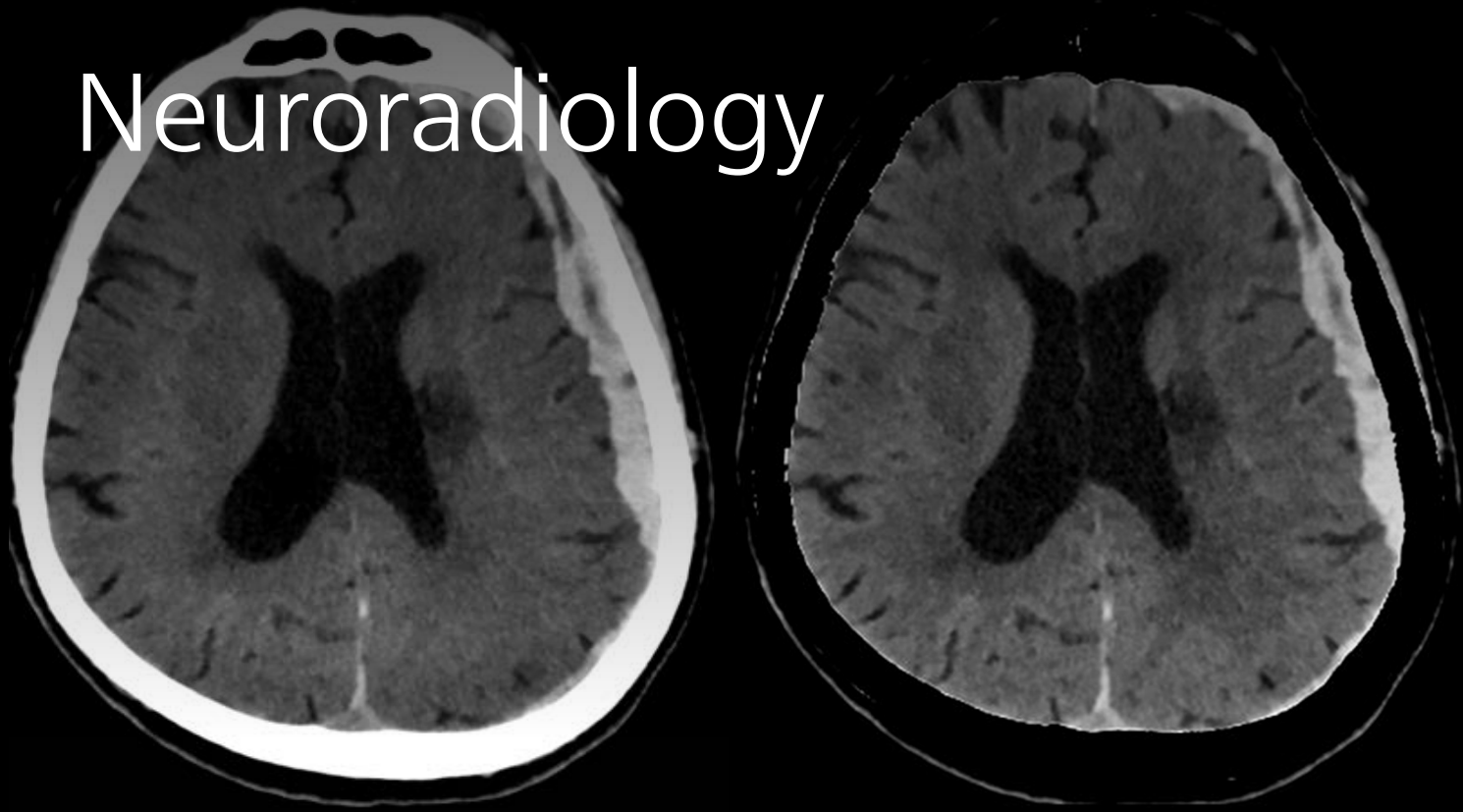
| First Time Right | Decreased Follow-Up Exams | Workflow Improvement / Simplicity | Improved Image Quality |

Neuroradiology

Improvement of image quality in unenhanced dual-layer CT of the head using virtual monoenergetic images compared with polyenergetic single-energy CT

Neuhaus V et al. Investigative Radiology 2017

Objective

To compare spectral CT MonoE vs. conventional CT image quality for non-contrast CT (NCCT) of the head and to determine keV level that optimizes image quality.

Method

- 40 patients received spectral CT NCCT head scans
- Quantitative attributes (signal-to-noise, contrast-to-noise, artifact indices) and qualitative attributes (grey / white matter differentiation, subcalvarial space assessment, artifacts, noise) were compared between conventional CT (iDose4) and multiple keV levels of MonoE spectral results

Results

- MonoE results significantly outscored conventional CT in all qualitative categories & outscored conventional in all quantitative categories (significantly for 6 / 7)
- 65 keV MonoE was optimal for grey / white matter differentiation & 120 keV Mono E for beam hardening reduction

Conclusion

- MonoE improves grey-white matter contrast and reduces beam hardening artifacts

Translation to practice

- NCCT of the head is a standard examination in imaging of intracranial pathologies, especially for rapid diagnosis of ischemia or intracranial hemorrhage. However, imaging can be impaired by low signal and low contrast, as well as by artifacts that are mainly caused by the skull
- Spectral CT MonoE results were shown to significantly improve NCCT head image quality in both grey / white matter differentiation and reduce beam hardening artifacts

First Time Right | Decreased Follow-Up Exams | Quantitative DL Spectral CT | Improved Image Quality

Acute infarction after mechanical thrombectomy is better delineable in virtual non-contrast compared to conventional images using a dual layer spectral CT

Riederer I et al. Scientific Reports 2018

Objective

To evaluate the use of NCCT spectral CT virtual non-contrast (VNC) results for the detection of acute infarcts after mechanical thrombectomy.

