Gemstone Spectral Imaging

HANDBOOK OF CLINICAL EVIDENCE

for Radiologists and Radiographers

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Introduction

Diagnostic Imaging is a fast-moving field harvesting the latest technologies from the newest in hardware capabilities to the first artificial intelligence applications in radiology. The objective is improving patient clinical outcomes and we are now expecting to go beyond by improving the patient pathway, reducing the number of exams and giving access to the right diagnosis, effortlessly.

CT imaging has quickly become the cornerstone of imaging departments, not only providing more and more anatomical information by improving image quality, but also taking the lead in functional information to really assess the impact of disease.

***Gemstone™ Spectral Imaging (GSI)** is the avenue to answer challenging clinical questions by using a single scan to provide both anatomical and functional information in one study thereby reducing the number of exams needed to deliver a diagnosis. This technique is widely accepted by clinical societies and peer reviewed publications show patient & clinical outcomes. Through this handbook, you will find the latest uses of our GSI technology, its outcomes and real testimonials from our users. We truly want to help you integrate this into your daily clinical practice in multiple clinical applications to further add value to your patient care pathway in CT. We have gathered infographics illustrating the use of GSI, clinical examples from all over Europe and a brief literature review.*

This handbook is for your patients, for your team and for you. We hope you find it valuable and as always contact your GE Healthcare representative if you have any questions.

Guillaume Fusari
CT Product Marketing Manager, Europe

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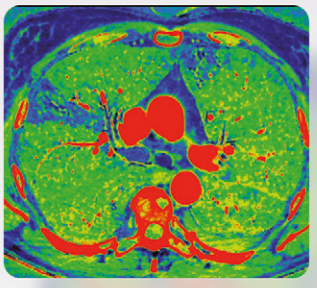
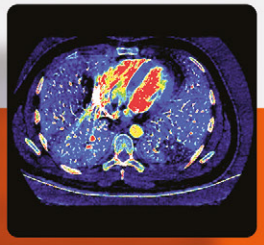
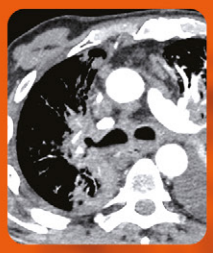
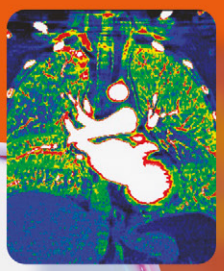


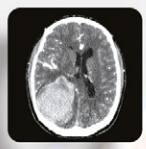
Vascular



TESTIMONIALS & PUTTING INTO PRACTICE







Interest of spectral imaging in cerebral angiography and supra-aortic trunks

Testimonial by Prof. Hodel
Henri Mondor University Hospital, Créteil, France

Patient History

- 73-year-old patient, left hemicorporeal deficiency
- Both extra and intracranial abnormalities are visible:
  1 - Ectasia of the internal carotid artery
  2 - Small aspect of the right middle cerebral artery associated with a 4 mm intracranial aneurysm
  3 - Moreover multiple intracranial arterial stenoses are visible

Acquisition

- GSI Assist
- $CTDI_{vol}$: 19.11 mGy
- DLP: 798.80 mGy-cm
- Acquisition Time: 5 sec

Injection

- 50 cc Iodine at 4 cc/s
- 350 mg/ml

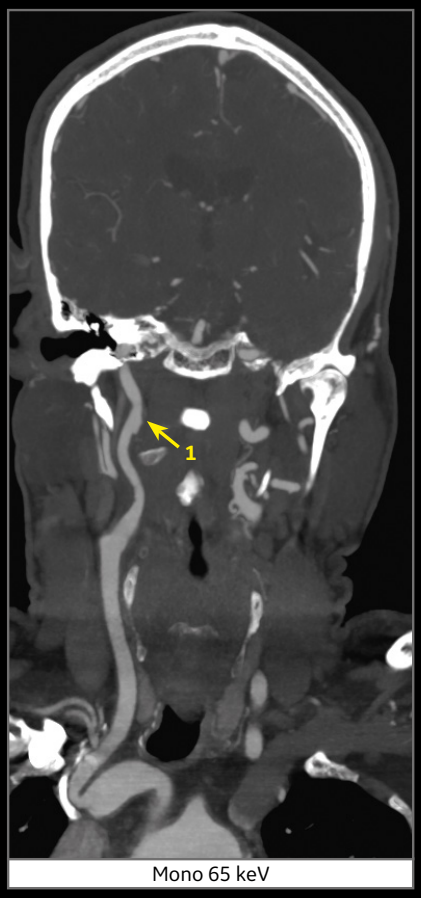
GSI Data Management

Acquisition console

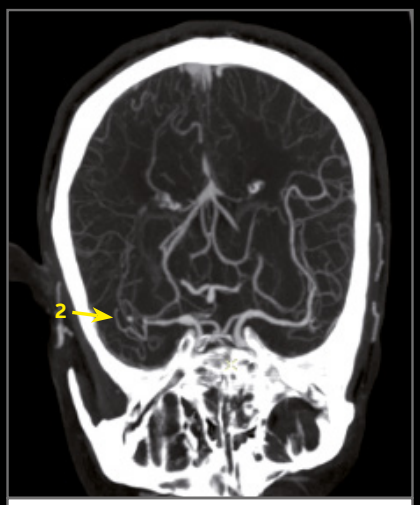
- Monochromatic images at 65 keV
- Multi-energy images

Post-processing console

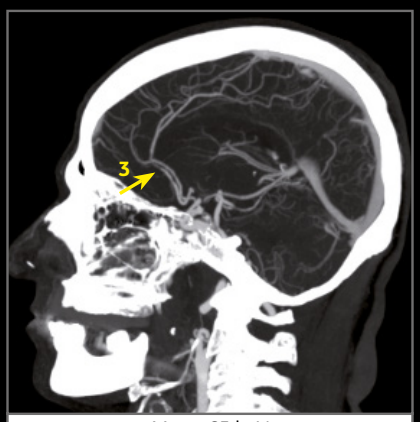
- PACS



Mono 65 keV



Mono 65 keV



Mono 65 keV

CLINICAL BENEFIT

The carotids and Circle of Willis CT angiography is common in the management of neurovascular emergencies.
The advantage of spectral acquisition is to allow excellent visualization of both the cerebral arteries and supra-aortic trunks (carotid and vertebral arteries).
Contrast optimization reliably evaluates the caliber of distal cerebral arteries while decreasing the amount of injected iodinated contrast media.

Post-Embolization Control of Pial Fistula

Benefit of Spectral Imaging for the Follow-up after Embolization of Cerebral Vascular Malformations

Testimonial by Prof. Hodel
Henri Mondor University Hospital, Créteil, France

Patient History

- 26-year-old patient
- Pial fistula with venous aneurysm of 9 cm long axis
- Control performed 3 days after exclusion of pial fistula by embolization

Acquisition

- GSI Assist
- $CTDI_{vol}$: 54.71 mGy
- DLP: 1081.87 mGy-cm
- Acquisition Time: 5 sec

Injection

- 50 cc Iodine at 4 cc/s
- 350 mg/ml

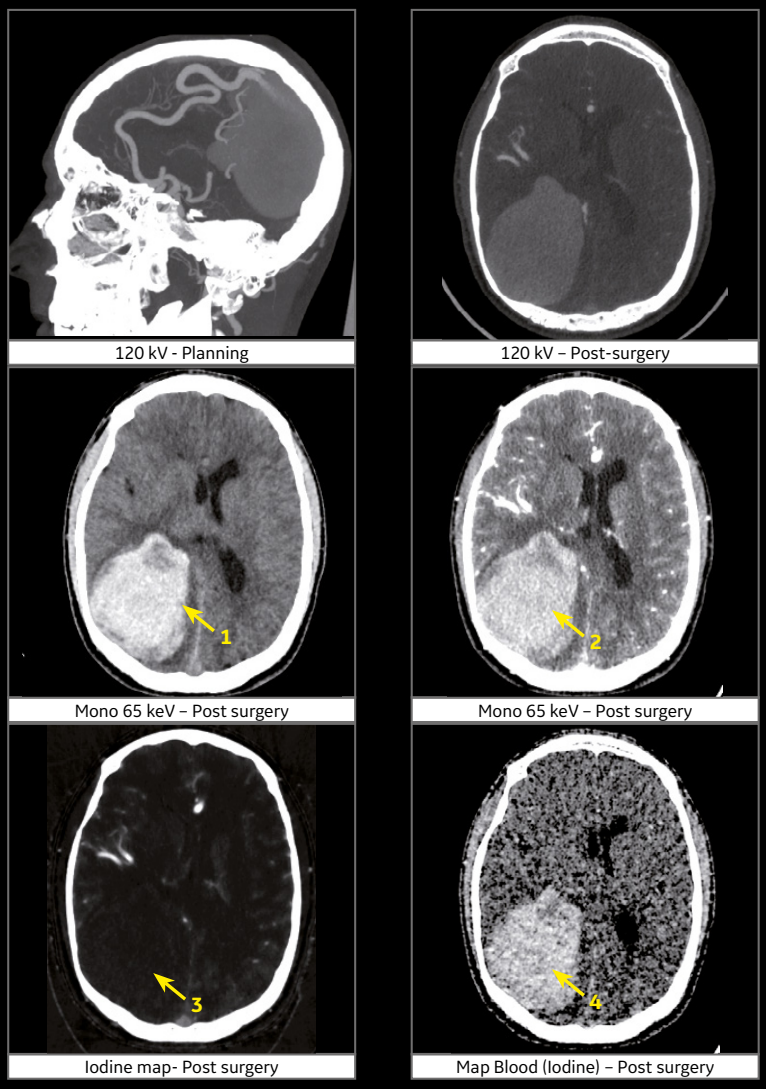
GSI Data Management

Acquisition console

- Monochromatic images at 65 keV
- Multi-energy images
- Iodine map
- Blood (Iodine) map

Post Processing Console

- GSI Volume Viewer
- PACS



120 kV - Planning | 120 kV – Post-surgery
Mono 65 keV – Post surgery | Mono 65 keV – Post surgery
Iodine map- Post surgery | Map Blood (Iodine) – Post surgery

CLINICAL BENEFIT

The CT scan was performed postoperatively in order to detect residual circulation in the large venous aneurysm.
After surgery, the venous aneurysm appears hyperdense without (**1**) and after injection (**2**). Spectral imaging easily answers this question by highlighting the total absence of iodinated contrast medium within the venous aneurysm ("iodine" images), thus testifying to its complete exclusion (**3**). The reconstruction of blood (iodine) makes it possible to affirm that it is indeed a complete thrombosis (**4**), explaining the spontaneous hyperdensity postoperatively.

Multiple subsegmental Pulmonary Embolism

after liver transplantation GSI distal pulmonary Embolism detection on GSI Iodine map

Testimonial by Prof. Alain Luciani
Henri Mondor University Hospital, Créteil, France

Patient History

- 51-year-old patient at 6 months after liver transplantation for HCC
- Systematic routine follow-up with multiphasic chest abdomen CT on late arterial phase, and abdominopelvic examination on portal-venous phase

Acquisition

- Chest Abdomen arterial phase
- GSI
- 320 mA
- Rotation Time 0,5 s
- Pitch 0,992/1
- Speed 100 mm/s
- Chest Abdomen DLP 740 mGy.cm

Injection

- 80 ml /3 ml/s
- 350 mg/ml

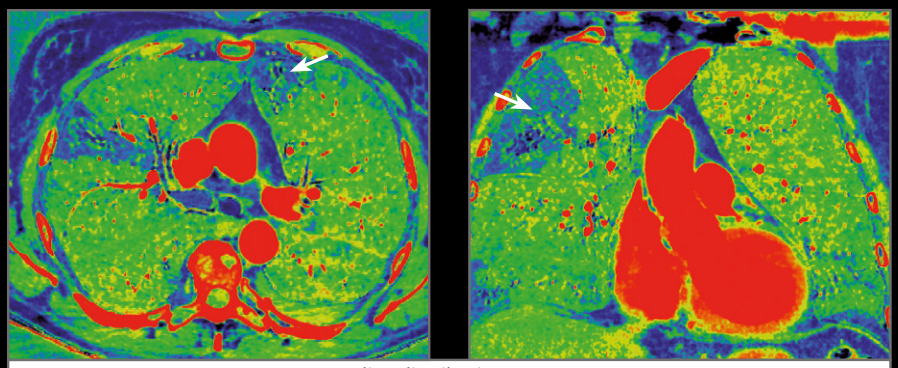
GSI Data Management

Acquisition console

- Iodine (Water) images
- GSI Data File

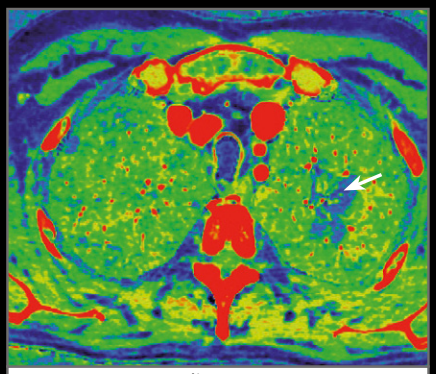
Post-processing console

- GSI Volume Viewer
- Dual-phase Iodine distribution maps



Iodine distribution maps

Morpho image 70 keV



Iodine map

CLINICAL BENEFIT

Systematic follow-up carried out using multiphasic arterial and portal-venous phase with GSI Xtream reveals multiple sub-segmental pulmonary embolism, with no clinical symptoms.

GSI Xtream can be fully integrated in routine follow-up protocols.

GSI Pulmonary Angiogram

Improving HU within the vessels on a Large Patient to aid visualization of Bi-lateral PE

Testimonial by Dr. Damian Tolan
Leeds Teaching Hospitals NHS Trust, UK

Patient History

Case 1.

- 61-year-old female
- 3 days shortness of breath with pleuritic chest pain. Previous DVT

Case 2.

- 61-year-old Male
- Right-sided pleuritic chest pain and loss of conciousness

Acquisition

Case 1 - GSI 54

- 0.6 seconds
- 275~mA
- Pitch 1.375
- Standard
- GSI ASiR 60%
- 55 keV Data File
- Iodine (Water)
- DFOV 40.2
- DLP 218 mGy.cm

Case 2 - GSI 16

- 0.6 seconds
- 640 ~mA
- Pitch 1.375
- Standard
- GSI ASiR 60%
- 55 keV Data File
- Iodine (Water)
- DFOV 45.1
- DLP 546 mGy.cm

Injection

- 90 ml at 3 ml/sec + 20 ml saline flush at 3 ml/sec
- 350 mg/ml

GSI Data Management

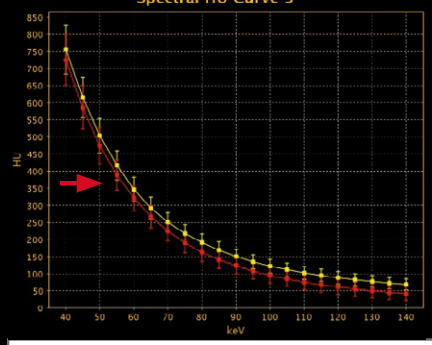
Acquisition console

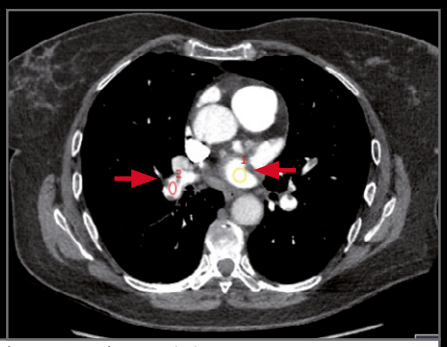
- Iodine (Water) images
- 55 keV Monochromatic images
- GSI Data File

Post-processing console

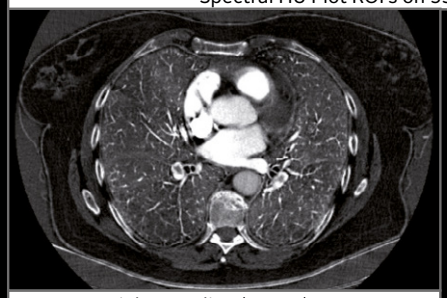
- GSI Volume Viewer
- Iodine (Water) images

Case 1

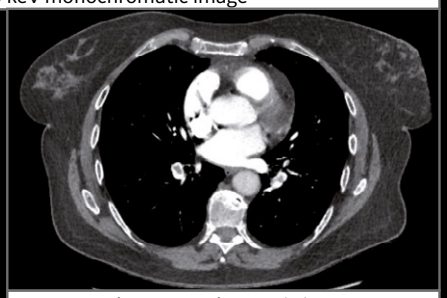




Spectral HU Plot ROI's on 55 keV monochromatic image

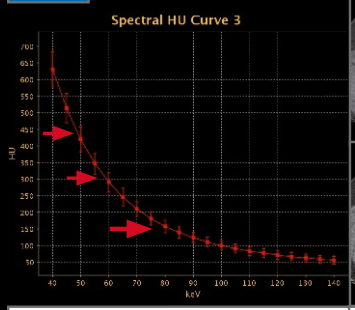


Axial MD Iodine (Water) Map

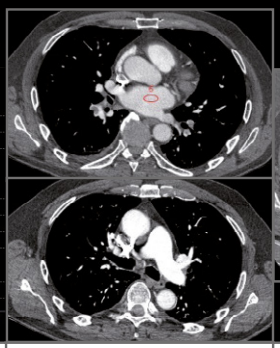


55 keV monochromatic image

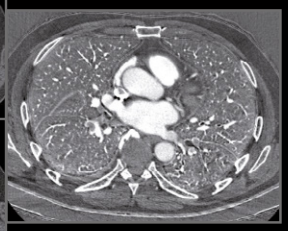
Case 2



Spectral HU Plot



Mono 55 keV & 45 keV



Mono 55 keV & 45 keV

CLINICAL BENEFIT

Case 1

Monochromatic Imaging at 55 keV increases the Hounsfield Units (HU) within the Pulmonary vessels as demonstrated on the spectral HU plot. ROI's placed on the Pulmonary Artery density at 55 keV is 380 HU compared to 75 keV (120 kVp) equivalent where the density is 200 HU. This Patient has non occulsive bi-lateral Pulmonary Emboli on the 55 keV monochromatic images and Material Denstiy Iodine (Water) images. There are no associated perfusion defects on the Iodine maps.

Case 2

Large Patient with a DFOV > 45 cm. Images at 55 keV and 45 keV clearly demonstrate the improvement in HU by reducing the monochromatic energy. On a patient of this size full, FOV imaging is possible. Using even lower keV can increase the density of the pulmonary arteries to > 500 HU.