Method

- 29 patients were imaged post mechanical thrombectomy with spectral CT and MRI
- VNC results were compared to convention CT utilizing contrast-to-noise ratio (CNR), infarction volume measurements, ASPECT scoring, sensitivity, and specificity
- Confirmed DWI-MRI results were used to define the correct diagnostic result

Results

Compared to conventional CT, VNC results demonstrated:

- Significantly higher CNR (more hypodense lesions)
- Higher sensitivity for the detection of acute infarction
- Volume estimation significantly higher and closer to the gold standard DWI-MRI
- Higher inter-rater reliability for ASPECT scores

Conclusion

- Spectral CT VNC images enable a better delineation of acute infarction after mechanical thrombectomy compared to conventional CT
- The improved delineation of infarction in VNC images is likely due to the suppression of extravasated iodinated contrast agent

Translation to practice

- NCCT is commonly performed after mechanical thrombectomy of ischemic stroke patients to assess for early complications such as hemorrhage. Secondarily, it may provide an early assessment of infarction development can be useful for prediction of outcome and adjustment of therapy management
- The ability of spectral CT VNC results to improve infarct assessment can enhance this assessment

| First Time Right | Enterprise Results On-Demand | Multimodality Comparison | Quantitative DL Spectral CT |

| Improved Image Quality |

Potential of dual-layer spectral CT
for the differentiation between hemorrhage and iodinated contrast medium in the brain after endovascular treatment of ischemic stroke patients

Objective

To evaluate the use of VNC & Iodine Density spectral CT results for the differentiation between intracranial hemorrhage and iodinated contrast medium in ischemic stroke patients after mechanical thrombectomy.

Method

- 47 post-mechanical thrombectomy patients were imaged with spectral CT and the results were compared with additional follow-up imaging
- Tubes with various concentrations of blood, iodine, and mixtures were imaged within a phantom with spectral CT

Results

- 23 hyperdense areas detected in 13 patients (blood: 7, contrast: 4, mixture: 12)
- Using spectral CT, the sensitivity and specificity for detecting blood was 100%
- There was excellent correlation between measured and true iodine concentration in the phantom measurements

Conclusion

- Spectral CT enables differentiation between intracranial hemorrhage and iodinated contrast medium in patients
- The clinical analysis process took about 2 minutes per patient and can be easily integrated into the clinical radiology workflow

Translation to practice

- Intracranial hemorrhage is a possible complication after endovascular thrombectomy for ischemic stroke patients, therefore a NCCT is often performed after the procedure
- Hyperdense areas are a common finding, but it can be difficult to differentiate between blood and iodinated contrast agent (residual from procedure). This differentiation has significant implications for patient management and outcome

First Time Right	Decreased Follow-Up Exams	Workflow Improvement / Simplicity	Enterprise Results On-Demand
Quantitative DL Spectral CT	Improved Image Quality		

Virtual versus true non-contrast images of the brain from spectral detector CT:
Comparison of attenuation values and image quality

Kessner R et al.
Acta Radiologica
2023

Objective

To investigate whether spectral CT virtual non-contrast (VNC) images can replace true non-contrast (TNC) images for brain imaging.

Method

- 33 adult patients received both contrast enhanced & non-contrast CT (NCCT) imaging
- HU attenuation was compared for 591 regions of interest and image quality was evaluated

Results

Only minor differences between VNC & TNC attenuation values (<4 HU on average), for almost all structures.

Conclusion

Spectral CT VNC images derived from post-contrast head studies demonstrate excellent image quality and can potentially replace a TNC head CT.

Translation to practice

- The protocol for contrast enhanced images of the head usually involves a NCCT followed by a contrast enhanced scan
- Replacing the true non-contrast scan with a spectral CT VNC result from a single scan would eliminate the radiation dose of the second scan

First Time Right

Decreased Follow-Up Exams

CT Dose Reduction

Workflow Improvement / Simplicity

Quantitative DL Spectral CT

Improved Image Quality

Virtual monoenergetic images by spectral detector computed tomography may improve image quality and diagnostic ability for ischemic lesions in acute ischemic stroke

Mellander H et al. Acta Radiologica 2022

Objective

To evaluate whether ischemic lesions can be more easily detected with spectral MonoE results compared to conventional CT in patients with acute stroke.

Method

- 29 patients with confirmed cortical ischemic lesions + 23 negative control patients (no pathology) received spectral CT non-contrast CT (NCCT) scans
- A qualitative & quantitative assessment of image quality and lesion detectability was performed comparing spectral CT MonoE and conventional CT results
- Diagnostic results were compared with known final results

Results

- Diagnostic sensitivity was 93% and 97% (two reviewers) with spectral CT, compared to 55% of the original reports based only on conventional images
- MonoE image quality & ability to diagnose were scored significantly higher than conventional CT
- MonoE signal-to-noise ration (SNR) & contrast-to-noise ratio (CNR) were higher, significantly so for lower MonoE settings

Conclusion

Spectral MonoE images may improve diagnostic ability by enhancing the tissue contrast, and this can improve the radiological accuracy in acute stroke assessments.

Translation to practice

- The role of the initial NCCT in patients with suspected ischemic stroke is to rule out hemorrhage, and to identify the size and the location of any early ischemic lesions that may affect patient care. But these lesions can be difficult to detect and visualize on conventional CT
- Spectral CT's ability to improve image quality, diagnostic sensitivity, and ability to diagnose could have meaningful clinical impact for these cases

First Time Right | Decreased Follow-Up Exams | Quantitative DL Spectral CT | Improved Image Quality

Virtual monochromatic image quality from dual-layer dual-energy computed tomography for detecting brain tumors

Objective

To determine the value of spectral CT MonoE results in assessing brain tumors in non-contrast CT (NCCT) images.

Method

Spectral CT images from 32 patients with confirmed brain tumors were analyzed:

- Quantitative attributes: attenuation, noise, contrast-to-noise ratio (CNR) of grey/white matter, tumor-to-WM, & tumor-to-GM
- Qualitative scoring: contrast, margin, noise, artifact, & diagnostic confidence

Results

- MonoE scored better than conventional CT in all of the quantitative image analysis categories, 6/8 significantly
- All MonoE energy levels had significantly lower measured noise than conventional CT

Conclusion

Spectral CT 40 keV MonoE results yielded superior tumor contrast & diagnostic confidence when compared to conventional images, especially for brain tumors located in the white matter.