Pulmonary embolism and neoplastic ilio-caval thrombus in a patient with pelvic nodal recurrence from uterine leiomyosarcoma

One-stop diagnosis with lung perfusion assessment and thrombus characterization from a single contrast-enhanced GSI scan

Testimonial by Dr. Lorenzo Faggioni
University Hospital of Pisa, Italy

Patient History

- A 67-year-old woman with known pelvic nodal recurrence from uterine leiomyosarcoma previously treated with surgery was admitted to our Department with fatigue, shortness of breath and chest pain. A cardiac ultrasound examination showed right heart enlargement with an elongated clot extending from the inferior vena cava to inside the pulmonary trunk. A CT pulmonary angiography and abdominal CT venography examination was performed on clinical suspicion of acute pulmonary embolism and caval thrombus

Acquisition

- GSI acquisition
- Cranio-caudal scan with bolus tracking on the pulmonary trunk (150 HU threshold)
- Minimum scan delay (≈ 6 sec)

Injection

- 100 ml contrast + 40 ml saline flush at 3 ml/sec for venous enhancement
- After 70 sec delay: 40 ml contrast + 60 ml saline at 4 ml/sec for CT pulmonary angiography scan
- 320 mgI/ml

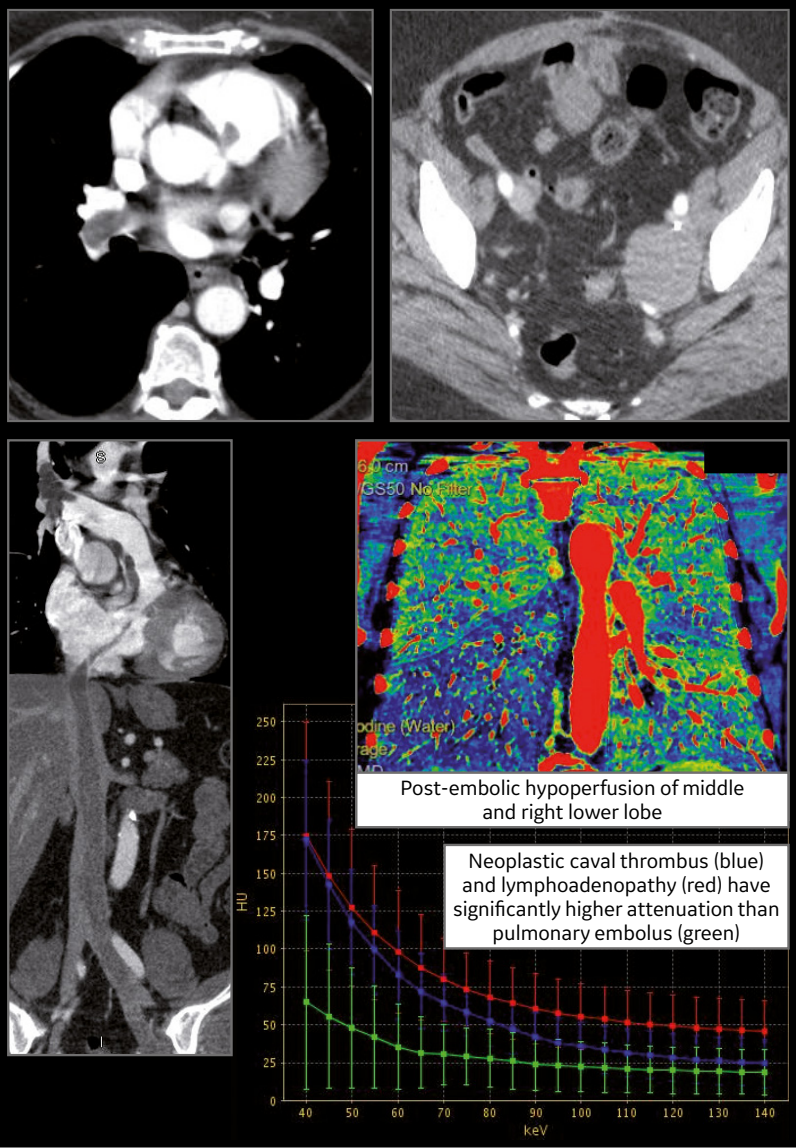
GSI Data Management

Acquisition console

- Iodine (Water) images
- GSI Data File

Post-processing console

- GSI Volume Viewer
- Iodine distribution maps
- Spectral attenuation curves



CLINICAL BENEFIT

The combination of GSI scanning and a dual-phase contrast injection protocol allows detection of pulmonary embolism and extensive neoplastic ilio-caval thrombus originating from pelvic lymph node metastasis with a single CT acquisition.

Iodine maps generated from GSI data can provide functional information about lung perfusion without the need for further testing

GSI Pulmonary Angiogram

Bilateral PE's - Iodine (Water) Map demonstrates Iodine Perfusion defects

Testimonial by Dr. Damian Tolan
Leeds Teaching Hospitals NHS Trust, UK

Patient History

- 45-year-old female
- Shortness of Breath.
  Admitted via A & E for exclusion of Pulmonary Embolism

Acquisition

- GSI
- 0.6 seconds
- 360~mA
- Pitch 1.375
- Standard
- GSI ASiR 60%
- 55 keV Data File
- Iodine (Water)
- DFOV 43.8
- DLP 326 mGy.cm

Injection

- 90 ml at 3 ml/sec + 20 ml Saline flush at 3 ml/sec
- 350 mg/ml

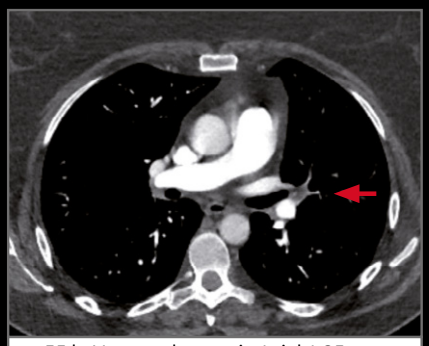
GSI Data Management

Acquisition console

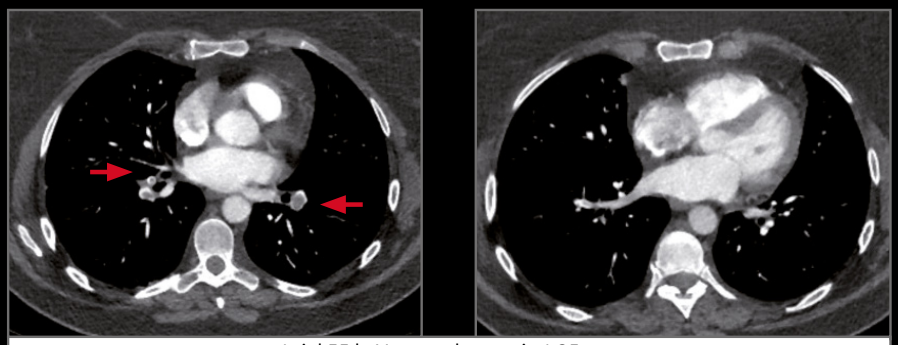
- Iodine (Water) images
- 55 keV Monochromatic images
- 45 keV Monochromatic images
- GSI Data File

Post-processing console

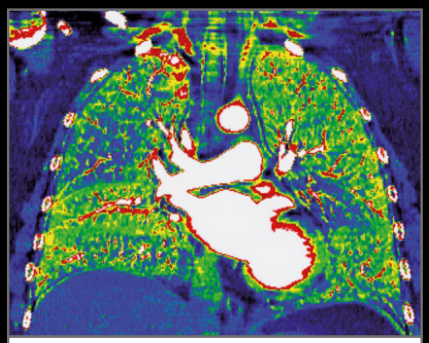
- GSI Volume Viewer
- Iodine (Water) images



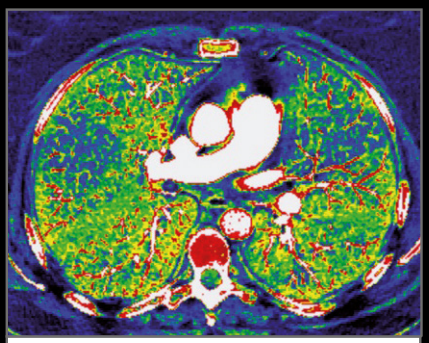
55 keV monochromatic Axial 1.25 mm



Axial 55 keV monochromatic 1.25 mm



Coronal MD Iodine (Water) with colour overlay



Axial MD Iodine (Water) with colour overlay

CLINICAL BENEFIT

Obese female scanned with Full FOV Imaging at 43 cm DFOV. Bilateral Pulmonary Embolism are present on contrast enhanced images. However the Colour Material density Iodine Map also clearly demonstrates well defined areas of associated reduced lung perfusion.

GSI Pulmonary Angiogram

Bilateral PE - Infarcted lower Left Lobe – Iodine Perfusion Deficient demonstrated

Testimonial by Dr. Damian Tolan
Leeds Teaching Hospitals NHS Trust, UK

Patient History

- 25-year-old male
- Increasing shortness of breath

Acquisition

- GSI
- 0.5 seconds
- 360~mA
- Pitch 1.375
- Standard
- GSI ASiR 60%
- 55 keV Data File
- Iodine (Water)
- DFOV 36
- DLP 242 mGy.cm

Injection

- 80 ml at 3 ml/sec + 20 ml Saline flush at 3 ml/sec
- 350 mg/ml

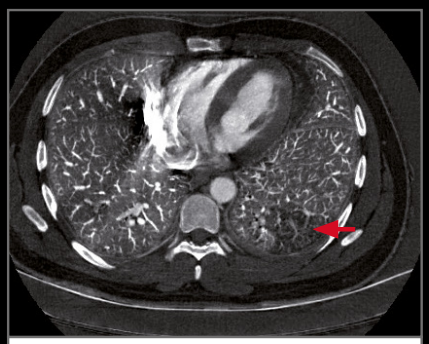
GSI Data Management

Acquisition console

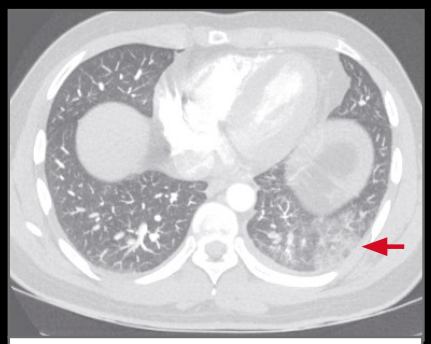
- Iodine (Water) images
- 55 keV Monochromatic images
- 45 keV Monochromatic images
- GSI Data File

Post-processing console

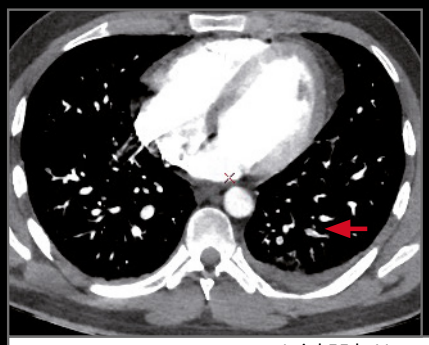
- GSI Volume Viewer
- Iodine (Water) images

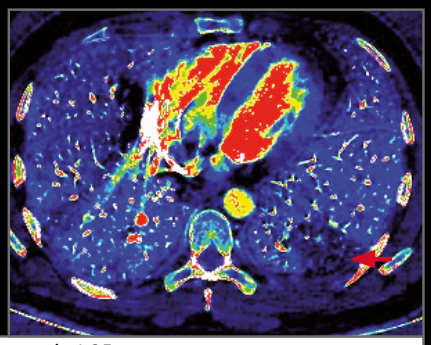


Iodine MD

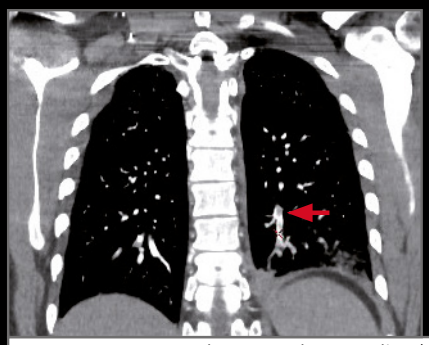


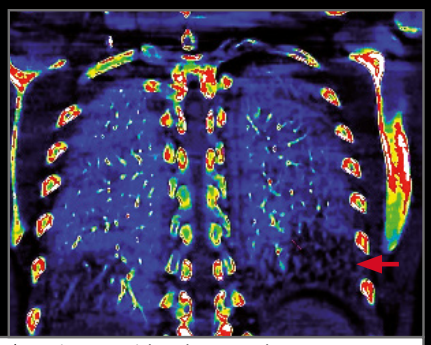
Axial Lung





Axial 55 keV monochromatic 1.25 mm





Coronal Mono 55 keV & Iodine (Water) MD image with colour overlay

CLINICAL BENEFIT

25-year-old male presenting with Bilateral PE complicated by infarction. It defined left lower lobe consolidation with loss of perfusion demonstrated in the Iodine MD image and in the Iodine (Water) MD image with colour overlay, indicating parenchymal infarction.

Pulmonary embolism suspicion

Benefits of low keV monochromatic image

Testimonial by Dr. Raquel Cano
University Hospital Quirónsalud, Madrid, Spain

Patient History

- 40-year-old patient
- Lung cancer
- Severe dyspnea, EP suspicion

Acquisition

- GSI Assist
- $CTDI_{vol}$: 9.03 mGy
- DLP: 310 mGy-cm
- Acquisition timing: 1.7 sec

Injection

- 25 cc at 2.5 cc/sec
- 350 mg/ml

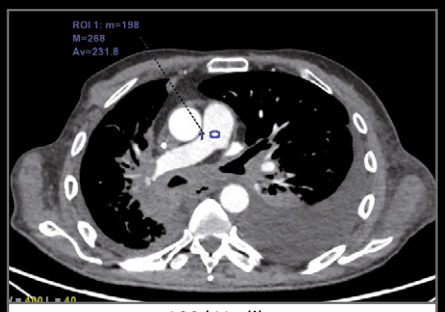
GSI Data Management

Acquisition console

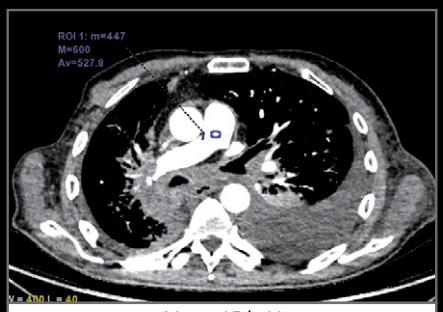
- 100 kVp-like images
- Monochromatic images at 45 keV
- Iodine map

Post-processing console

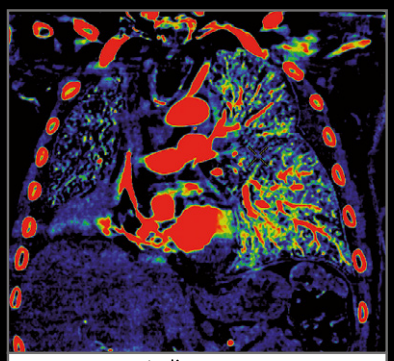
- GSI Volume Viewer
- PACS

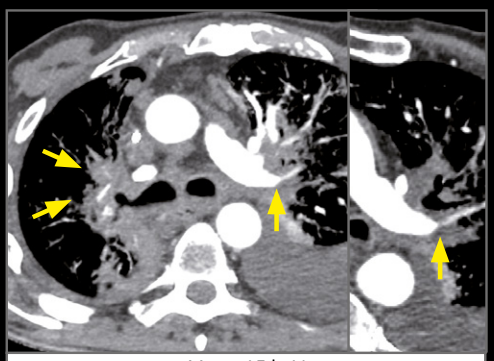


100 kVp-like



Mono 45 keV


Iodine map


Mono 45 keV

CLINICAL BENEFIT

Pleural effusion, the pulmonary mass invades the mediastinum affecting the vessels, the iodine mapping shows areas of hypoperfusion on both lungs that correspond to the compression and invasion of the vessels GSI Xtream can be fully integrated in routine follow-up protocols Injection at 2.5 ml/s but because of an injection problem injected 25 ml. Better visualization at low energies to recover this contrast compared to 100 kVp like images.

Pulmonary embolism assessment in patient on therapy

Benefits of material decomposition imaging

Testimonial by Dr. Vaudano
San Giovanni Bosco Hospital (Turin) Italy

Patient History

- Male, 44-year-old, basis right hemi-thorax
- Xray suggest BPCO, antibiotic therapy and patient left
- 10 days later, edema with left leg pain: doppler showed PVT without dyspnea and thorax pain
- PA CTA showed massive right PE
- Pt underwent therapy and follow-up one year later to evaluate perfusion problems
- GSI acquisition showed hypoperfusion of right postero-inferior lobe not visible with traditional acquisition

Acquisition

- GSI
- Tube current 640 mA
- Rotation time 0.5 sec
- Slice thickness 1.25 mm
- Collimation 40 mm
- Beam pitch 1.531:1
- SmartPrep on pulmonary arteries

Injection

- 60 ml at 5 ml/sec + 60 cc + 40 ml of saline flush at 5 ml/sec
- 400 mgI/ml

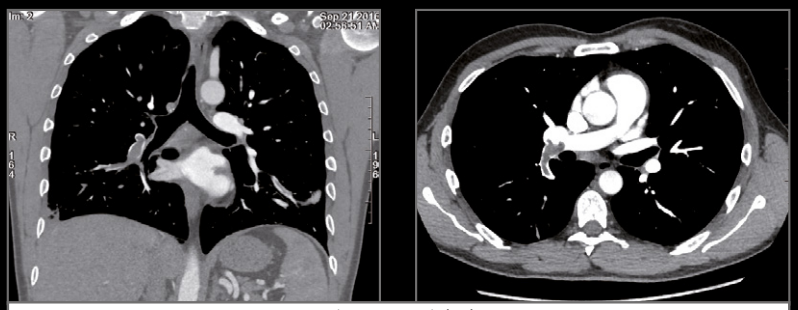
GSI Data Management

Acquisition console

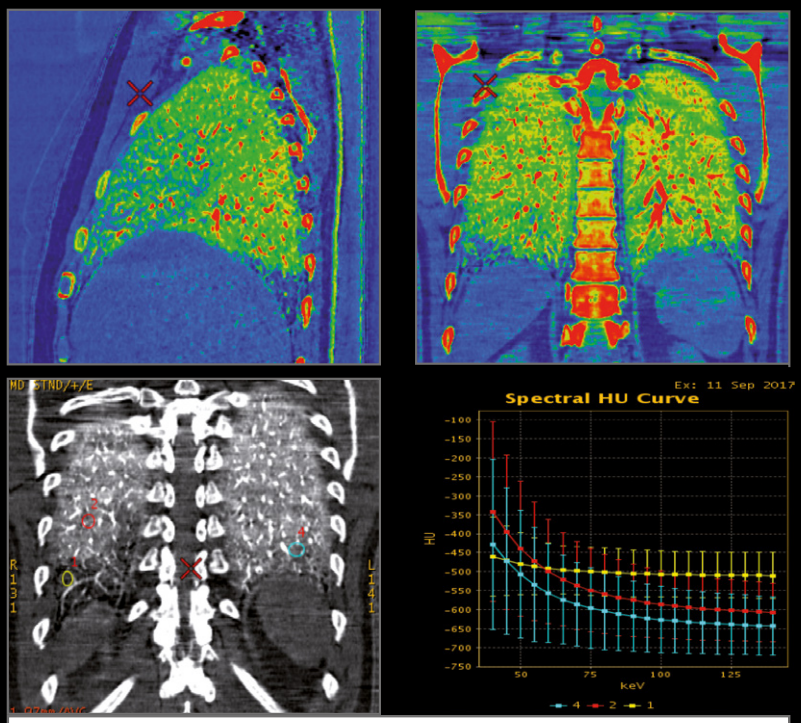
- Iodine (Water) images
- GSI Data File

Post-processing console

- GSI Volume Viewer
- Dual-phase Iodine distribution maps
- Spectral attenuation curves



Massive PE on right lung



Hypoperfusion of right postero-inferior lobe 1-year later

CLINICAL BENEFIT

GSI acquisition with material decomposition images Iodine (Water) and spectral attenuation curves allow to identify clearly hypoperfusion of postero-inferior lobe of the lung that was not visible with traditional polychromatic beam acquisition.

Iodine maps generated from GSI data can provide functional information about lung perfusion and help in follow-up of patients in therapy without the need for further testing.

Spectral attenuation curves easily enable assessment and quantification of a small region with perfusion defects.

Follow-up after embolization of a pulmonary arteriovenous malformation (Rendu-Osler disease)

Benefits of metal artefact reduction on coils

Testimonial by Dr. Mostafa El Hajjam
Ambroise Paré Hospital, Boulogne-Billancourt, France

Patient History

- 73-year-old patient
- Rendu-Osler disease follow-up
- Right/Left shunt seen at the echocardiogarphy
- Endovascular embolization indication

Acquisition

- GSI Assist
- Arterial timing
- $CTDI_{vol}$: 7.40 mGy
- Acquisition timing: 3.2 sec

Injection

- 90 ml - 3 ml/sec Iodine
- 20 ml - 3 ml/sec Saline

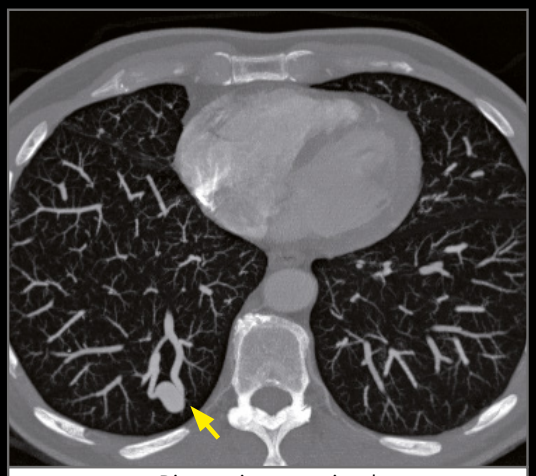
GSI Data Management

Acquisition console

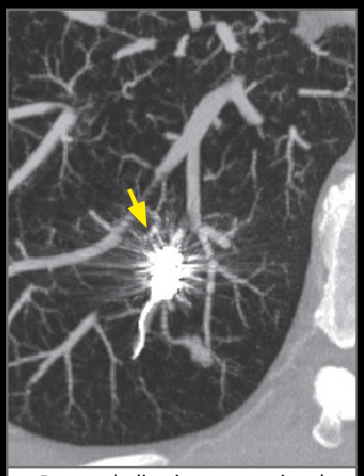
- Multi-energy images
- Monochromatic images at 60 keV + MAR

Post-processing console

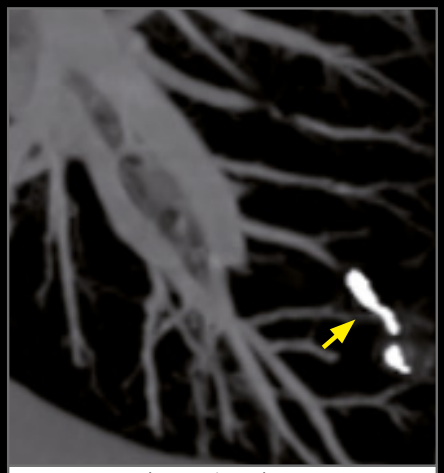
- GSI Volume Viewer
- PACS



Diagnostic conventional imaging



Post embolization conventional imaging



Monochromatic 60 keV + MAR

Iodine – map

CLINICAL BENEFIT

Conventionnal CT for diagnostic assessment of a lower right lobar pulmonary AVM.
Difficult evaluation of the post-embolization result due to the metallic artefacts of the coils.
The spectral acquisition associated with the reduction of metallic artefacts generated by metal coils allowing a better evaluation of the post-therapeutic follow-up: its total occlusion or its repealing.

CTA of the Lower Limb Arteries on moderate renal insufficiency

Benefits of a Fast Vascular Imaging GSI with 60 ml of iodine at 65 keV

Testimonial by Dr. Alain Prouvé
Saint-Augustin Clinic, Pessac, France

Patient History

- 75-year-old patient
- Moderate Renal Impairment
- Follow-up for diffuse arteriopathy
- Challenge: iodine volume

Acquisition

- GSI Assist
- Fast lower limb arteries Acqusition
- ASiR: 60%

Injection

- Biphasic injection
- 60 ml at 2.5 ml/s Iodine
- 40 ml at 1.5 ml/s Saline

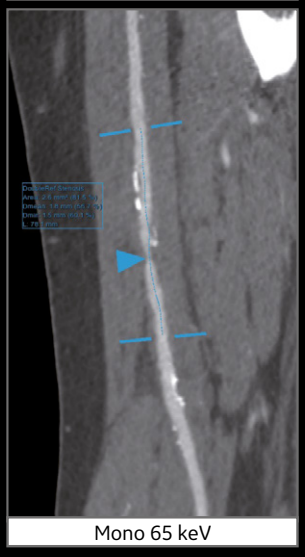
GSI Data Management

Acquisition console

- Monochromatic images at 65 keV
- MAR: Metal Artefact Reduction

Post-processing console

- GSI Volume Viewer
- Autobone Xpress lower limb arteries
- AWS & AW
- PACS



CLINICAL BENEFIT

CT performed with an amount of iodine respecting renal function for a diagnosis perfectly answering the clinical question.

GSI's speed to the arteries in the lower limbs enable the reduction of iodine.

The visualization of stenotic pathologies of this diffuse arteriopathy are well identified.

Coil Embolization of left ACI Aneurysm – Post Interventional Cranial Spectral CT with MAR for Metal Artefact Reduction

Testimonial by Prof. Dr. Müller-Hülsbeck
DIAKO Hospital, Flensburg, Germany

Patient History

- Patient in her 40s acute subarachnoidal hemorrhage
- Hunt & Hess II at rupture of PCom-aneurysm left side. Known Factor V-disease with recurrent thrombosis, present thrombosis of left subclavian artery

Acquisition

- 1.0 seconds
- 550 mA
- GSI ASiR 40%
- Preset 30
- 2.5-20 mm Collimation
- Iodine (Water)
- $CTDI_{vol}$: 49 mGy
- DLP 784 mGy.cm

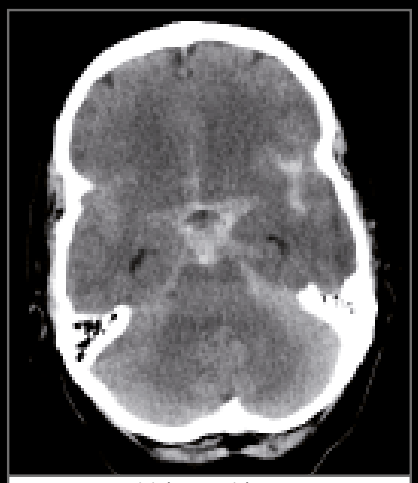
GSI Data Management

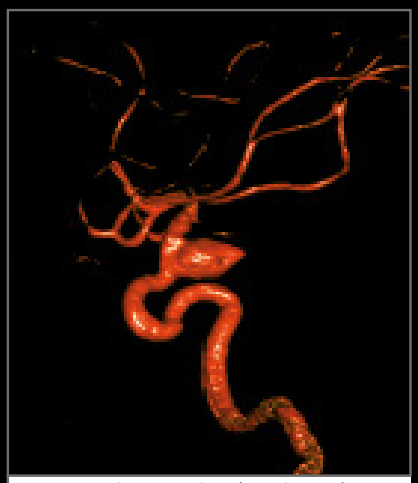
Acquisition console

- Iodine (Water) images
- 65 keV monochromatic images
- GSI Data File

Post-processing console

- GSI CCT
- Iodine (Water) images


Initial CCT with SAB


3D VR interventional Angiography

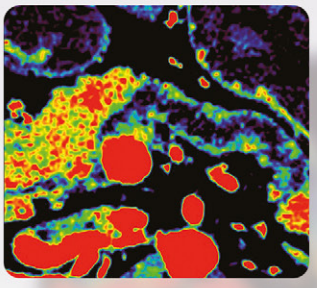

post Coiling


GSI scan 65 keV non MAR


GSI scan 65 keV with MAR

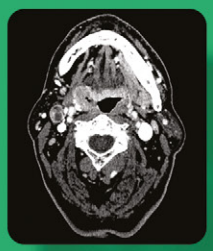
CLINICAL BENEFIT

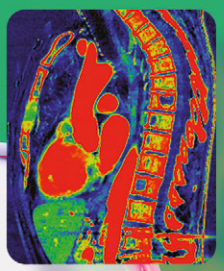
In the initial cranial CT scan, a subarachnoidal hemorrhage Fisher III was detected. The following CTA of carotids and cerebral vessels revealed a posterior communicant aneurysm of left carotids artery. Diagnostic CT imaging was directly followed by a coil embolization of the detected ACI aneurysm without any neurologic deficits. In repeated Doppler sonography exams, no vessel spasms could be seen. As the patient was known for a factor-V-disease, an anti-coagulation therapy with Clexane was started.
A 24-hour post interventional cranial CT scan in spectral imaging technique including MAR algorithm for metal artefact reduction was performed. This could exclude any signs for developing a hydrocephalus. Subarachnoidal hemorrhage was reabsorbed almost completely. Patient could be dismissed without any sensomotoric deficits.

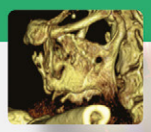


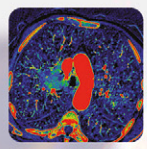
Oncology

TESTIMONIALS & PUTTING INTO PRACTICE









PUTTING INTO PRACTICE

ONCOLOGY

Testimonial by Prof. FERRETTI - *MD & Chairman at Grenoble University Hospital - France*

Thanks to the trust and proximity of our application engineer and the implementation of the PACS, we are serenely making progress in the use of our scanner and in our practices.

Which are the clinical applications in the thorax impacted since the upgrade of your Revolution CT?

- **The diagnosis of Pulmonary Artery Hypertension** with chronic thrombosis and percutaneous interventional guidance in the disobstructive treatment of chronic peripheral thrombosis of the pulmonary artery (Dr. Frederic Thony and Dr. Hélène Bouvay – Thesis). Iodine vs Water mapping is very useful for locating infusion abnormalities and helping this pre-treatment anatomical identification.
- **The evaluation of PAH** is done only in GSI in our service (Dr. Jankowski and Team).
- In some types of **CAP Oncology** acquisition, we use a new bi-phasic injection protocol to optimize the pulmonary arteries and the portal vein opacification in a single portal passage. As a result, **GSI is an undeniable gain in the embolus research and the tumor disease monitoring (RECIST 1.1) at Iso-Dose.**
- And clearly, the acute **pulmonary embolism diagnosis** and parenchyma impact visualization (perfusion abnormalities: **Pulmonary Scintigraphy Like**)

Spectral acquisition is also used by my vascular team in all abdominal aortic examinations.

PUTTING INTO PRACTICE

ONCOLOGY

Testimonial by Dr. CALAME - *Radiologist at Besançon University Hospital - France*

At the University Hospital of Besançon, we are now performing a GSI acquisition for all hepatic and pancreatic arterial studies in our patients.

Hepato-gastroenterology activity has an important place in the University Hospital of Besançon.

More than ever, imaging plays a key role in the consideration and strategy of patients care coming from this field.

In hepatic pathologies, arterial enhancement is a key point, both for **lesion characterization and for detection of hepatocellular carcinoma lesions.**

Regarding pancreas, the arterial time is essential both for the assessment of pancreatic adenocarcinoma (precise delineation of the tumor and its extension) and for the diagnosis and follow-up of **Intraductal Papillary Mucinous Neoplasms of the pancreas** (research of abnormal enhancement within ductal dilatation).

For these indications, spectral imaging obviously offers real added value by providing a daily boost of confidence in the arterial enhancement analysis. At the University Hospital of Besançon, we are now performing a GSI acquisition for all hepatic and pancreatic arterial times in our patients.

Spontaneous nasal liquorrhea

Determining bone damage of the skull base with GSI cisternography

Testimonial by Dr. Alexander Antonenko
Republican Research and Clinical Center of Neurology and Neurosurgery, Minsk, Belorussia

Patient History

- Female, 49-year-old
- Pre-surgery CT cisternography for bone defect determination & surgery planning

Acquisition

- Head: GSI-9
- Rot 0.5 s
- 20 mm
- Pitch 0.984: 1.375:1
- GSI ASiR: 40% DI: 56
- Prone position

Injection

- Intrathecal injection 15 ml @ 300 mg/ml

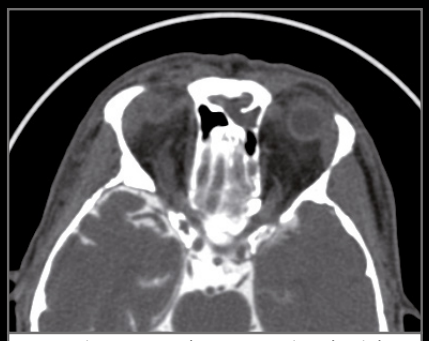
GSI Data Management

Acquisition console

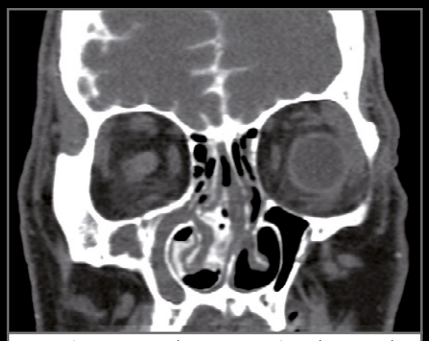
- GSI Data File

Post-processing console

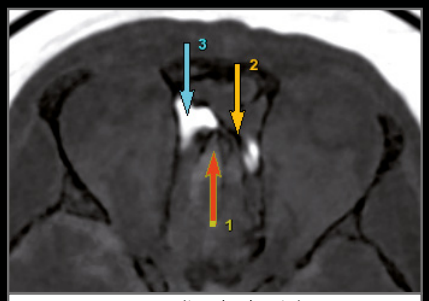
- GSI Volume Viewer
- MD Calcium (Iodine) & Iodine (Calcium) & fused images



CT cisternography, conventional axial

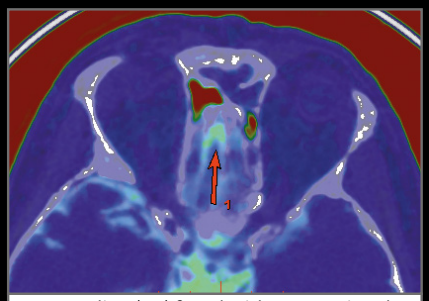


CT cisternography, conventional coronal

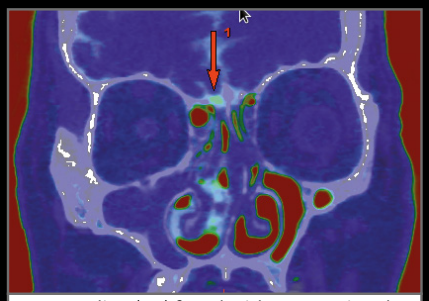


MD Iodine (Ca) axial:
1 Iodine, 2 -excluded Ca, 3 - air

MD Iodine (Ca) coronal: 1 Iodine in pathological bone aperture



MD Iodine (Ca) fused with conventional axial
1 - Iodine spot near pathological bone aperture



MD Iodine (Ca) fused with conventional coronal
1 - Iodine spot in pathological bone aperture

CLINICAL BENEFIT

In this case, GSI improves efficiency and sensitivity of CT cisternography in the diagnosis of spontaneous liquorrhea. Iodine (Ca) Material Decomposition images fused with conventional CT images help to pinpoint the pathological opening of the skull base bone. It clearly confirms the presence of iodine leakage through the bone, despite the similarity of bone and iodine density.

ENT oncology

Benefits of 55 keV monochromatic imaging and Iodine density

Testimonial by Prof. Jean Rousset
Military Teaching Hospital Clermont Tonnerre, Brest, France

Patient History

- Patient suffering from odynophagia
- Prior carcinoma of the esophagus and recurrent carcinoma oral cavity and epiglottis
- Implementation of MED-EL brand cochlear implants
- GSI follow-up

Acquisition

- GSI Assist
- ASiR: 60%
- Detail
- DLP 579

Injection

- 1st Time Impregnation
- 2nd Arterial

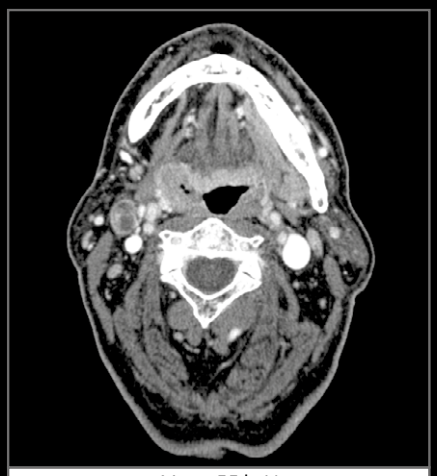
GSI Data Management

Acquisition console

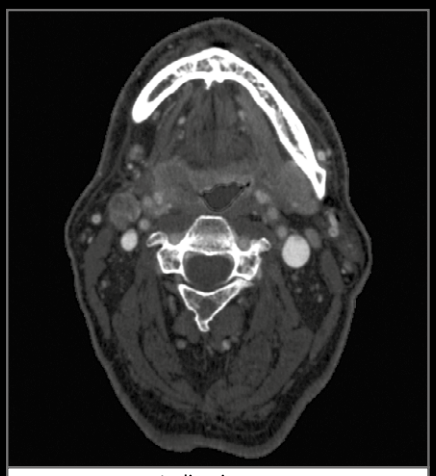
- Monochromatic images at 65 keV
- Iodine (Water) images
- VIEW images

Post-processing console

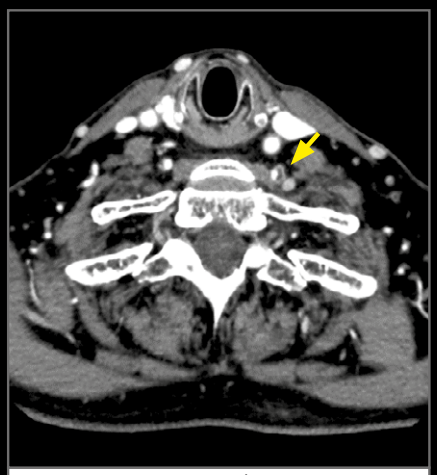
- MPR / GSI Viewer
- GSI Volume Viewer
- PACS



Mono 55 keV



Iodine image



Mono 55 keV

Iodine image

CLINICAL BENEFIT

The contribution of low keV images and the Iodine image.
Confirmation of a right oropharyngeal ulcerative-infiltrative recurrence.
Easier visualization of ipsilateral necrotic lymphadenopathies.
Right mandibular gland absent (antecedent of selective dissection and sub-mandibulectomy).
Despite a mixed injection time, good visualization of soft-tissue stenosis of the second segment of the left vertebral artery.