Translation to practice

- CT is frequently the first imaging modality for diagnosing intracranial disease. But it can be difficult to detect and visualize some brain tumors because of the low contrast with normal tissue on conventional CT images
- Spectral CT MonoE results were shown to improve quantitative and qualitative performance in visualizing these tumors

First Time Right   **Quantitative DL Spectral CT**   **Improved Image Quality**

Pediatric
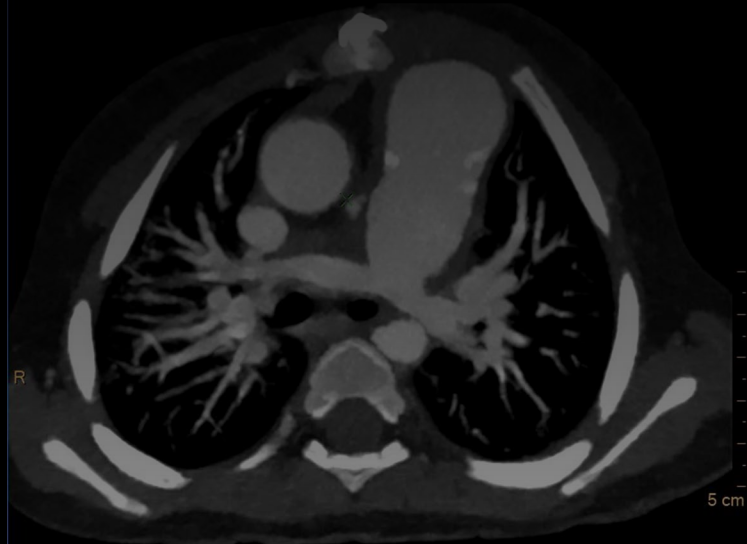
Conventional [HU]

MonoE 40keV[HU]

5 cm

5 cm

5 cm

5 ci

10 cm

Quantifying potential reduction in contrast dose with monoenergetic images synthesized from dual-layer detector spectral CT

Objective

To quantify the contrast-to-noise ratio (CNR) increase and estimate the potential dose reduction in iodinated contrast when using spectral CT low MonoE (40-70 keV) results.

Method

- 51 pediatric patients received contrast enhanced spectral CT scans as a part of a radiotherapy CT simulation protocol
- CNRs were compared between multiple MonoE energies and conventional CT images by comparing vessel to surrounding soft tissue attenuation at two anatomical locations per patient
- Additionally, a phantom with multiple iodine inserts (2-20 mg/ml) were scanned and CNRs calculated relative to a water background

Results

- In patient images, 50 keV MonoE provided a 2.4x increase in CNR compared to 120 kVp conventional iDose[4] L3 CT images with nearly identical noise
- The gain was similar in the phantom analysis

Conclusion

- A 50% reduction in contrast dose with a 50 keV MonoE image should maintain comparable or better CNR as compared with conventional CT in over 80% of CT studies. The baseline CNR was already very high in the remaining 20%
- 50 keV was the preferred MonoE energy level because of the significant (>2x) CNR improvement and nearly identical noise compared to conventional CT
- Clinicians can easily switch from 40-50 keV images for vessel segmentation to 70 keV images for evaluation of structures of interest during RT planning, all with CNR improvements

Translation to practice

The use of spectral CT to improve the visualization of contrast-enhanced vessels will reduce the amount of iodinated contrast required for radiotherapy treatment planning. This study focused on pediatric oncology patients where the desire for reduced contrast doses is high.

First Time Right | IV Contrast Reduction | Cost Savings | Radiation Oncology

Pediatric Imaging | Quantitative DL Spectral CT | Improved Image Quality

Phantom-based quantification of the spectral accuracy in dual-layer spectral CT for pediatric imaging at 100 kVp

Objective

To determine the accuracy of spectral results obtained from a spectral CT system at 100 kVp for dose levels and object sizes relevant to pediatric imaging.

Method

- A spectral CT phantom containing tissue-equivalent materials and iodine inserts of varying concentrations were scanned on a Spectral CT 7500 system. Two 3D-printed rings were used to mimic varying pediatric patient sizes
- Scans were performed at 100 and 120 kVp and at progressively reduced radiation dose levels, down to 0.9 mGy $CTDI_{vol}$
- Spectral results (MonoE 40-200 keV, Iodine Density, Z_{eff} and ED) were analyzed and compared to their expected values

Results

- The accuracy of spectral results was not significantly different between 100 and 120 kVp.
- 62 keV MonoE images demonstrated similar attenuation values to conventional 100 kVp images
- Spectral results were accurate and reliable for radiation exposures down to 0.9 mGy $CTDI_{vol}$.
- Iodine quantification errors were within 1 mg/mL.
- Z_{eff} and electron density showed excellent accuracy (better than 3% and 1%, respectively)

Conclusion

Spectral CT at 100 kVp can provide on-demand or retrospective spectral information with high accuracy even at extremely low doses, thereby making it an attractive solution for pediatric imaging.

Translation to practice

- The paramount need to minimize dose for pediatric CT imaging provides potential barriers to the utilization of multi-energy CT
- The ability of detector-based spectral CT to provide accurate spectral results under pediatric imaging conditions, including at 100 kVp, opens the door to the clinical benefits of spectral CT for pediatric patients

First Time Right	CT Dose Reduction	Workflow Improvement / Simplicity	Enterprise Results On-Demand
Pediatric Imaging	Quantitative DL Spectral CT	Improved Image Quality	

Dual-layer detector head CT to maintain image quality while reducing the radiation dose in pediatric patients

Tan Z et al.
American Journal of Neuro-radiology
2023

Objective

To determine whether 60 keV MonoE spectral CT results can reduce the radiation dose for pediatric cranium scans while maintaining image quality compared to conventional CT images

Method

- 106 pediatric patients (12 years or younger) received unenhanced head scans. 53 were scanned with 180 mAs and 53 were scanned with 250 mAs
- Quantitative and qualitative image quality was assessed for conventional CT images and 60 keV Mono E spectral results
- Radiation dose parameters were analyzed

Results

- Mean dose-length product values were 717.47 and 530.74 mGyxcm for the 250 and 180 mAs groups, respectively
- DLP did not differ within the 250-mAs group for age while DLP increased with age in the 180-mAs group
- Irrespective of dose, the noise level, SNR, CNR and subjective evaluations were significantly superior for the 60 keV MonoE images compared to conventional CT
- SNR, CNR, and subjective analysis in the 60 keV MonoE images were not significantly different between the two groups

Conclusion

60 keV MonoE spectral CT results allowed a 28% dose reduction without image quality loss compared to conventional CT images.

Translation to practice

- Unenhanced CT of the head is considered a first-line imaging technique for pediatric patients suspected of intercranial injury. But as the use of CT in children has risen dramatically, radiation exposure from CT scanning has become an increasing concern
- The ability of detector-based spectral CT to reduce dose while maintaining image quality can deliver the required diagnostic performance while reducing radiation risk

First Time Right
CT Dose Reduction
Quantitative DL Spectral CT
Improved Image Quality

Interventional

Role of iodine density value on dual-energy CT for detection of high tumor cell proportion region in lung cancer during CT-guided transthoracic biopsy

Objective

To evaluate the value of spectral CT in planning the puncture path for transthoracic lung biopsy to target high tumor cell proportion regions of lung cancer tumors.

Method

Two phase prospective study:

- A biopsy was performed of a high and low tumor cell region, as informed by spectral CT iodine concentration, in 41 lung cancer patients. This data was used to determine an iodine concentration cutoff value
- The use of the Iodine spectral result cutoff value to target a high tumor cell proportion region for biopsy was validated in 15 patients

Results

- There was a significant correlation between tumor cell proportions & spectral CT results. Weak/no correlation found with conventional CT
- 100% accuracy was demonstrated when applying the iodine concentration cutoff value to guide the intervention in the 15 validation patients

Conclusion

Spectral CT can be used to identify the high tumor cell proportion region of the tumor during biopsy planning.

Translation to practice

- Many molecular and immuno-histochemical analyses require a minimum tumor cell proportional, but biopsy specimens commonly don't meet the requirements
- Spectral CT shows promise in being able to improve this success rate and potentially avoid a repeat biopsy

Value of spectral detector computed tomography for the early assessment of technique efficacy after microwave ablation of hepatocellular carcinoma

Objective

To investigate whether spectral CT improves early assessment of technique efficacy after microwave ablation (MWA) for hepatocellular carcinoma (HCC) in liver cirrhosis.

Method

- 39 patients with 49 HCC lesions were treated with MWA
- The patients were imaged with Biphasic spectral CT post ablation
- Low MonoE and Iodine spectral CT results were quantitatively and qualitatively compared to conventional CT images

Results

- Compared to conventional CT images, 50 keV MonoE results demonstrated:
  - Improved subjective ablation zone (AZ) to liver contrast, hyperemic rim (HR) to liver contrast, and visualization of AZ margin & adjacent vessels
  - Significantly higher attenuation of the liver parenchyma, HR, & residual tumor (RT); SNR of liver parenchyma and HR; and CNR of AZ and HR
  - Significantly higher diagnostic confidence for detecting incomplete ablation and slightly higher diagnostic accuracy
- Iodine concentration differed significantly between HR and RT

Conclusion

Spectral CT low MonoE and Iodine results provide superior early assessment of MWA efficacy in HCC compared to conventional CT.

Translation to practice

- MWA is a common treatment for early stage HCC. Spectral CT's ability to improve assessment of treatment efficacy is likely valuable in patient management
- SDCT derived low-keV virtual monoenergetic images and iodine maps facilitate an improved early assessment of technique efficacy after MWA of HCC compared to Conventional Imaging

| First Time Right | Decreased Follow-Up Exams | Workflow Improvement / Simplicity | Quantitative DL Spectral CT |

| Improved Image Quality |

CT-Guided liver biopsy:

Evaluation of spectral data from dual-layer detector CT for improved lesion detection

Objective

To evaluate the ability of spectral CT to enhance the visibility of liver lesions in images used for CT image-guided biosy.

Method

- 20 patients were identified that had received CT-guided needle biopsies of focal liver lesions on a spectral CT system
- Each patient had received a triphasic diagnostic CT before biopsy
- Spectral CT results for CT acquisitions used during the biopsy procedure were compared objectively and subjectively to the conventional images to assess lesion visibility

Results

- Compared to conventional CT images, in 18/20 cases the spectral CT results, either low MonoE or virtual non-contrast (VNC), produced the higher subjective visibility scores
- Compared to conventional CT images, ether the contrast-to-noise ratio (CNR) of the center of the lesion (to normal liver parenchyma) and/or the periphery of the lesion (to normal liver parenchyma) was higher with the spectral CT results

Conclusion

A clear advantage of spectral CT in the subjective visibility and objective contrast of liver lesions could be shown in the majority of the cases.

Translation to practice

- In clinical practice, the decreasing visibility of liver lesions over time after the application of contrast medium can make CT-guided biopsies more difficult
- The ability of spectral CT to prolong and improve lesion enhancement may make biopsy procedures easier, faster, more successful, and less prone to complications

| First Time Right | Decreased Follow-Up Exams | Workflow Improvement / Simplicity | Quantitative DL Spectral CT |

| Improved Image Quality |

Reduction of microwave ablation needle related metallic artifacts from dual-layer detector spectral CT in a rabbit model with VX2 tumor

Wang G et al. Scientific Reports 2021

Objective

To investigate the application of MonoE spectral CT results in reducing metal artifacts associated with microwave ablation (MWA).

Method

- 31 VX2 rabbit liver cancer models were imaged with spectral CT during MWA therapy
- Conventional CT images with the most severe metal artifacts from the MWA antenna were analyzed at various MonoE energy levels
- Objective and subjective image quality analysis was performed

Results

- In the subjective analysis, reductions in hyperdense and hypodense artifacts were observed at high MonoE levels
- In the objective analysis, high MonoE images reduced the corrected attenuation of hyperdense and of artifact-impaired liver parenchyma compared to conventional CT images
- The outcomes of the diagnostic evaluation of adjacent liver tissue were significantly higher in high MonoE images compared to conventional CT images

Conclusion

Spectral CT MonoE results at 170–200 keV can decrease the microwave ablation needle-related metal artifacts objectively and subjectively in rabbit VX2 liver cancer models.