Local recurrence of laryngeal squamous cell carcinoma with anterior commissure involvement after surgery and chemo-radiation therapy

Differentiation from laryngeal edema and surgical residual sign using monochromatic images and iodine maps from a GSI scan

Testimonial by Dr. Lorenzo Faggioni
University Hospital of Pisa, Italy

Patient History

- A 64-year-old man had been diagnosed with laryngeal squamous cell carcinoma and treated with partial laryngectomy and adjuvant chemo-radiation therapy. One year later, he complained about worsening laryngeal discomfort and hoarseness, and endoscopic inspection revealed narrowing of the glottic lumen with diffuse edema and anterior mucosal abnormality. A contrast-enhanced CT examination of the neck was performed due to suspicion of disease recurrence

Acquisition

- GSI acquisition
- Cranio-caudal scan with highest pitch (1.375:1) to minimize potential motion artefacts
- 70-sec scan delay after beginning of contrast injection

Injection

- 100 ml contrast + 40 ml saline flush at 3 ml/sec
- Iodixanol 320 mgI/ml

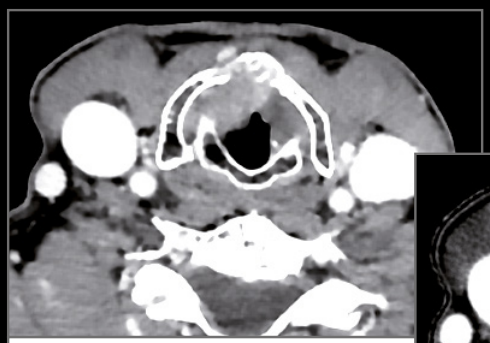
GSI Data Management

Acquisition console

- Iodine (Water) images
- GSI Data File

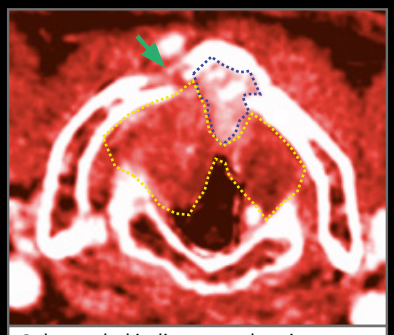
Post-processing console

- GSI Volume Viewer
- Monochromatic (60 keV) images
- Iodine distribution maps



60 keV image

Iodine map



Color-coded iodine map showing tumor extent (blue dashed line). Notice bilateral glottic edema (yellow dashed line) and post-surgical focal interruption of thyroid cartilage (green arrow) with no increased iodine content

Volume rendering image showing cartilage erosion due to anterior commissure cancer (red arrow) vs post-surgical discontinuity (green arrow)

CLINICAL BENEFIT

The combination of monochromatic images and iodine maps allows a comprehensive assessment of the soft tissue and bony components of the larynx in patients with suspected laryngeal cancer.

Iodine maps generated from GSI data can increase sensitivity in recurrent disease detection and improve differentiation between viable cancer tissue vs post treatment changes.

Pulmonary lesion follow-up

Benefits of iodine map images

Testimonial by Dr. Raquel Cano
University Hospital Quirónsalud, Madrid, Spain

Patient History

- 61-year-old patient
- Hip pain
- Dyspnea
- Weight loss
- Lung cancer

Acquisition

- GSI Assist
- $CTDI_{vol}$: 9.03 mGy
- DLP: 310 mGy-cm
- Acquisition time: 1.7 sec

Injection

- 80 ml at 3 ml/sec
- 350 mg/ml

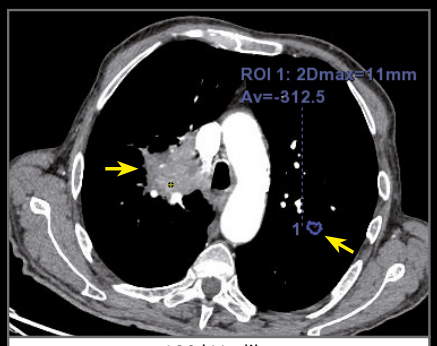
GSI Data Management

Acquisition console

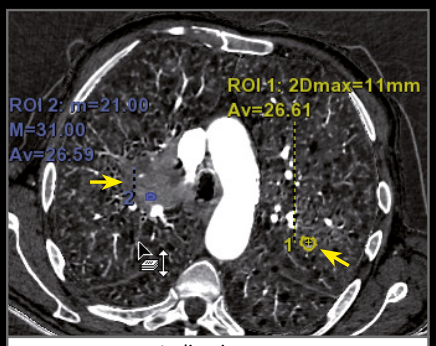
- 100 kVp-like images
- Monochromatic images at 45 keV
- Iodine map

Post-processing console

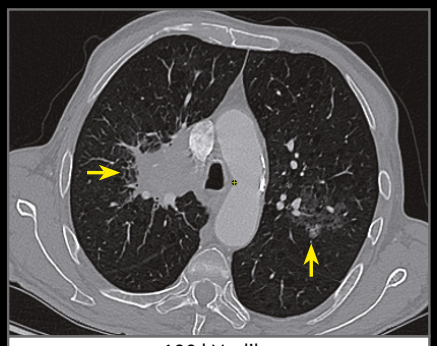
- GSI Volume Viewer
- PACS

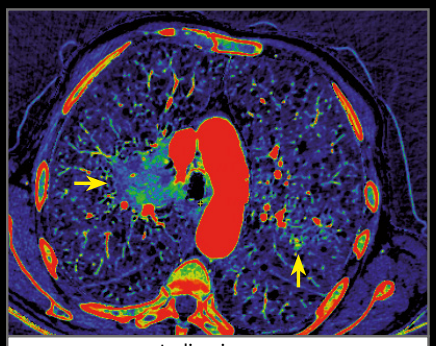


100 kVp-like



Iodine image


100 kVp-like


Iodine image

CLINICAL BENEFIT

Pulmonary mass in the right upper lobe, enhancement of the pulmonary nodule of the left upper lobe. Bone metastases in the right sacrum, iliac and femur. The images of iodine make it possible to better know the absorption of iodine in the small lesions, directing the diagnosis towards the malignancy. The uptake of iodine in the small nodule is similar to that of the more active areas of the lung mass.

Pulmonary lesion follow-up

Benefits of iodine map images combined with MAR

Testimonial by Dr. Raquel Cano
University Hospital Quirónsalud, Madrid, Spain

Patient History

- 72-year-old patient
- Multiple myeloma follow-up

Acquisition

- Neck-Chest- Abdomen- Pelvis
- GSI Assist
- $CTDI_{vol}$: 5.58 mGy / DLP: 246 mGy-cm
- $CTDI_{vol}$: 6.85 mGy / DLP: 295 mGy-cm
- Acquisition timing: 3 sec

Injection

- 80 ml at 3 ml/sec
- 350 mg/ml

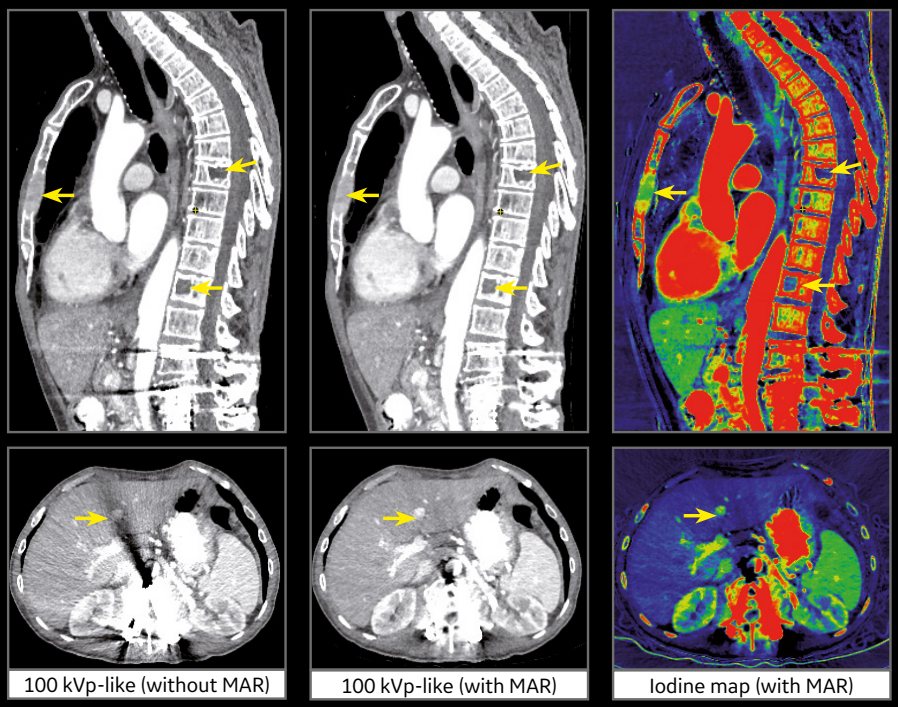
GSI Data Management

Acquisition console

- 100 kVp-like images
- Monochromatic images at 55 keV
- Iodine map
- Multi-energy images

Post-processing console

- GSI Volume Viewer
- PACS



100 kVp-like (without MAR) | 100 kVp-like (with MAR) | Iodine map (with MAR)

CLINICAL BENEFIT

Finding of multiple active lesions, in the liver.

The correction of artefacts, low keV and iodine images allow for a better diagnosis.

GSI Xtream Lesion detection in Breast Cancer Follow-up

Testimonial by Dr. Raquel Cano
University Hospital Quirónsalud, Madrid, Spain

Patient History

- Patient BMI 34-year-old known for breast cancer
- Cancer staging with chest, abdomen, pelvis 2-phase study

Acquisition

Scan type	GSI 80 mm helical
Rotation time, s	0.8
Pitch	0.992
Slice, mm	1.25 mm
mA	520/480
Noise index	20/19
Kernel	GSI Std/Bone+
ASiR-V, %	40
$CTDI_{vol}$, mGy	20.18
DLP mGy x cm	908

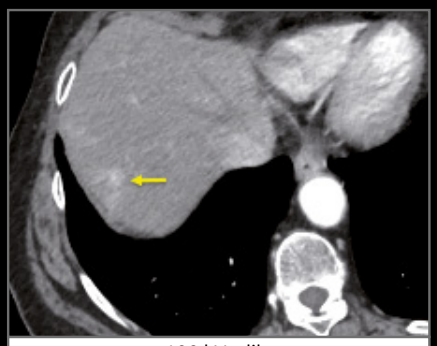
GSI Data Management

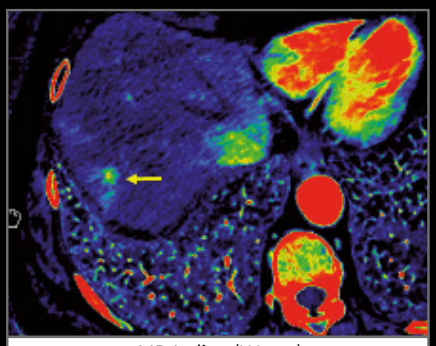
Acquisition console

- 120 kVp-like images
- Monochromatic images at 55 keV
- Iodine map
- Multi-energy images

Post-processing console

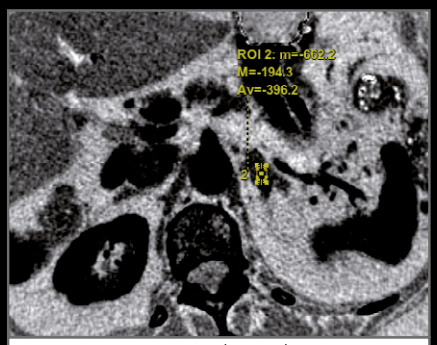
- GSI Volume Viewer
- PACS


100 kVp-like

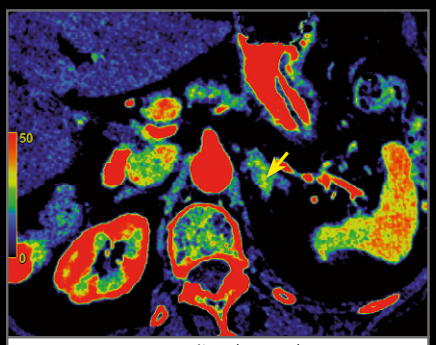

MD Iodine (Water)


100 kVp-like


MC 50 keV



MD Fat (Water)



MD Iodine (Water)

CLINICAL BENEFIT

Better visualization of metastases with low keV and iodine image. Adrenal lesion, contrast enhancement are better observed in 50 keV and iodine images compared with 100 kVp-like images.

Fat mapping (Water), ROI with negative values, which shows that there is no presence of fat, it will help to guide the diagnosis by excluding the adenoma.

Follow-up of operated hepatocholangiocarcinoma

Benefits of monochromatic imaging at 65 keV

Testimonial by Dr. Magaly Zappa
Beaujon APHP Hospital, Clichy, France

Patient History

- 76-year-old patient
- Hepatocholangiocarcinoma on hepatitis C liver
- Left hepatectomy in 2017

Acquisition

- GSI Assist
- Late arterial phase
- ASiR: 30%
- $CTDI_{vol}$: 7.62 mGy NRD $CTDI_{vol}$: 20 mGy
- DLP: 467 mGy-cm
- Portal Phase

Injection

- 90 ml at 3.5 ml/sec Iodine
- 30 ml at 2.5 ml/sec Saline

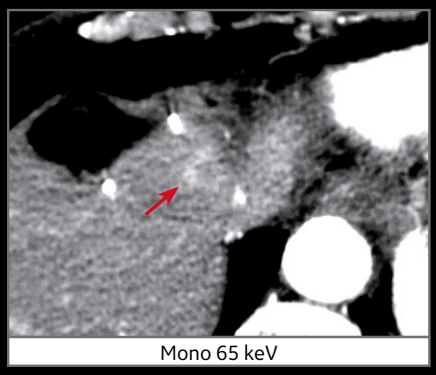
GSI Data Management

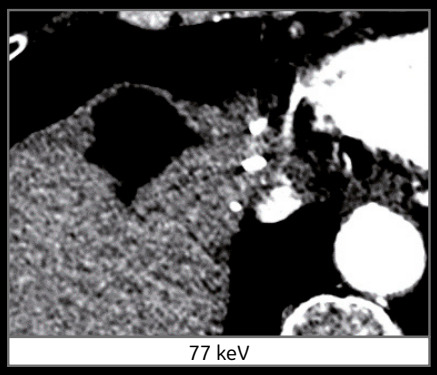
Acquisition console

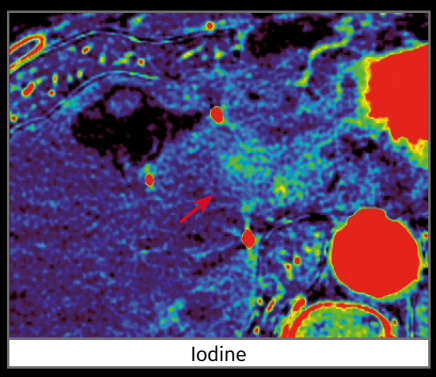
- Monochromatic images at 65 keV
- MD images in Iodine (Water)
- Multi-energy images

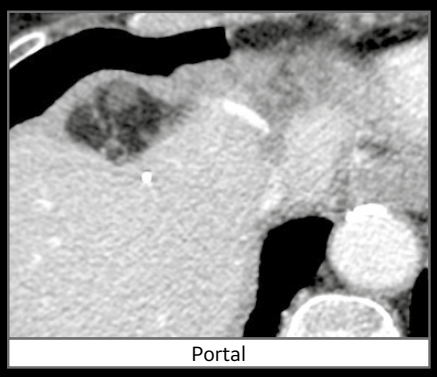
Post-processing console

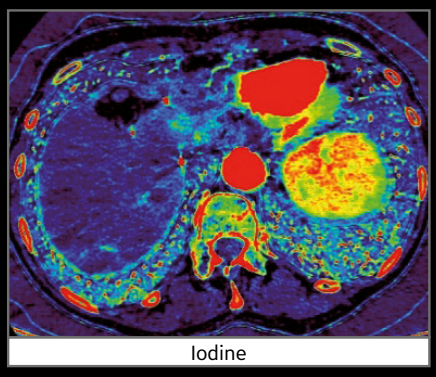
- GSI Volume Viewer & GSI Viewer
- PACS

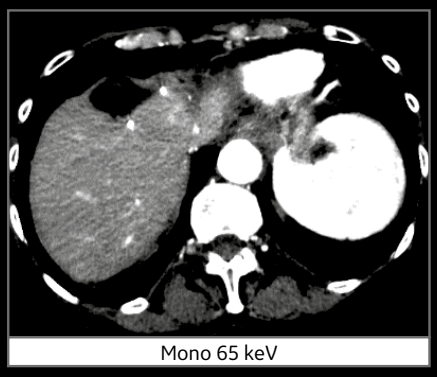

Mono 65 keV


77 keV


Iodine


Portal


Iodine


Mono 65 keV

CLINICAL BENEFIT

Focal nodular recurrence in contact with surgical clips.

Hypervascular lesion in late arterial phase with discrete portal time wash out.

The lesion is visualized on the images at 65 keV whereas it is not on the monochromatic at 77 keV (120 kVp) like.

Pancreatic Duct Adenocarcinoma

Better detection and lesion conspicuity with GSI

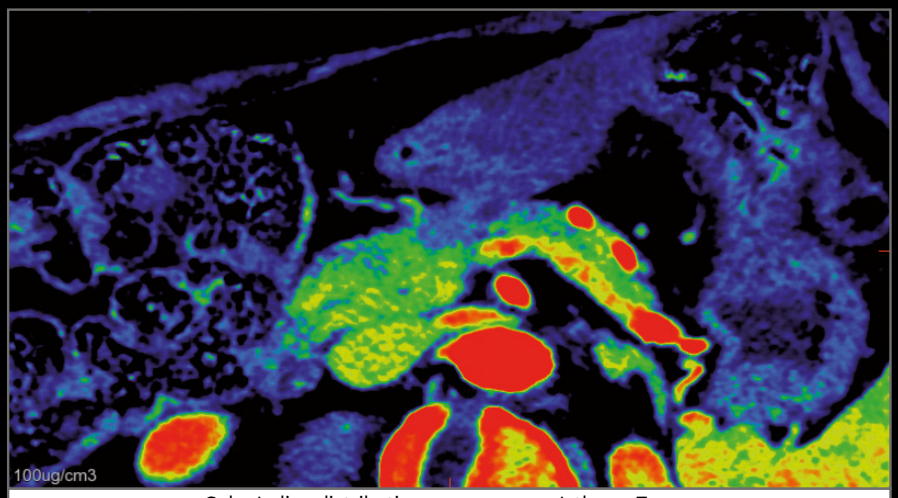
Testimonial by Prof. Alain Luciani
Henri Mondor University Hospital, Créteil, France

Patient History

- 64-year-old patient referred for pre-operative evaluation of a suspicious hypodense lesion of the pancreatic isthmus
- Multiphasic CT acquisition performed with GSI
- Late arterial phase with GSI and MD Iodine maps

Monochromatic 70 keV image

MD Iodine image with hypo-perfused tumor



Color Iodine distribution map pancreas Isthmus Tumor

Acquisition

- GSI
- 400 mA
- Rotation Time 0.8 s
- Pitch 0.992:1
- Speed 100 mm/s
- Patient BMI 35
- Abdomen pelvis DLP 780 mGy.cm

Injection

- 90 ml 3 ml/sec
- 350 mg/ml

GSI Data Management

Acquisition console

- Iodine (Water) images
- 50 keV
- Virtual Unenhanced
- GSI Data File

Post-processing console

- GSI Volume Viewer

CLINICAL BENEFIT

Low keV images and MD Iodine maps using GSI Xtream allow a better delineation of the hypoenhancing Pancreatic Duct Adenocarcinoma (PDAC) with increasing pancreatic lesion contrast to noise ratio. This confirms previously reported data (Hardie et al. JCAT 2015; 39(5):716-20).

GSI Xtream improves lesion conspicuity and can be fully integrated in pre-operative staging of PDAC.