Translation to practice

- Microwave ablation therapy is known to be effective in destroying tumor tissue, particularly in the liver. However, it is also known that MWA antennas generate metal artifacts that can impede the assessment of antenna location relative to tumor while under CT guidance
- The ability of high MonoE spectral CT results to reduce these metal artifacts in the ablation zone can improve the quality of CT MWA therapy guidance
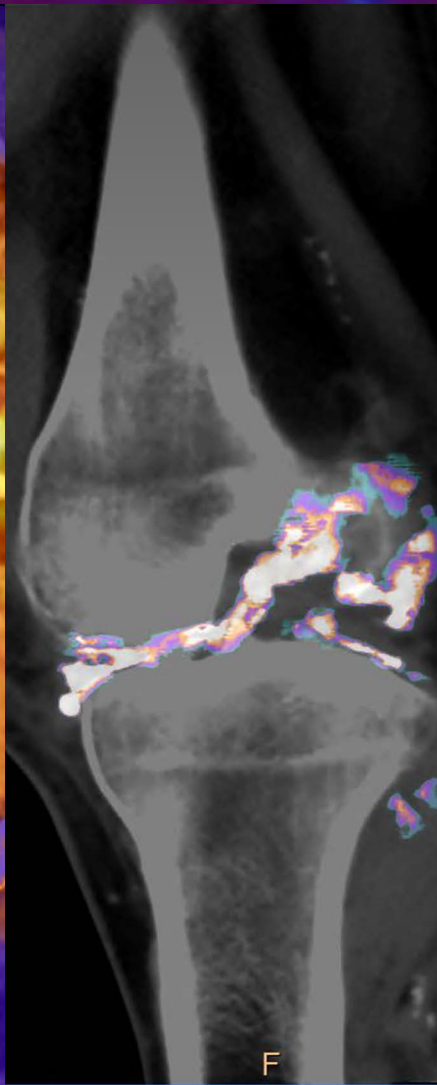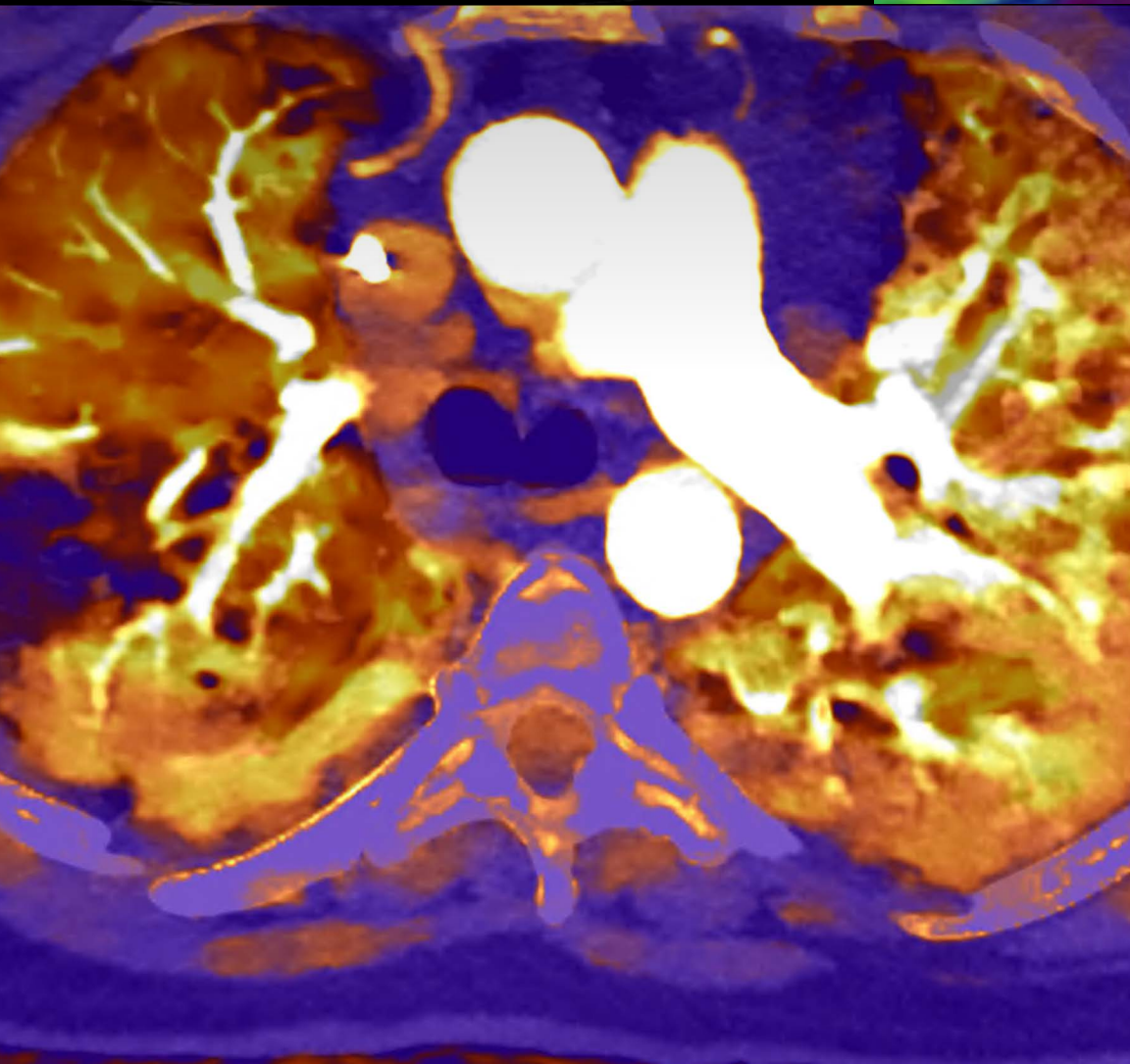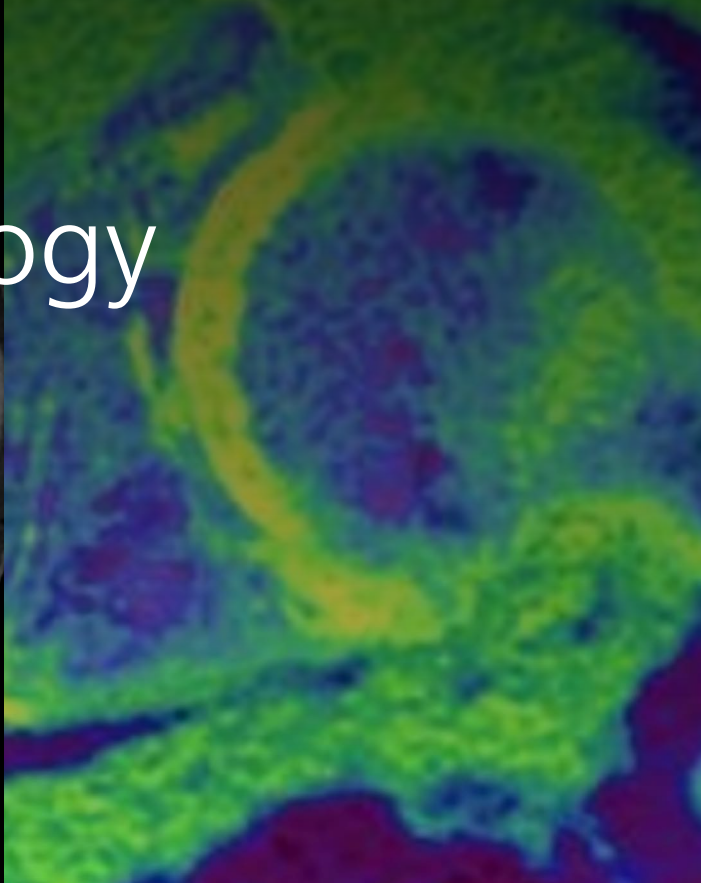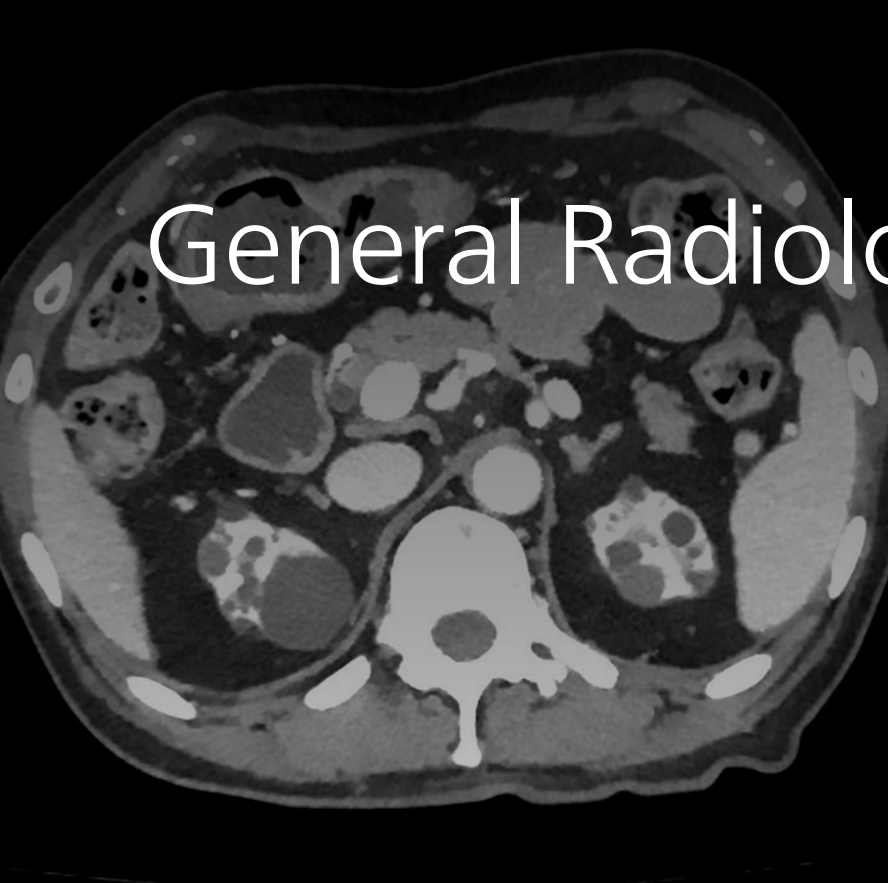
First Time Right | Workflow Improvement / Simplicity | Quantitative DL Spectral CT | Improved Image Quality