Follow-up of acute pancreatitis after 3 months

Benefits of 55 keV monochromatic imaging

Testimonial by Dr. Paul Calame
Besançon University Hospital, France

Patient History

- 55-year-old patient
- Previous non-severe acute pancreatitis (AP)
- At the time of the initial AP scan, the CT showed an unobstructed dilatation of the pancreatic duct
- Etiological assessment at 3 months

Acquisition

- GSI Assist
- Pancreatic arterial time
- ASiR-V: 30%

Injection

- 120 ml at 4 ml/sec Iodine
- 20 ml at 4 ml/sec Saline
- 1.5 ml/kg Iodine

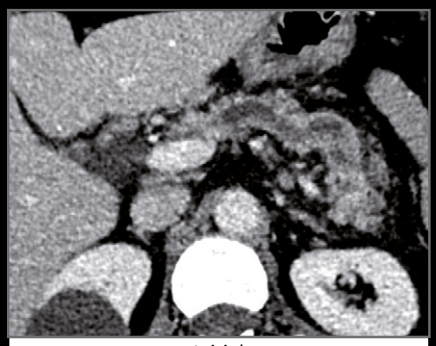
GSI Data Management

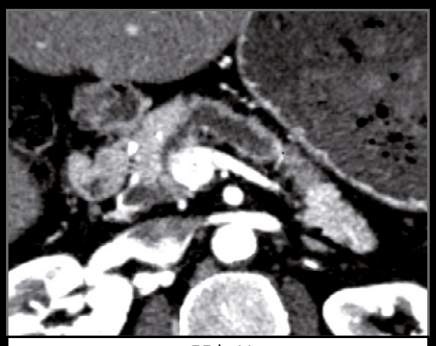
Acquisition console

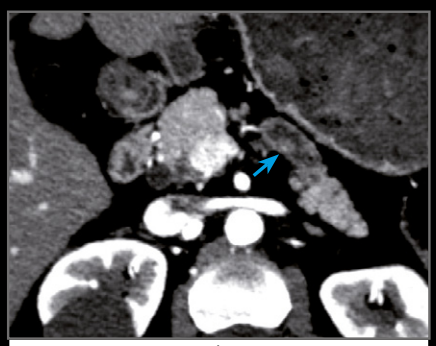
- 77 keV images
- Monochromatic images at 55 keV
- Images in Iodine (Water)
- Multi Energy images

Post-processing console

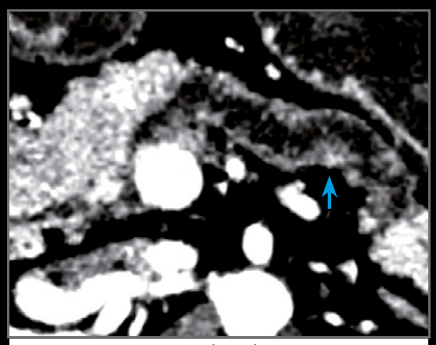
- GSI Volume Viewer & GSI Viewer
- PACS

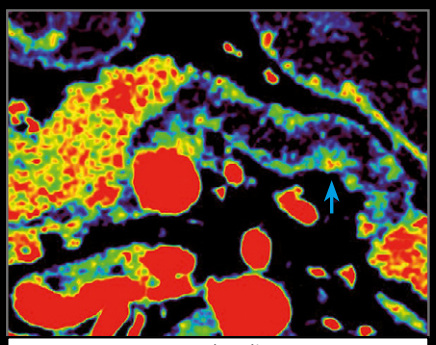

Initial


55 keV


77 keV


55 keV


Curved: 55 keV


Curved: Iodine

CLINICAL BENEFIT

Initial CT without spectral imaging.

Follow-up after 3 months with GSI.

The GSI acquisition characterizes the dilatation of the pancreatic duct and confirms the presence of a bud within the main pancreatic duct (strong suspicion of malignant conversion).

Breast Cancer

Benefit of the GSI application

Testimonial by Prof. Maria Antonietta Mazzei
University of Siena, Italy

Patient History

- A 37-year-old woman with a newly diagnosed breast cancer detected with mammography and US in the upper inner quadrant. Biopsy revealed an IDC: ER/PgR 90/30%, Her 2/neu:2+ and Ki67 of 60%. Breast MRI was not performed because of claustrophobia whereas a whole body staging CT was performed because of the high value of Ki67

Acquisition

- Acquisition parameters
- Thorax (GSI)
- Rapid kVp switching 80/140
- Tube current 640 mA
- Rotation time 0.6 s
- Slice thickness 2.5 mm Collimation 40 mm
- Beam pitch 0.938, RI 0.8 mm
- Late arterial phase (50 sec) abdomen (conventional CT)

Injection

- 100 ml at 4 ml/sec (1.5 ml/kg) + 40 ml of saline flush at 3 ml/sec
- Concentration: 320 mg/ml

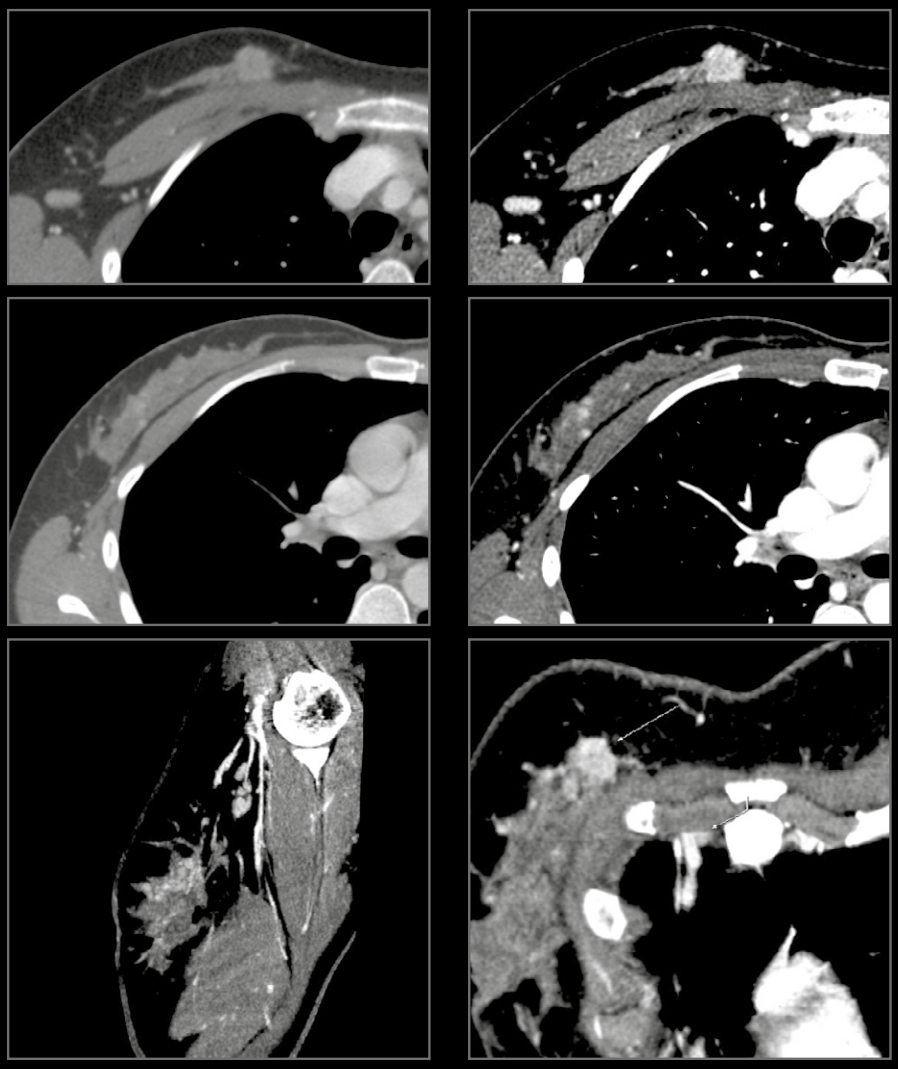
GSI Data Management

Acquisition console

- Iodine (Water) images
- GSI Data File

Post-processing console

- GSI Volume Viewer
- Dual-phase Iodine
- Distribution maps



CLINICAL BENEFIT

DECT clearly demonstrates the nodule in the upper inner quadrant and also multiple smaller lesion in the outer quadrant, not visible at mammograpy + US nor in conventional CT. DECT also demontrates an axillary and internal mammary lymphnodal involvement.
For patients newly diagnosed with breast cancer, DECT allows for a reliable locoregional staging. It could be useful when a distant staging is also indicated (DECT allows to avoid breast MRI) or when breast MRI is not available or if there are clinical contraindications (i.e. claustrophobia, implantable devices, etc).

Follow-up of a Neuro Endocrine Tumour (NET)

Benefits of monochromatic imaging at 60 keV

Testimonial by Dr. Magaly Zappa
Beaujon APHP Hospital, Clichy, France

Patient History

- 59-year-old patient
- Neuro Endocrine Tumour (NET) Grade 2
- Cephalic Duodenopancreatectomy in 2012
- Comparison between two CTs 6 months apart for evaluation of Somatostatin analog therapy showing stability of secondary hepatic lesions

Acquisition

- GSI Assist
- Late arterial phase
- ASiR: 30%
- $CTDI_{vol}$: 3.76 mGy NRD $CTDI_{vol}$: 20 mGy
- DLP: 705 mGy-cm

Injection

- 150 ml at 4 ml/sec Iodine
- 30 ml at 3 ml/sec Saline
- 2 ml/kg (Oncology)

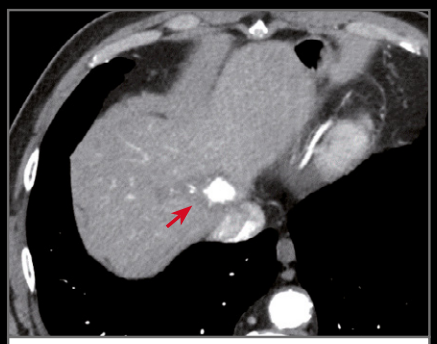
GSI Data Management

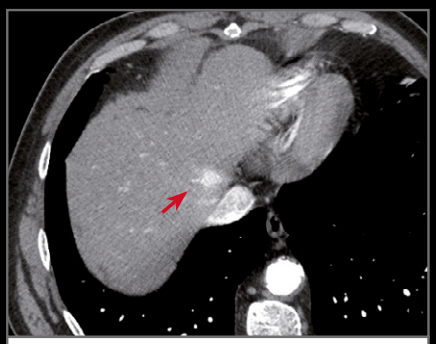
Acquisition console

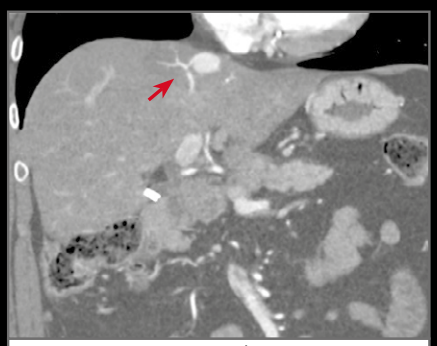
- Monochromatic images at 60 keV
- Iodine (Water) images
- Multi-energy images

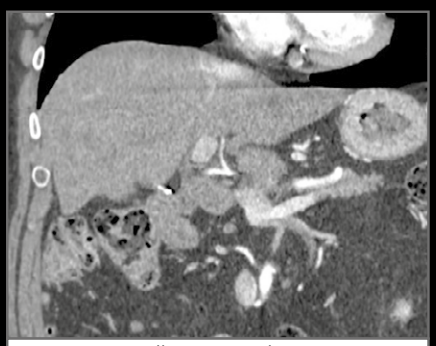
Post-processing console

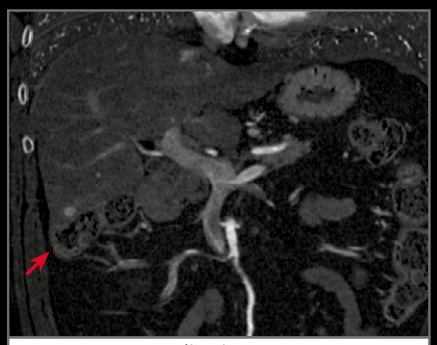
- GSI Volume Viewer & GSI Viewer
- PACS

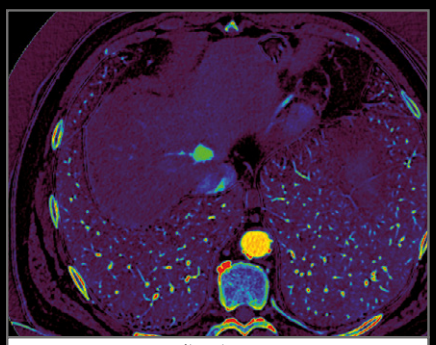

Mono 60 keV


Follow-up 120 kVp


Mono 60 keV


Follow-up 120 kVp


Iodine image


Iodine image

CLINICAL BENEFIT

Baseline CT in GSI.

Follow-up CT without GSI.

Spectral acquisition highlights arterial enhancement and gives a better definition of the contours of the secondary hepatic lesions.

CAP oncological monitoring and post-radio frequency control in GSI

Benefits of monochromatic imaging at 55 keV and in material density Iodine

Testimonial by Prof. Gilbert Ferretti
Grenoble University Hospital, France

Patient History

- 60-year-old patient BMI 25
- Follow-up for an operated kidney cancer with pulmonary metastases
- Radio frequency of metastasis (indication following PET/CT)

Acquisition

- GSI Assist
- Slices Thickness 2.5 and 1.25 mm
- Pitch: 1.53:1 (HyperDrive)
- ASiR-V: 60%
- $CTDI_{vol}$: 3.76 mGy
- DLP: 276 mGy-cm

Injection

- Multiphasic injection
- 95 ml at 3 ml/sec Iodine
- Pause 32 sec
- 15 ml at 3 ml/sec Iodine
- 20 ml at 3 ml/sec Saline

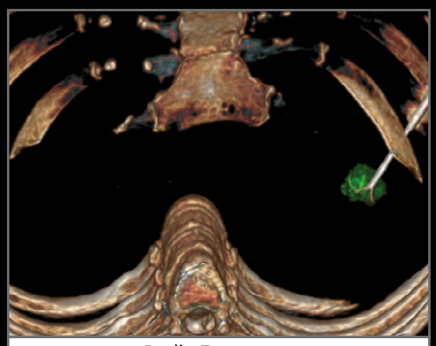
GSI Data Management

Acquisition console

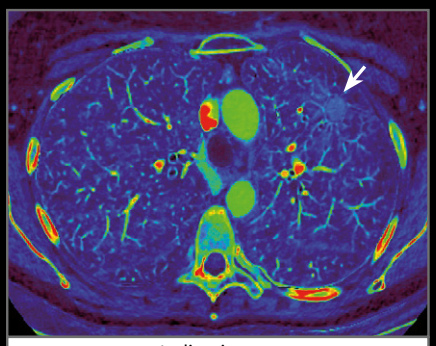
- Monochromatic images at 55 keV and 77 keV
- Iodine (Water) images
- VUE Virtual unenhanced images
- Water (Calcium) Bone Metastases images
- Multi-energy images

Post-processing console

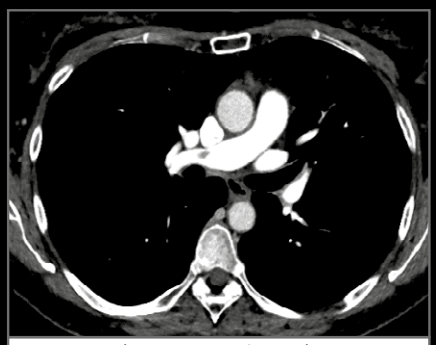
- PACS



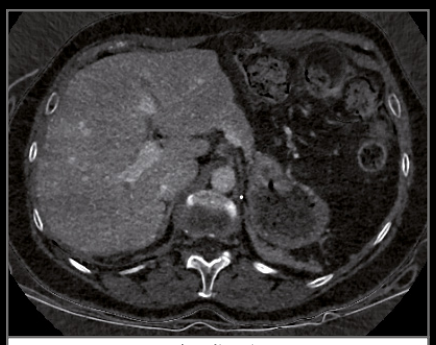
Radio Frequency



Iodine image

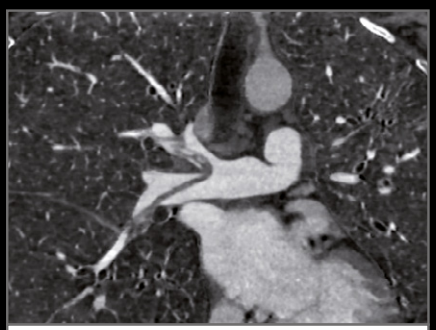


Pulmonary arteries 55 keV



Portal Iodine image

Pulmonary arteries 55 keV



Iodine image

CLINICAL BENEFIT

The GSI CAP Isodose Portal Phase CT at 80 sec in the follow-up of the post-radio frequency nodule doesn't show any enhancement of iodine within the nodule on the iodine image.
The injection protocol allows us to have portal phase and pulmonary arterial time. Incidental finding of pulmonary embolism (55 keV and Iodine). No visceral lesions. Acquisition in 2.5 mm (RECIST 1.1l and post processing in 1.25 mm for multi-plane reconstructions).

Post-chemo follow-up embolization of hepatocellular carcinoma

Benefits of monochromatic imaging at 55 keV and Iodine (ASiR-V 60%)

Testimonial by Dr. Madleen Chassang and Prof. Patrick Chevallier
L'Archet 2 Hospital, Nice, France

Patient History

- 56-year-old patient
- Hepatocellular carcinoma
- Suspicion of evolutionary tumor recurrence (near a thermodestuction zone)
- Hyperselective chemo-energetic session

Acquisition

- GSI Assist
- Arterial and Portal Phase
- ASiR-V: 60%
- 0.625 mm

Injection

- 90 ml at 3.0 ml/sec Iodine
- 30 ml at 2.0 ml/sec Saline

GSI Data Management

Acquisition console

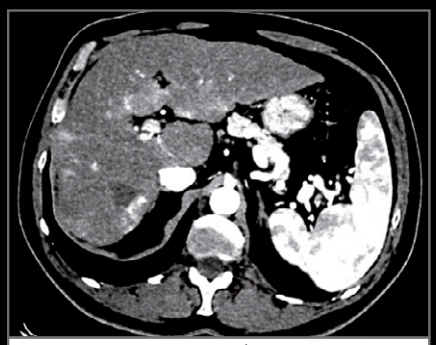
- Monochromatic images at 55 keV
- MD Iodine (Water) images
- Multi-energy images

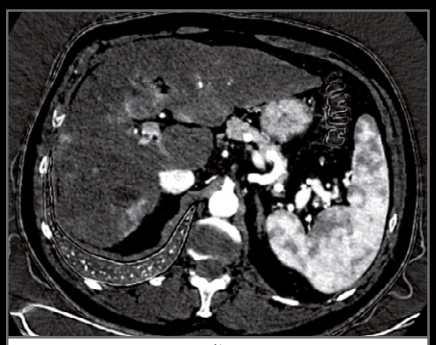
Post-processing console

- GSI Volume Viewer & GSI Viewer
- PACS


Mono 55 keV


Iodine


Mono 55 keV


Iodine


Volume Rendering 55 keV


Volume Rendering 77 keV

CLINICAL BENEFIT

Visualization of the thermodestruction necrotic zone.
Arterial phase at 55 keV more than contributive despite a relatively low injection rate.
Easier visualization of the enhancement of contrasts allowing time saving for the interpretation.