General Radiology

Follow-up recommendation rates associated with spectral detector dual-energy CT of the abdomen and pelvis:

A retrospective comparison to single-energy

Atwi NE et al. Journal of American Collage of Radiology 2020

Objective

To determine the effect of spectral CT iodine results on abdominopelvic imaging follow-up recommendation rates.

Method

- Follow-up imaging recommendations were analyzed for 3221 contrast enhanced abdominopelvic examinations:
    - 1423 included iodine spectral CT results
    - 1798 has only conventional CT
- Follow up recommendations due to incomplete radiologic workup were identified

Results

- Studies that included spectral iodine results had a follow-up recommendation rate of 19.5%, which was lower than the 21.4% for conventional CT
- 9.1% of studies that included iodine results had follow-up recommendations due to incomplete radiologic workup, which was significantly lower than the 11.9% for conventional CT
- 9.6% of studies that included iodine results had MRI or PET as recommended follow-up exams, which was significantly lower than the 13.0% for conventional CT

Conclusion

Including iodine results in the diagnostic workflow decreased the overall follow-up recommendation rate, follow-ups due to incomplete diagnostic workup, and recommendations for follow-up PET and MRI exams.

Translation to practice

A decrease in downstream imaging recommendations may improve patient care as well as decrease imaging costs.

First Time Right	Decreased Follow-Up Exams	CT Dose Reduction	Cost Savings
Multimodality Comparison	Improved Image Quality		

Economic impact of IQon for patients with renal insufficiency

Objective

To investigate the impact of MonoE spectral CT results on management of patients with a high risk of contrast-induced nephropathy (CIN).