Hepatic Calcified Metastasis in Colon Cancer

Lesion characterization with GSI MD

Testimonial by Dr. Raquel Cano
University Hospital Quirónsalud, Madrid, Spain

Patient History

- Male, 47-year-old
- Follow-up of Colon Cancer with treated hepatic Mx
- Arterial Chest and Portal Abdo-Pelvis with GSI Oncology protocol
- BMI 31

Acquisition

Chest-Liver Arterial phase

- kV GSI; Pitch 0.992; Rot 0.6 s
- GSI Assist with NI 20; mA 480, DLP 491 mGy-cm

Abdo-Pelvis Portal Phase

- kV GSI; Pitch 0.992; Rot 0.6 s
- GSI Assist with NI 19 ; mA 480, DLP 840 mGy-cm

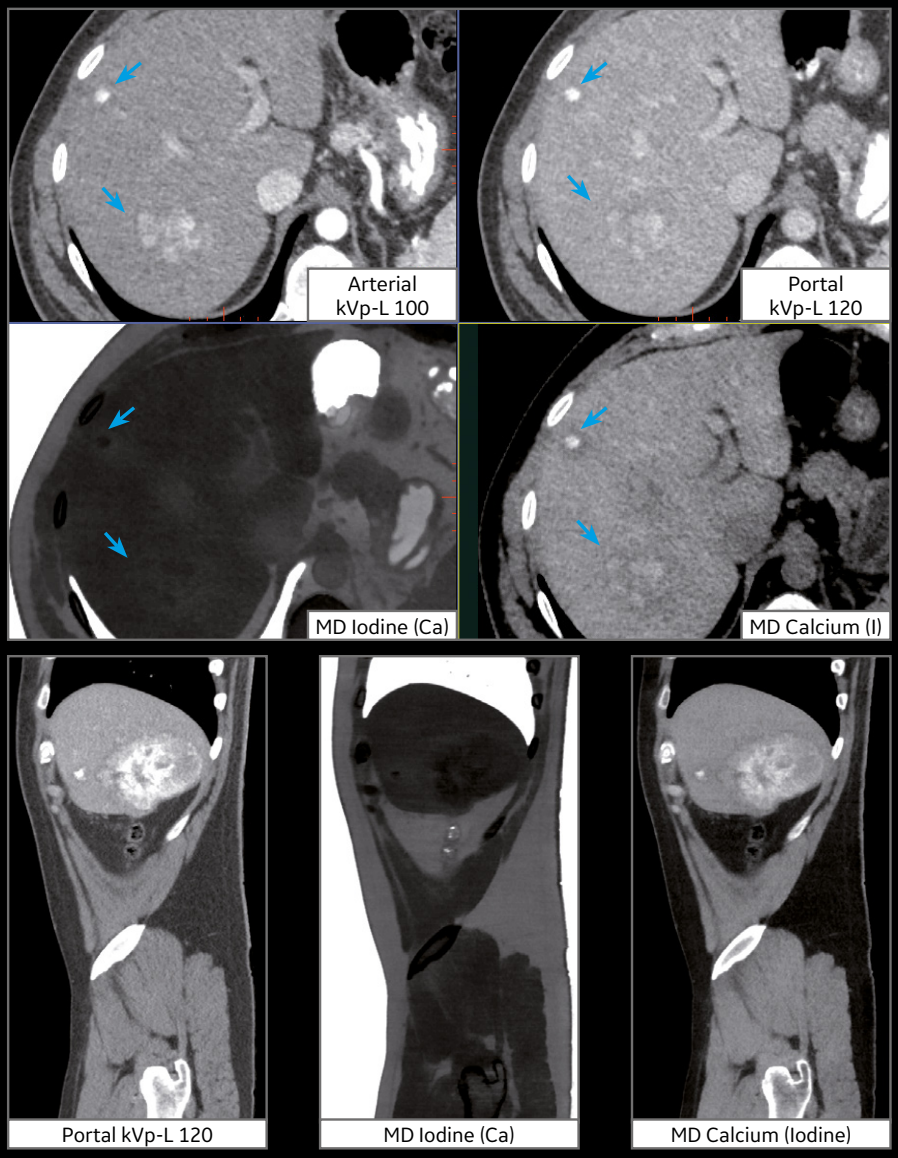
Injection

- 90 ml C + 30 ml SF at 3 ml/sec
- 300 mg/ml

GSI Data Management

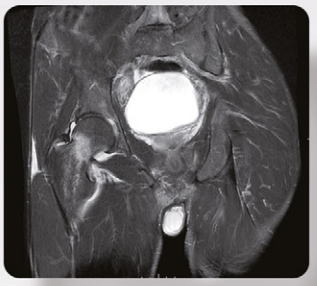
Acquisition console

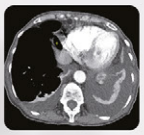
- kVp like (100-120)
- MC 55 keV
- MD Iodine (W)
- MD Fat (W)
- MD Calcium (I) & Iodine (Ca)
- GSI Data File

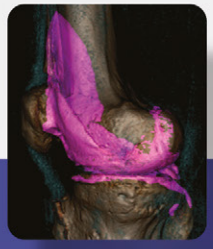


CLINICAL BENEFIT

Hyperdense lesions in the liver in both Arterial and Portal phases, no native scan was performed. Calcium (I) and Iodine (Ca) Material Decomposition images clearly confirm the presence of calcified metastasis, helping to differenciate from enhancing lesions.
All images created from the Operator console and directly reviewed in the PACS.

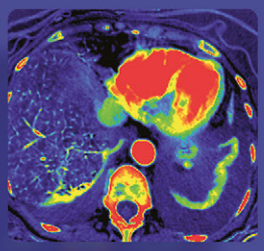


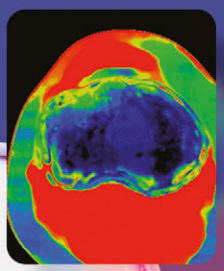


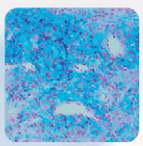


Material Decomposition

TESTIMONIALS & PUTTING INTO PRACTICE







PUTTING INTO PRACTICE

MATERIAL DECOMPOSITION

Testimonial by Prof. FERRETTI - *MD & Chairman at Grenoble University Hospital, France*

> Thanks to the trust and proximity with our application engineer and the implementation of the PACS, we are serenely making progress in the use of our scanner and in our practice.

What brings the Revolution CT in your medical imaging department?

At the arrival of our Revolution CT, my first thought was to develop the thoracic Ultra Low Dose (ULD) thanks to Gemstone Clarity detector coverage and the new iterative reconstruction system ASiR-V.
The **0.24 mGy $CTDI_{vol}$ acquisitions, that are less than 10 mGy-cm DLP** for a 30 cm average volume acquired, allow us to **routinely control** our patients with **cystic fibrosis** and **pneumonia**.
We are currently finalizing a clinical research protocol with Doctor Marie Ludwig about the equivalence of nodule detection in ULD vs Standard (100 mGy-cm) exams.

Which are clinical applications impacted since the upgrade of your Revolution CT in GSI Xtream?

In my area and anatomic specialty: thorax. I identified possible acquisitions in GSI routine in and for my service. Such as:

- **Quantitative** evaluation of **iodine in nodules** in µ/cm^3 after radiofrequency treatment to follow the necrotic evolution and the therapeutic success of the targeted nodule.

PUTTING INTO PRACTICE

MATERIAL DECOMPOSITION

Groupe hospitalier Paris Saint-Joseph
Soigner, accompagner, innover, former

Testimonial by Dr. ZINS - *Head of Service in Saint-Joseph Hospital, Paris, France*

> Spectral imaging is here to stay like T1 and T2. In Saint-Joseph Hospital, we did a rapid implementation of this new technology without impact in our workflow.

Spectral imaging at the heart of abdominal pathologies

For some months now, we have rapidly and systematically implemented spectral imaging to manage the **abdominal emergencies** in our hospital. It is an added value to the diagnosis that directly influences the nature of the treatment (medical or surgical).

This new technology has clinical benefits in our emergency procedure and in oncology. Indeed, it allows the improvement of **lesion detection** and digestive walls **enhancement study** while maintaining **good image quality.**

Here are some examples of GSI applications implemented within my medical imaging department:

- **Pancreatic cancer stage diagnosis and assessment:** the ability to study images at different keV can certainly improve the diagnosis of peri-nerve extensions in small vessels, a significant risk factor of wrong diagnosis and postoperative recurrence.
- **Abdominal emergency diagnosis:** quality of bowel wall enhancement study in the case of acute cholecystitis, walls loop analysis in a context of intestinal obstruction...

In case of metallic artefacts, the addition of the MAR technology allows a better analysis of the concerned area.

Spectral imaging in diffuse ischemic Colitis

Testimonial by Dr. Marc Zins
Saint-Joseph Hospital, Paris, France

Patient History

- 63-year-old female coming to the emergency ward for a diffused abdominal pain and in a state of shock. CT was requested in the context of gastro-intestinal emergency

Acquisition

- 140 kV, 275 mA
- Slice thickness 0.625 mm
- Without contrast, Arterial, Portal
- DLP: 1128 mGy.cm

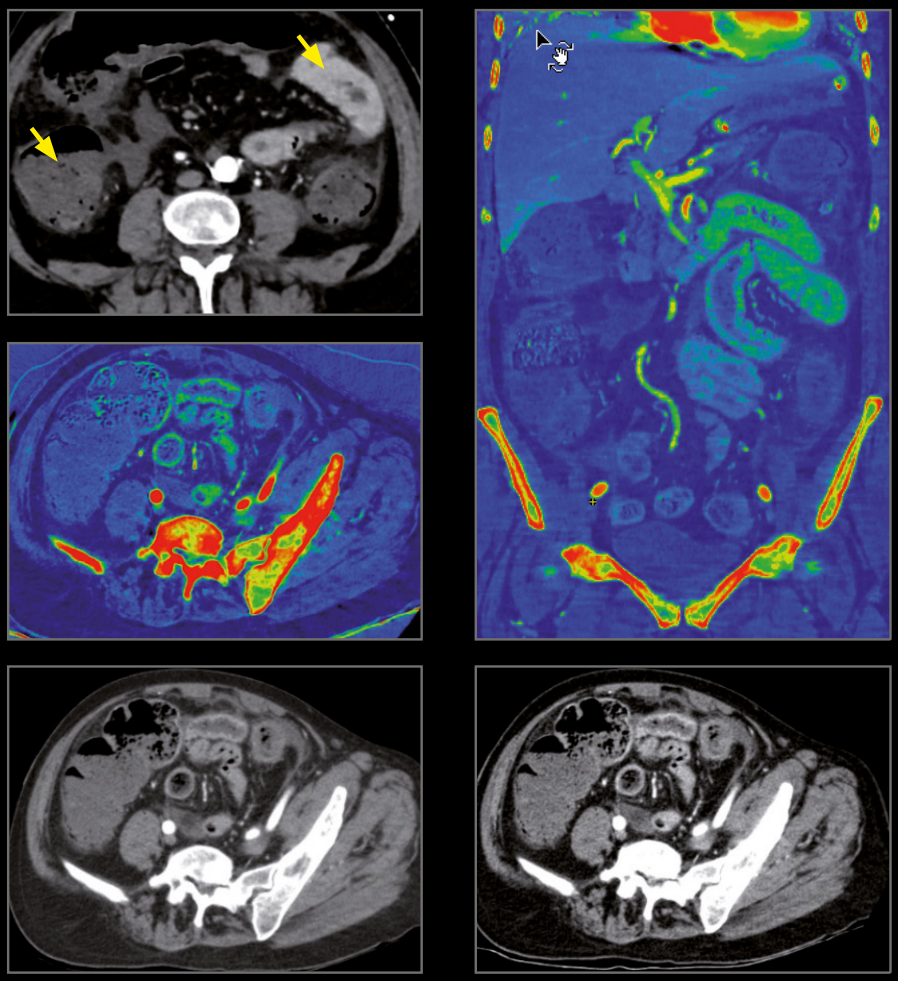
GSI Data Management

Acquisition console

- Two data sets acquired at 80 and 140 kV by a single X-ray Tube
- GSI Data File

Post-processing on Advantage Window Workstation

- Load the multi-energy level data set In GSI Volume Viewer
- Analyze the iodine (Water) map and compare the 60 keV with the 40 keV images



CLINICAL BENEFIT

Iodine map, obtained thanks to the spectral imaging, allows to identify the perfused regions of the small intestine, making a distinction between diseased loop and healthy loops.
Using low keV shows a better image contrast helping to have a better detectability of the ischemia.
GSI allows to diagnose colonic ischemia in a context of shock bowel syndrome.

GSI Xtream Abdominal pain after renal surgery (1/2)

Testimonial by Dr. Raquel Cano
University Hospital Quirónsalud, Madrid, Spain

Patient History

- Patient known for renal cancer, surgery
- Abdominal pain

Acquisition

Scan type	GSI 80 mm helical
Rotation time, s	0.8
Pitch	0.992
Slice, mm	1.25 mm
mA	230
Noise index	20
Kernel	GSI Std
ASiR-V, %	40
$CTDI_{vol}$, mGy	8.83
DLP mGy x cm	310/416

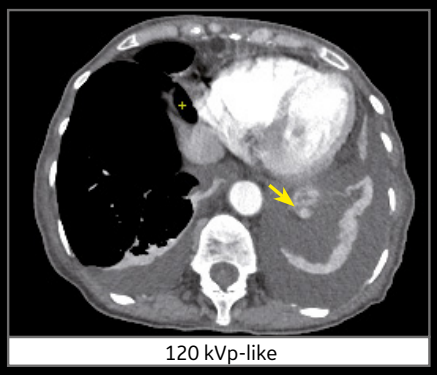
GSI Data Management

Acquisition console

- 120 kVp-like images
- Monochromatic images at 55 keV
- Iodine map
- Multi-energy images

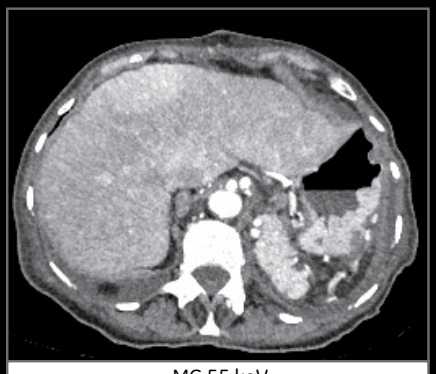
Post-processing console

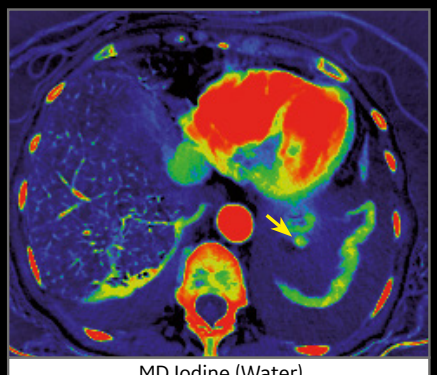
- GSI Volume Viewer
- PACS

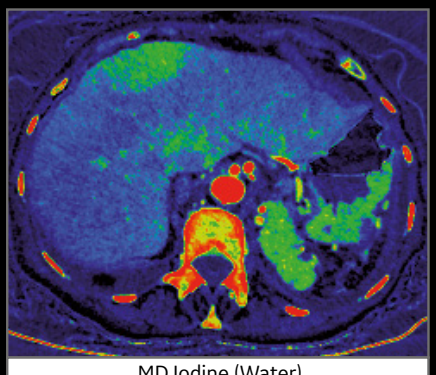

120 kVp-like


120 kVp-like


MC 55 keV


MC 55 keV


MD Iodine (Water)


MD Iodine (Water)

CLINICAL BENEFIT

Findings: pleural effusion, lesion compatible with tumor remains or peritoneal implants (arrow). Colonic Invagination at transverse (arrowheads).

MD Iodine & Low keV enhance visualization of Iodine uptake in the search for Tumoral or Inflammatory diseases.

GSI Xtream Abdominal pain after renal surgery
(2/2)

Testimonial by Dr. Raquel Cano
University Hospital Quirónsalud, Madrid, Spain

Patient History

- Patient known for renal Cancer, surgery
- Abdominal pain

Acquisition

Scan type	GSI 80 mm helical
Rotation time, s	0.8
Pitch	0.992
Slice, mm	1.25 mm
mA	230
Noise index	20
Kernel	GSI Std
ASiR-V, %	40
$CTDI_{vol}$, mGy	8.83
DLP mGy x cm	310/416

GSI Data Management

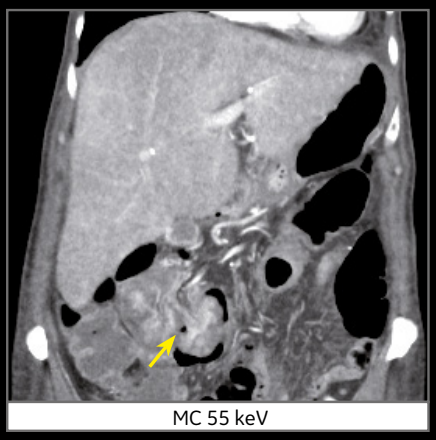
Acquisition console

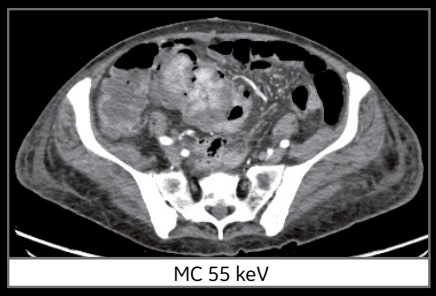
- 120 kVp-like images
- Monochromatic images at 55 keV
- Iodine map
- Multi-energy images

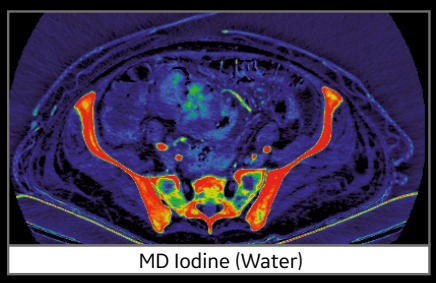
Post-processing console

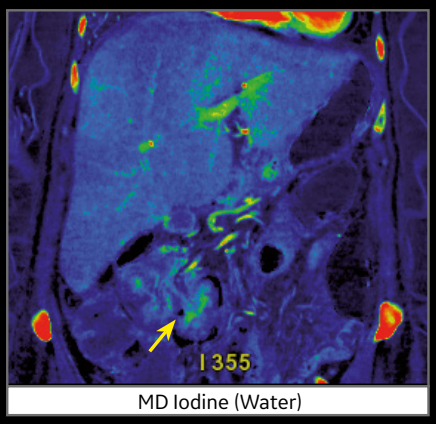
- GSI Volume Viewer
- PACS


120 kVp-like


MC 55 keV


MC 55 keV


MD Iodine (Water)



MD Iodine (Water)

CLINICAL BENEFIT

MD Iodine & Low keV enhanced visualization of Iodine uptake in the search for Tumoral or Inflammatory diseases.