Method

- 60 patients with high risk of CIN were divided into two cohorts:
    - 30 patients: non-contrast conventional CT (NCCT) scan (normal protocol)
    - 30 patients: low contrast dose (50-80cc), including low MonoE spectral results
- Subsequent patient workups were tracked.

Results

Compared to the NCCT cohort, the low MonoE cohort demonstrated:

- A 25% reduction in follow-up scans
- A 34% reduction in time to diagnosis (66 vs. 100 days)
- An average savings of $453 per avoided follow-up scan (USA rates)

Conclusion

- Low MonoE results boost the iodine signal, improving visualization at low volumes of iodinated contrast
- There was a clinical benefit in enabling imaging with (low dose) contrast for patients who would normally have received a NCCT scan

Translation to practice

Spectral CT demonstrated the ability to reduce follow-up scans, reduce the time to diagnosis by a month, and avoid costly follow-up exams.

| First Time Right | IV Contrast Reduction | CT Dose Reduction | Cost Savings |

| Workflow Improvement / Simplicity | Improved Image Quality |

Benefit of dual-layer spectral CT in emergency imaging of different organ systems

Objective

To demonstrate the added clinical value of spectral CT in the emergency department in different organ systems.

Method

The authors describe where they have found incremental clinical value for spectral CT in their institution's emergency department and provide illustrative clinical examples.

Results

- Spectral CT benefits relative to conventional imaging included differentiating intracranial hemorrhage from contrast medium extravasation, better delineation and demonstration of extension of head and neck abscess, better detection of subtle filling and perfusion defects in pulmonary embolism, detection of bone injury, characterization of incidental lesions, and detection of multiple types of lesions and abnormalities in the abdomen

- These advantages were found in a wide variety of organ systems in the brain, head & neck, chest, abdomen, and musculoskeletal anatomy

Conclusion

- Spectral CT may facilitate diagnosis in many organ systems beyond what is capable with conventional CT

- Not needing to preselect a spectral CT scan is particularly beneficial in emergency settings

- Spectral CT may obviate the need for additional imaging as well as allow for the use of lower doses of contrast medium

Translation to practice

The "always on" dual layer spectral CT workflow can be particularly beneficial in an emergency department setting where a rapid diagnosis is critical and incidental findings are common.

First Time Right	Increased Throughput	Decreased Follow-Up Exams	IV Contrast Reduction
CT Dose Reduction	Cost Savings	Workflow Improvement / Simplicity	

Effect of energy level on the spatial resolution and noise frequency characteristics of virtual monochromatic images:

A phantom experiment using four types of CT scanners

Objective

To evaluate the effects of Virtual Monoenergetic Image (VMI) energy level on spatial resolution and noise frequency characteristics across different dual-energy CT technologies.

Method

- A cylindrical acrylic phantom containing diluted contrast agent was prepared
- The phantom was scanned at a constant $CTDI_{vol}$ of 35 mGy using normal abdominal clinical settings on CT scanners utilizing four different technologies for dual-energy CT: dual-layer detector (Philips), rapid kVp switching (GE), dual source (Siemens), and sequential acquisition (Canon)
- VMI datasets were created at multiple energy levels from 70 keV and below, including the lowest possible on each scanner
- Modulation transfer functions (MTF), noise power spectrum (NPS), and low contrast resolution was compared

Results

- Dual-layer technology spatial resolution was not significantly affected by VMI energy level, spatial resolution degraded as energy level decreased for source-based technologies
- Dual-layer technology has superior contrast-to-noise ratios at all energy levels, with >2x the CNR at the lowest VMI energy level

Conclusion

Philips dual-layer spectral CT technology demonstrated lower noise levels and the noise characteristics were less sensitive to VMI energy level compared to source-based dual-energy CT technologies.

Translation to practice

Low energy VMI images are frequently used in clinical practice. This technical study demonstrated the performance advantages of Philips spectral CT MonoE results.

First Time Right	Increased Throughput	Decreased Follow-Up Exams	IV Contrast Reduction
CT Dose Reduction	Cost Savings	Workflow Improvement / Simplicity	

Summary Publication Review

Oncology

- Andersen, 2020, Impact of spectral body imaging in patients suspected for occult cancer: a prospective study of 503 patients
- Andersen, 2021, Economic impact of spectral body imaging in diagnosis of patients suspected for occult cancer
- Yoon, 2020, Double Low-Dose Dual-Energy Liver CT in Patients at High-Risk of HCC
- Nagayama, 2017, Dual-Layer DECT for multiphasic hepatic CT with 50 percent iodine load: a matched-pair comparison with a 120 kVp protocol
- Zopfs, 2022, Head and neck squamous cell carcinoma: evaluation of iodine overlay maps and low-energy virtual mono-energetic images acquired with spectral detector CT
- El Kayal, 2019, Value of spectral detector computed tomography for assessment of pancreatic lesions
- Lennartz, 2019, Dual-Energy CT–derived Iodine Maps: Use in Assessing Pleural Carcinomatosis
- Buus, 2021, Comparison of contrast-enhanced CT, dual- layer detector spectral CT, and whole-body MRI in suspected metastatic breast cancer: a prospective diagnostic accuracy study
- Zopfs, 2021, Value of spectral detector CT for pretherapeutic, locoregional assessment of esophageal cancer
- Nagayama, 2020, Adrenal Adenomas versus Metastases: Diagnostic Performance of Dual-Energy Spectral CT Virtual Noncontrast Imaging and Iodine Maps
- Wen, 2022, Application value of double-layer spectral detector CT in differentiating central lung cancer from atelectasis
- Gehling, 2022, Dual-Layer Spectral Detector CT in Comparison with FDG-PET/CT for the Assessment of Lymphoma Activity
- Zheng, 2024, The value of dual-layer spectral detector CT in preoperative T staging of laryngeal and hypopharyngeal squamous cell carcinoma
- Greffier, 2021, Performance of four dual-energy CT platforms for abdominal imaging: a task-based image quality assessment based on phantom data
- Greffier, 2022, Comparison of virtual monoenergetic imaging between a rapid kilovoltage switching dual-energy computed tomography with deep-learning and four dual-energy CTs with iterative reconstruction