Assessment of a Pulmonary Hypertension

Benefits of monochromatic imaging at 55 keV and Iodine images

Testimonial by Prof. Gilbert Ferretti
Grenoble University Hospital, France

Patient History

- 73-year-old patient
- Follow up for Pulmonary Hypertension
- Assessment before intervention

Acquisition

- GSI Assist
- Pitch: 1.53:1 (HyperDrive)
- ASiR-V: 60%
- $CTDI_{vol}$: 7.4 mGy
- DLP: 289 mGy-cm

Injection

- 45 ml at 4 ml/sec Iodine
- 30 ml at 3 ml/sec Saline

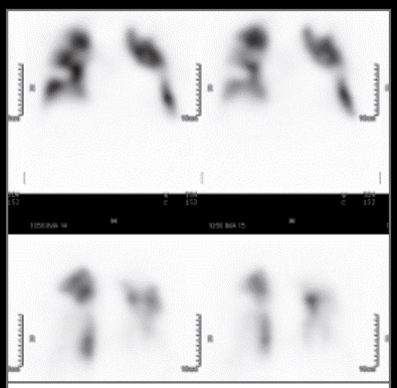
GSI Data Management

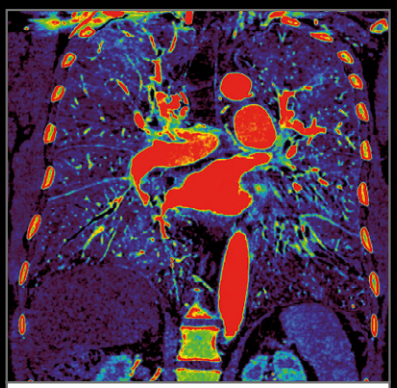
Acquisition console

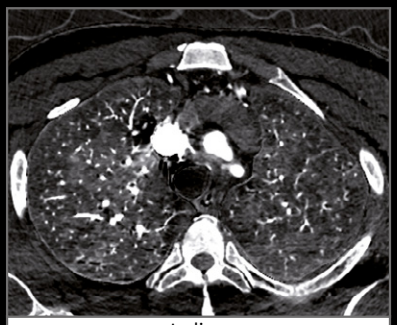
- Monochromatic images at 55 keV and 77 keV
- Iodine (Water) images
- VUE Virtual unhenanced images
- Multi-energy images

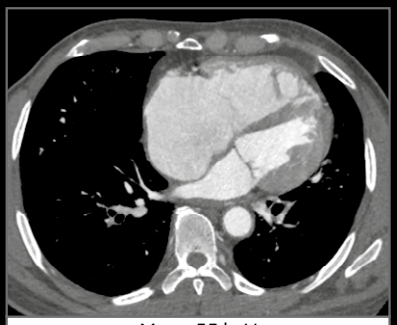
Post-processing console

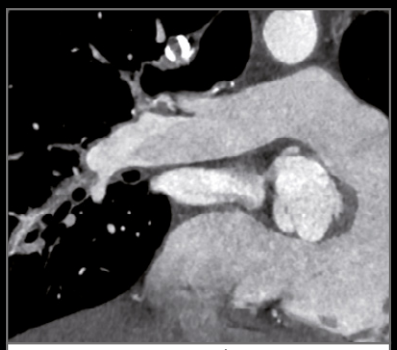
- PACS
- GSI Volume Viewer

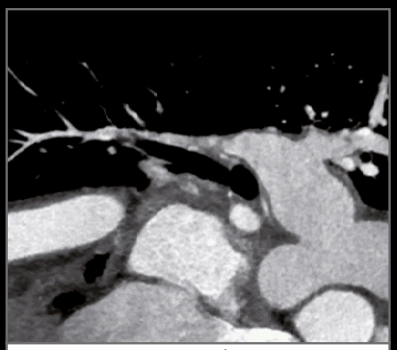

Nuclear Medicine


Iodine – Color map


Iodine


Mono 55 keV


Mono 55 keV


Mono 55 keV

CLINICAL BENEFIT

Iodine map of the parenchyma highlighting the defects.
Planning for intervention.

Comparison with SPECT/CT.

Importance of the iodine image.

GSI Hands Case of polyarthralgia

Benefits of calcium/urate decomposition

Dual energy CT (spectral imaging) has unique applications in musculoskeletal imaging. DECT with simultaneous acquisition at two energy levels (80 and 140 kVp) allows assessment of difference in tissue absorption and thus a non-invasive determination of chemical composition of said tissues. Clinical examination is challenging in patients with advanced and mixed disease. It can be difficult to determine if gout exists alone or in combination with calcium pyrophosphate disease or other arthropathies. Similarly, physical examination is limited in its assessment of whether there has been superadded calcium deposition in soft tissues due to gouty nephropathy versus a typical uric acid tophus. Conventional imaging (x-ray, US, CT and MRI) can also be non specific in such cases as amyloid deposition, PVNS, CPPD/RA as well as indolent infectious processes such as TB can result in similar appearing findings of a soft tissue mass/pannus causing osseous erosions.

Patient History

- **39-year-old male diagnosed with gout 8-years ago but defaulted from follow up to re-present 6 months ago. He has been non compliant with medication thus far due to difficulties with side effect profile. CT was to determine if his arthropathy was purely gout, other erosive elements or chronic tophaceous**

Acquisition

- **GSI 40**
- **0.6 seconds**
- **360~mA**
- **Pitch 0.984**
- **Detail**
- **GSI ASiR 40%**
- **70 keV Data File**
- **Uric Acid (Ca) & Calcium (Uric Acid)**
- **DLP 250 mGy.cm**

GSI Data Management

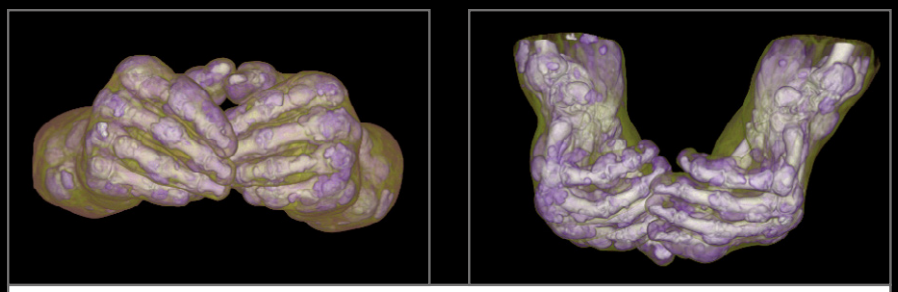
Acquisition console

- **70 keV Monochromatic images**
- **Calcium (Water) & Water (Ca)**
- **GSI Data File**

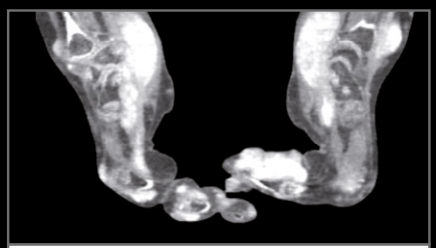
Post-processing console

- **GSI Volume Viewer**
- **Calcium (Uric Acid) & Uric Acid (Calcium)**
- **Volume Rendered images**

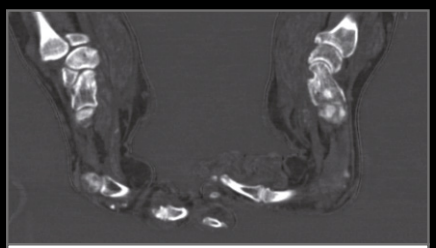
Testimonial by Dr. Nina Marshall
Cork University Hospital, Ireland



Volume Rendered - Showing Uric Acid Tophi



Uric Acid (Calcium)



Calcium (Uric Acid)

CLINICAL BENEFIT

In this case, there was dual diagnosis of gout coexisting with psoriatic arthropathy. Dual energy CT was of particular use on this occasion to determine if the tophi where chronically calcified versus purely uric acid. In addition, it was not clear whether his low back pain was related to gout or psoriatic sponydyloarthritis.

Conclusion:
Treatment in this case will be challenging due to the extremely high volumes of uric acid tophi and compliance issues and GSI DECT will be helpful to monitor progress. It also offers an opportunity to determine response to treatment in cases where clinical examination is limited by significant deformity.

Preoperative non-invasive identification and mapping of iron/hemosiderin deposits in tenosynovial giant cell tumor (TGCT)/pigmented villonodular synovitis (PVNS)

Testimonial by Dr. Fabio Becce
Lausanne University Hospital, Switzerland

Patient History

- 35-year-old woman
- 1-year history of non-traumatic gradual painful swelling of the first ray of the left foot
- Physical examination reveals a firm, slightly tender mass in the medial plantar soft tissues
- Laboratory investigations are normal

Acquisition

- Discovery CT750 HD scanner with GSI technique
- Gantry revolution time, 0.8 s
- Beam pitch, 0.516:1
- $CTDI_{vol}$: 15.8 mGy
- Scan FOV, 32×32 cm^2

GSI Data Management

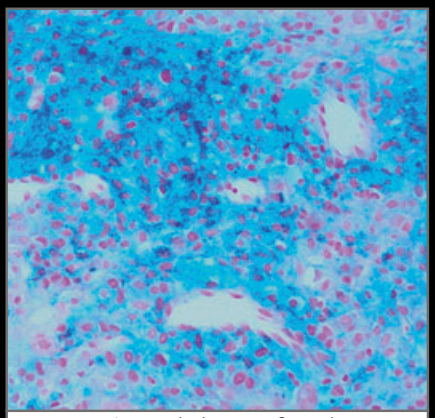
Acquisition console

- GSI datafile
- Display FOV, 20×20 cm^2
- Section thickness/interval, 0.625/0.312 mm
- Standard kernel
- ASiR 50%

Post-processing console

- 1) Automatic bone removal
- 2) Semi-automated volumetric tumor segmentation
- 3) Two-basis material decomposition (Iron/Water) with color coding

3D volume-rendered dual-energy CT images of the left foot illustrate the presence of iron (hemosiderin) material (color-coded in dark blue) within the tumor (color-coded in aqua) involving the distal synovial sheath of the flexor hallucis longus tendon, suggestive of TGCT, also referred to as PVNS



Histopathology confirmed intra- and extra-cellular hemosiderin deposits (Prussian blue stain)

CLINICAL BENEFIT

Dual-energy CT with GSI allowed for the non-invasive identification and characterization of iron (hemosiderin) deposits in the soft-tissue mass, thereby confirming the diagnosis of TGCT/PVNS pre-operatively (which was subsequently confirmed histologically).
The detailed mapping of hemosiderin deposits helped the orthopedic surgeon to plan with greater ease and confidence the surgery (approach and extent), thus allowing a complete excision of the mass with no residual tumor.

Combined preoperative assessment of intra-articular lesions and bone morphology with dual-energy CT arthrography

Testimonial by Dr. Fabio Becce and Dr. Patrick Omoumi
Lausanne University Hospital, Switzerland

Patient History

- 27-year-old man
- Presents with persistent right knee pain
- History of right tibial shaft fracture treated with intramedullary nailing

Acquisition

- Discovery CT750 HD scanner with GSI technique
- Gantry revolution time, 0.7 s
- Beam pitch, 0.984:1
- $CTDI_{vol}$: 15.8 mGy
- Scan FOV, 32×32 cm^2

Injection

- Intra-articular injection of 5 ml Contrast media (300 mg I/ml) diluted with 10 ml saline and 5 ml bupivacaine hydrochloride 0.25%

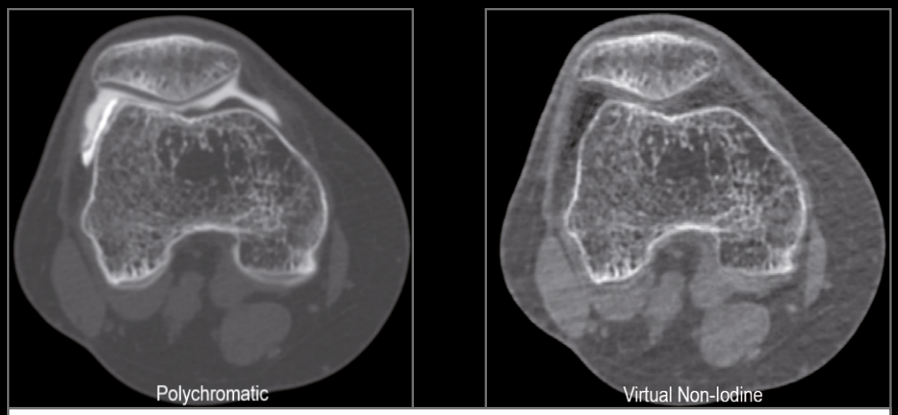
GSI Data Management

Acquisition console

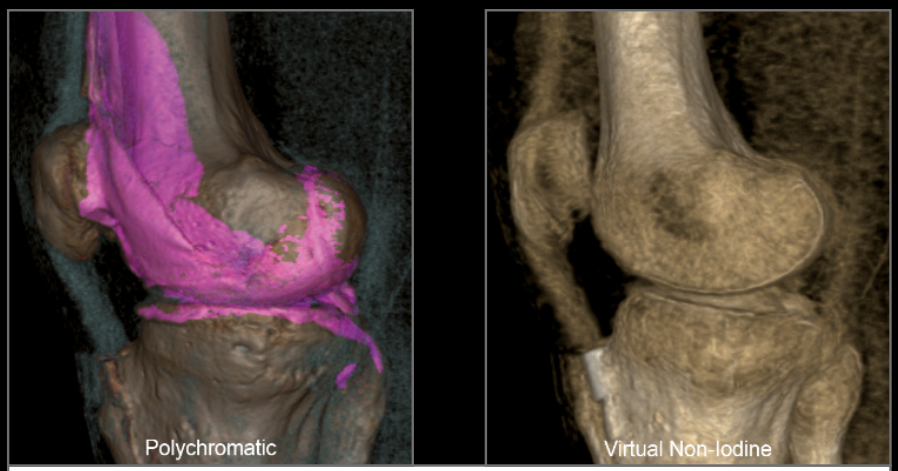
- GSI datafile
- Display FOV, 20×20 cm^2
- Section thickness/interval, 0.625/0.625 mm
- Standard kernel
- ASiR 50%

Post-processing console

- Automatic contrast medium (iodine) removal (or two-basis material decomposition (Iodine/Water) with color coding)



Axial CT images of the right knee. Both contrast-enhanced (CT arthrogram) and virtual non-contrast (non-iodine) CT images can be reconstructed from a single dual-energy CT scan



Corresponding 3D volume-rendered dual-energy CT images. The diluted intra-articular iodinated contrast medium (color-coded in pink) can be automatically removed from the joint cavity to provide a virtual non-contrast 3D CT dataset

CLINICAL BENEFIT

In this case, dual-energy CT arthrography with GSI allowed for the metal-artefact-free preoperative assessment of intra-articular lesions (articular cartilage defects and meniscal tears) in a patient with a relative contraindication to MRI (tibial intramedullary nail). In patients undergoing subsequent joint replacement surgery, dual-energy CT arthrography may offer a combined one-stop-shop evaluation of both intra-articular lesions and bone morphology. The virtual non-contrast (non-iodine) CT dataset is required to build patient-specific cutting guides prior to joint replacement surgery (arthroplasty). Furthermore, DECT arthrography can also help optimize the image contrast and quality, with concomitant reduction in the iodine load.

Bone Marrow Edema detection

Benefit of the GSI application

Testimonial by Prof. Dr. U. Teichgräber
Institute for Diagnostic & Interventional Radiology - IDIR
Jena University Hospital, Germany

Patient History

- 77-year-old female patient after a bicycle accident was referred to ER dept with suspicious fracture in right knee
- Patient underwent CT scan using the Gemstone Spectral Imaging technique

Acquisition

- GSI 40 mm helical
- Rotation time 0.8 s
- Pitch 0.516
- Slice 0.625 mm
- mA 190
- Noise Index 30
- Kernel GSI Std/Bone+
- ASiR-V % 60/40
- $CTDI_{vol}$: 14.0 mGy
- DLP mGy x cm 366
- BMI 28

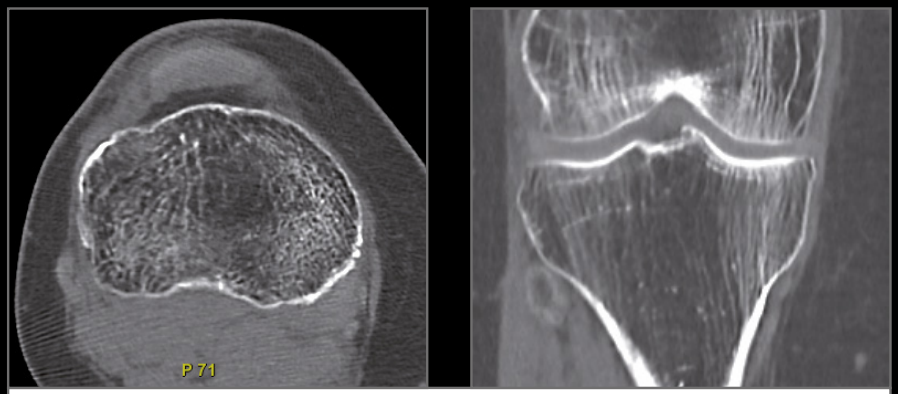
GSI Data Management

Acquisition console

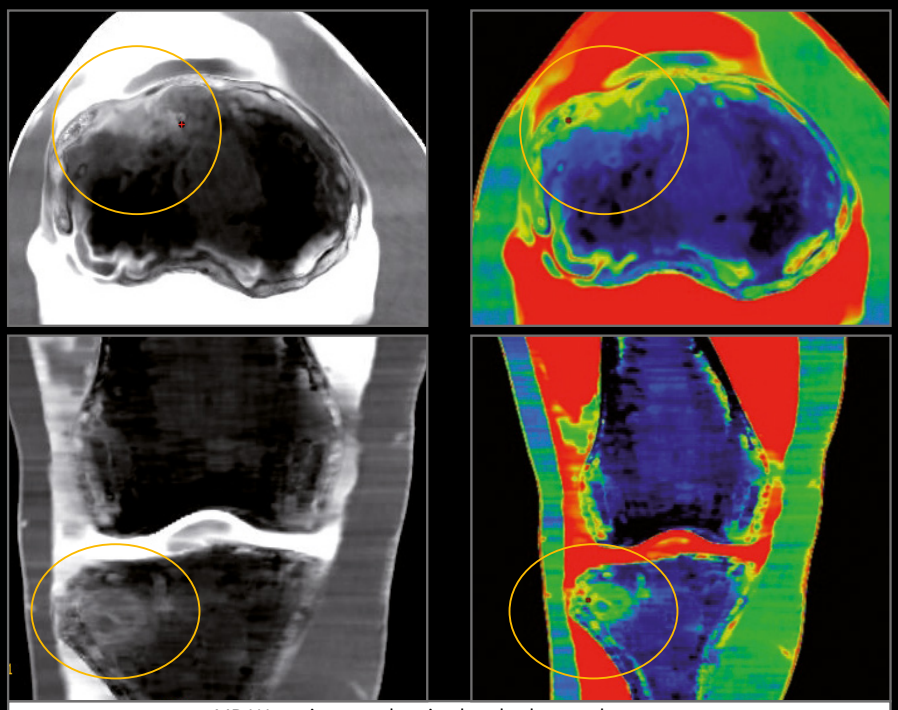
- HAP (Water) images
- Bone+ images
- GSI Data File

Post-processing console

- GSI Volume Viewer
- MD images HAP / Water
- MD colour overlay



Mono 110 keV Bone +



MD Water images showing hypderdense edema area

CLINICAL BENEFIT

With GSI Xtream and the flexibility of multi-material separation, we can extend our diagnostic possibilities with CT in emergency diagnostics. Whereas a bone marrow edema could only be detected in MRI before GSI, we are now able not only to see the fracture of a bone structure but also to analyse a bone bruise without any damage of the cortical bone structure.
GSI Xtream delivers new horizons of emergency imaging in CT.