Radiation Oncology

- Kruis, 2022, Improving radiation physics, tumor visualisation, and treatment quantification in radiotherapy with spectral or dual-energy CT
- Hua, 2018, Accuracy of electron density, effective atomic number, and iodine concentration determination with a dual-layer dual-energy computed tomography system
- Longarino, 2022, Potential of a Second-Generation Dual-Layer Spectral CT for Dose Calculation in Particle Therapy Treatment Planning
- Ates, 2021, Feasibility of using post-contrast dual-energy CT for pediatric radiation treatment planning and dose calculation
- Sauter, 2020, Dual-energy CT parameters in correlation to MRI-based apparent diffusion coefficient: evaluation in rectal cancer after radiochemotherapy

Cardiovascular

- Rajiah, 2017, Spectral detector CT for cardiovascular applications
- Rotzinger, 2021, Reduced-iodine-dose dual-energy coronary CT angiography: qualitative and quantitative comparison between virtual monochromatic and polychromatic CT images
- Mochizuki, 2022, Spectral imaging with dual-layer spectral detector computed tomography for the detection of perfusion defects in acute coronary syndrome
- Lee, 2020, Relationship between Coronary Iodine Concentration Determined Using Spectral CT and the Outcome of Percutaneous Coronary Intervention in Patients with Chronic Total Occlusion
- Xu, 2021, Incremental improvement of diagnostic performance of coronary CT angiography for the assessment of coronary stenosis in the presence of calcium using a dual-layer spectral detector CT: validation by invasive coronary angiography
- Huang, 2020, The optimal monoenergetic spectral image level of coronary computed tomography (CT) angiography on a dual-layer spectral detector CT with half-dose contrast media
- Cavallo, 2019, Low dose contrast CT for transcatheter aortic valve replacement assessment: Results from the prospective SPECTACULAR study (spectral CT assessment prior to TAVR)
- Nadjiri, 2022, Coronary plaque characterization assessed by delayed enhancement dual-layer spectral CT angiography and optical coherence tomography
- Kauw, 2023, Detection of Cardioembolic Sources With Nongated Cardiac Computed Tomography Angiography in Acute Stroke: Results From the ENCLOSE Study
- Ren, 2021, Feasibility of low-dose contrast media in run-off CT angiography on dual-layer spectral detector CT.
- Igi, 2023, Computed Tomography Coronary Angiography on a Detector-Based Spectral Computed Tomography Platform: Evaluation of Patients With Coronary Artery Disease Reporting and Data System Score of 3 and Higher
- Liang, 2022, Iodine-based extracellular volume for evaluating myocardial status in patients undergoing percutaneous coronary intervention for acute myocardial infarction by using dual-layer spectral detector computed tomography: a comparison study with magnetic resonance
- Park, 2022, Identifying fragile calcifications of the aortic valve in transcatheter aortic valve replacement: iodine concentration of aortic valvular calcification by spectral CT
- Si-Mohamed, 2019, Virtual versus true non-contrast dual-energy CT imaging for the diagnosis of aortic intramural hematoma
- Sauter, 2020, CTPA with a conventional CT at 100 kVp vs. a spectral-detector CT at 120 kVp; Comparison of radiation exposure, diagnostic performance and image quality
- Dobrolinska, 2024, The influence of motion-compensated reconstruction on coronary artery analysis for a dual-layer detector CT system: a dynamic phantom study

Neuroradiology

- Neuhaus, 2017, Improvement of Image Quality in Unenhanced Dual-Layer CT of the Head Using Virtual Monoenergetic Images Compared With Polyenergetic Single-Energy CT
- Riederer, 2018, Acute infarction after mechanical thrombectomy is better delineable in virtual non-contrast compared to conventional images using a dual layer spectral CT
- Riederer, 2021, Potential of dual-layer spectral CT for the differentiation between hemorrhage and iodinated contrast medium in the brain after endovascular treatment of ischemic stroke patients
- Kessner, 2022, Virtual versus true non-contrast images of the brain from spectral detector CT: comparison of attenuation values and image quality
- Mellander, 2022, Virtual monoenergetic images by spectral detector computed tomography may improve image quality and diagnostic ability for ischemic lesions in acute ischemic stroke
- Tanoue, 2021, Virtual Monochromatic Image Quality from Dual-Layer Dual-Energy Computed Tomography for Detecting Brain Tumors

General Radiology

- Atwi, 2020, Follow-up recommendation rates associated with spectral detector dual-energy CT of the abdomen and pelvis: a retrospective comparison to single-energy CT
- Norwood, 2017, Economic impact of spectral detector CT for patients with renal insufficiency
- Demirler Simsir, 2020, Benefit of dual-layer spectral CT in emergency imaging of different organ systems
- Suzuki, 2022, Effect of energy level on the spatial resolution and noise frequency characteristics of virtual monochromatic images: a phantom experiment using four types of CT scanners

Pediatric

- Tsang, 2017, Quantifying potential reduction in contrast dose with Monoenergetic images synthesized from dual layer detector spectral CT
- Meyer, 2023, Phantom-based quantification of the spectral accuracy in dual-layer spectral CT for pediatric imaging at 100 kVp
- Tan, 2023, Dual-Layer Detector Head CT to Maintain Image Quality While Reducing the Radiation Dose in Pediatric Patients

Interventional

- Ma, 2023, Role of iodine density value on dual-energy CT for detection of high tumor cell proportion region in lung cancer during CT-guided transthoracic biopsy
- Reimer, 2021, Value of spectral detector computed tomography for the early assessment of technique efficacy after microwave ablation of hepatocellular carcinoma
- Sauter, 2023, CT-Guided Liver Biopsy: Evaluation of Spectral Data From Dual-Layer Detector CT for Improved Lesion Detection
- Wang, 2021, Reduction of microwave ablation needle related metallic artifacts using virtual monoenergetic images from dual layer detector spectral CT in a rabbit model with VX2 tumor

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