Bone marrow edema in trauma of the hip

Testimonial by Dr. Phan Catherine
Saint-Antoine Hospital, Paris, France

Patient History

- 33-year-old man coming to the emergency ward for a hip pain secondary to a bike fall. Elective pain of the proximal part of the femur with limping gait. CT was requested to rule out fracture of the femoral neck

Acquisition

- 140 kV, 22 mAs
- Slice thickness 0.625 mm
- Without contrast media
- DLP: 1576 mGy.cm

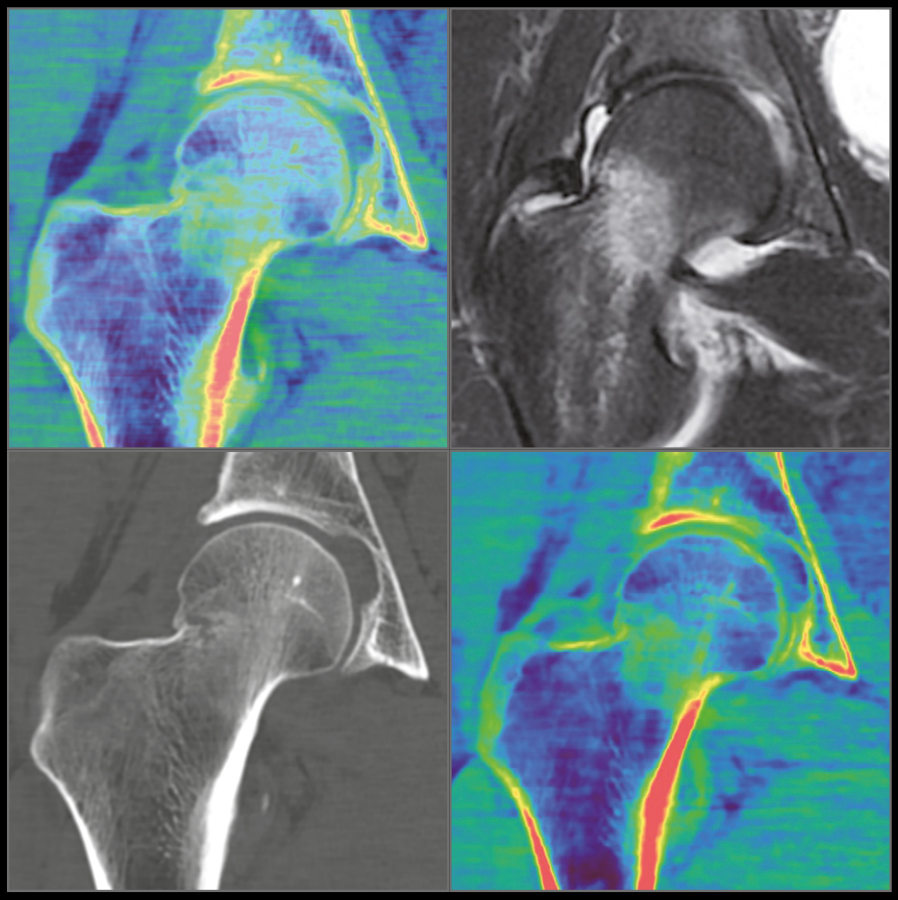
GSI Data Management

Acquisition console

- Two data sets acquired at 80 and 140 kV by a single X-ray Tube
- GSI Data File

Post-processing on Advantage Window Workstation

- Load the multi-energy level data set In GSI Volume Viewer
- Analyze and compare the Water/ HAP and HAP/Water images and define edema related to bone bruise
- Distribution maps

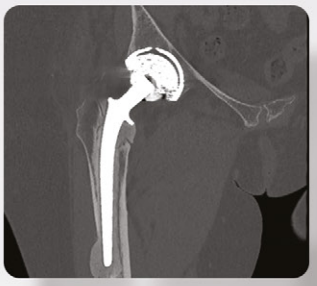


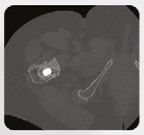
CLINICAL BENEFIT

Comparison of the edematous bone marrow lesion with MRI.

Evidence of bone marrow edema linked to bone bruising.

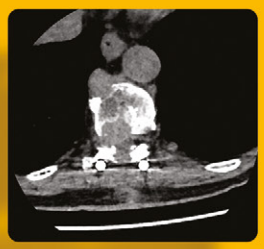
GSI shows the presence of liquid, the inflammation in front of the bone fracture.

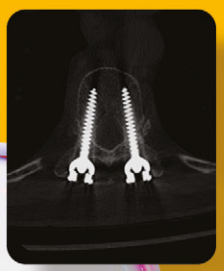


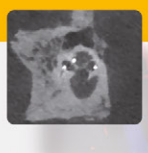


Artefact Reduction

TESTIMONIALS & PUTTING INTO PRACTICE







Post-embolization control of vertebral metastasis

Benefits of monochromatic imaging higher than 110 keV

Testimonial by Dr. Adrian Kastler
Grenoble University Hospital, France

Patient History

- 63-year-old patient
- Follow-up for right kidney adenocarcinoma
- Post-embolization T11 metastasis control
- Laminectomy and release of the root canal
- Osteosynthesis

Acquisition

- GSI from T8 to L1
- ASiR: 30%
- $CTDI_{vol}$: 22.57 mGy NRD $CTDI_{vol}$: 45 mGy
- DLP: 451 mGy-cm

GSI Data Management

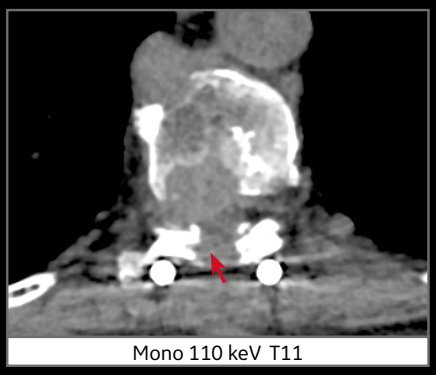
Acquisition console

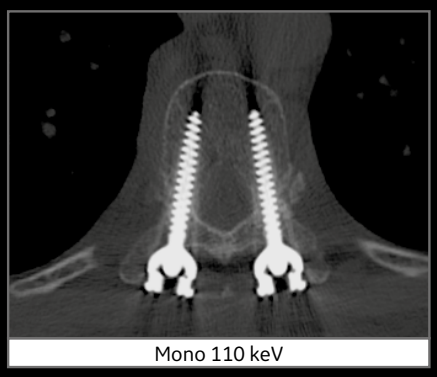
- QC
- Monochromatic Images at 110 keV
- Monochromatic images at 70 keV
- Multi-energy images
- Discs and vertebrae

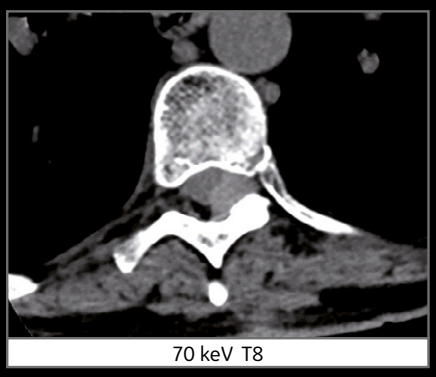
Post-processing console

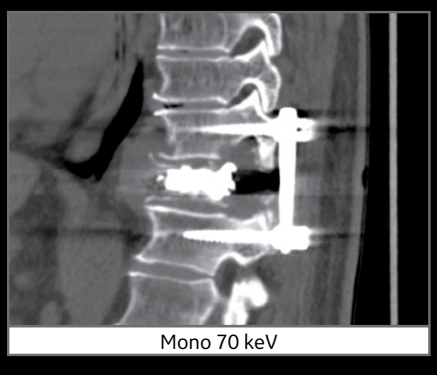
- GSI Volume Viewer & GSI Viewer
- PACS

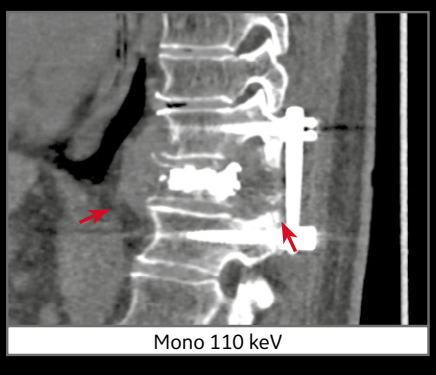

Mono 70 keV


Mono 110 keV T11


Mono 110 keV


70 keV T8


Mono 70 keV


Mono 110 keV

CLINICAL BENEFIT

The metastatic lesion at T11 is visualized in the 70 keV and 110 keV images. But its contours and limits are better indivualized at 110 keV energy (reduction of metal artefacts X,Y axis).

Good visualization in high resolution kernel filter of the osteosynthesis threads and its environment.

Cochlear implants

Benefits of high keV and MAR monochromatic imaging

Testimonial by Dr. Arnaud Attyé
Grenoble University Hospital, France

Patient History

- 60-year-old patient
- Profound deafness
- Placement of cochlear implants
- GSI scan control

Acquisition

- GSI Assist
- $CTDI_{vol}$: 66.9 mGy
- ASiR: 40%
- Bone Plus

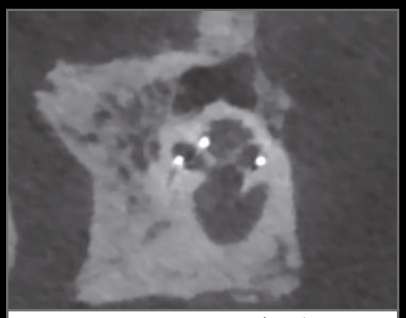
GSI Data Management

Acquisition console

- Monochromatic images at 120 keV
- Monochromatic images at 120 keV + MAR
- Reconstruction of each ear

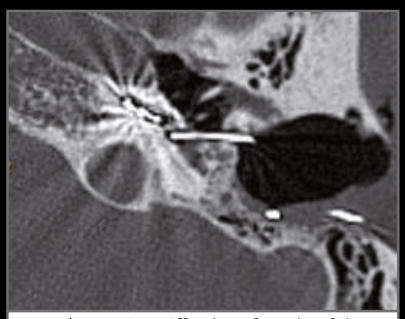
Post-processing console

- MPR
- PACS



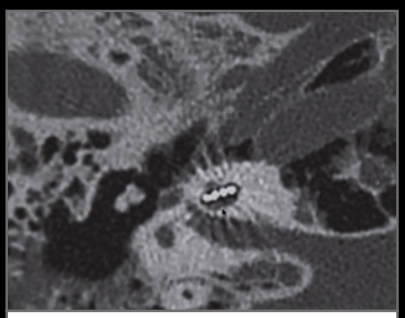
Cone Beam CT: Implant in tympanic position

Cone Beam CT: Implant with translocation in vestibular position



HR/HD ASiR: Difficulty of study of the intra-cochlear position of the implant

GSI Bone Plus 120 keV: Localisable implant in intratympanic position



GSI Bone Plus 120 keV: Localisable implant in intravestibular position

CLINICAL BENEFIT

Exploration in a single CT acquisition of both ears (versus the Cone Beam CT). Reduction of the delivered dose by 35% ($CTDI_{vol}$ from 98.2 to 66.9 mGy) between High Resolution and GSI. Objective: to identify the position in the tympanic or vestibular ramp of the cochlea. Translocation into the vestibular ramp is at risk of neuro-sensory injury.

The high energy 120 keV and metal artefact reduction combined with a high resolution kernel filter allows control of cochlear implants without artefacts.

Better visualization of prosthesis

Benefits of imaging at 110 keV and 110 keV + GSI MAR

Testimonial by Dr. Jean-Louis Bertrand
Perpignan Hospital Center, France

Patient History

- 65-year-old patient
- Follow-up for recurrent subluxation of a hip prosthesis
- Radiofrequency of a metastasis (indication following PET/CT)

Acquisition

- GSI Assist
- Slices Thickness 0.625 mm
- Pitch: 0.516:1
- Kernel: Bone Plus
- ASiR-V: 30%

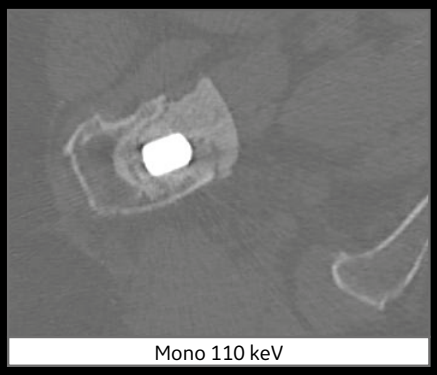
GSI Data Management

Acquisition console

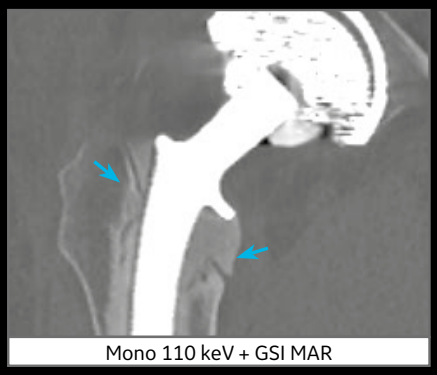
- Monochromatic images at 110 keV
- Monochromatic images 110 keV + GSI MAR

Post-processing console

- AW
- PACS



Mono 110 keV



Mono 110 keV + GSI MAR

Mono 110 keV

Mono 110 keV + GSI MAR

CLINICAL BENEFIT

Better visualization around the prosthesis identifying a fracture in the small trochanter.

Efficient visualization of the bone vs prosthesis interface.

Visualization of prosthetic loosening.

GSI Infographics

GSI: Delivering Value Based Care

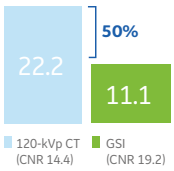
*Example findings from peer reviewed GSI publications**

ANGIOGRAPHY

Low keV images can reduce iodine load by at least 50%

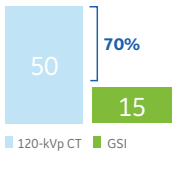
benefitting patients with compromised renal function[3,4,5]

Pulmonary Angiography Imaging, Total Iodine, g[4]



Dong, 2013

CT Aortography (no difference in CNR or SNR), Total Iodine, g[5]



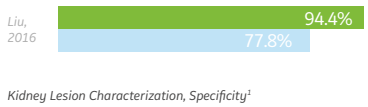
Shuman, 2017

ABDOMEN – ONCOLOGY

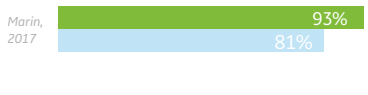
Improves liver lesion detection 17% and kidney lesion characterization 12%

reducing unnecessary follow-ups[1,2]

Liver Lesion Detection after transarterial chemoembolization (TACE), Specificity[2]



Kidney Lesion Characterization, Specificity[1]

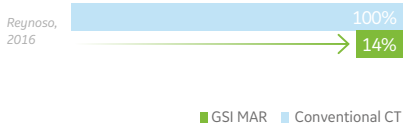


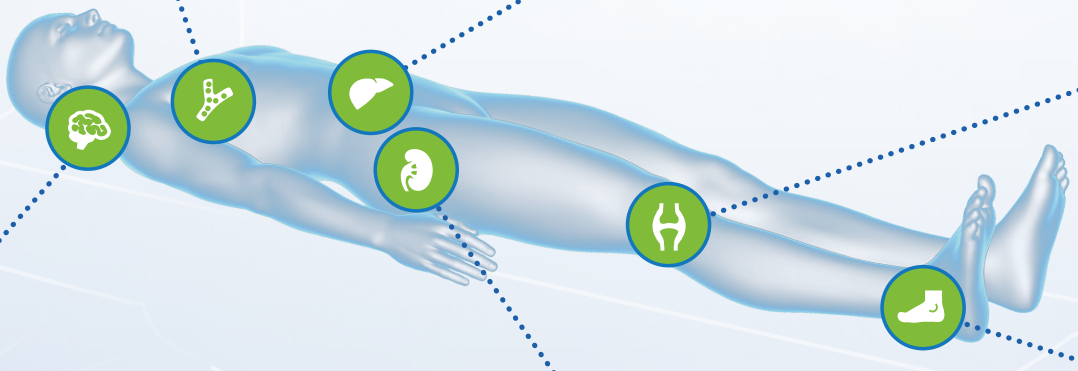
ORTHOPEDICS - REDUCED METAL ARTIFACT

6x reduction in non-diagnostic scans with GSI MAR

enhancing evaluation of metal implants and adjacent bone or tissue[6,7]

Periprosthetic Imaging, Rate of Non-Diagnostic Studies[6]





HEAD AND NECK TUMOR VISIBILITY

2.3x higher average tumor attenuation

for increased tumor conspicuity and improve tumor evaluation[10]

RENAL STONE CHARACTERIZATION

100% Sensitivity and 99.7% Specificity for uric acid stones,[8] & atomic number for stone composition

for faster and simplified diagnosis workflow

GOUT

100% detection by uric acid (calcium) mapping

for non-invasive diagnosis[9]

* The example findings cited are limited to the referenced studies only and may not be broadly applicable to your clinical practice.

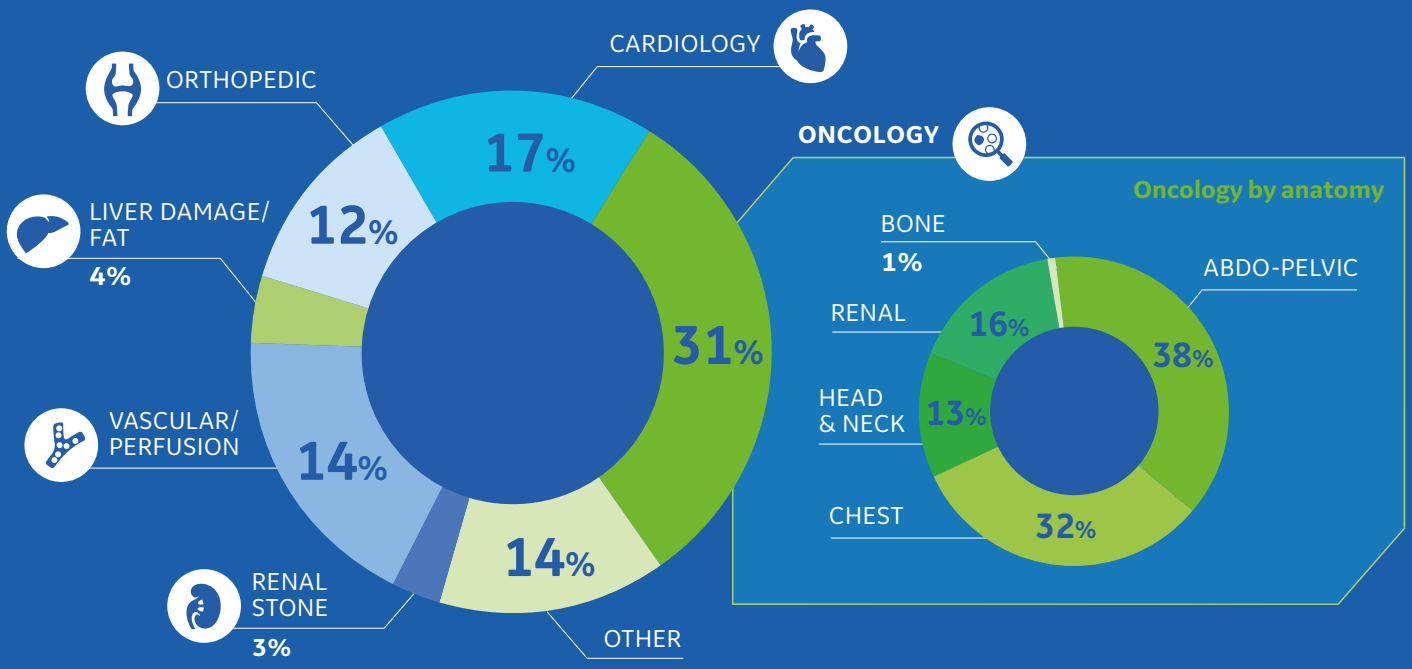
Evidence for **Spectral Imaging CT** is mounting...

INCREDIBLE BREADTH OF RESEARCH ON GSI

330+ Journal publications 2010-2019

33% Avg. yearly growth in # of publications 2011-2019

BY CLINICAL APPLICATION



Professional society consensus statements on DECT clinical utility for**:

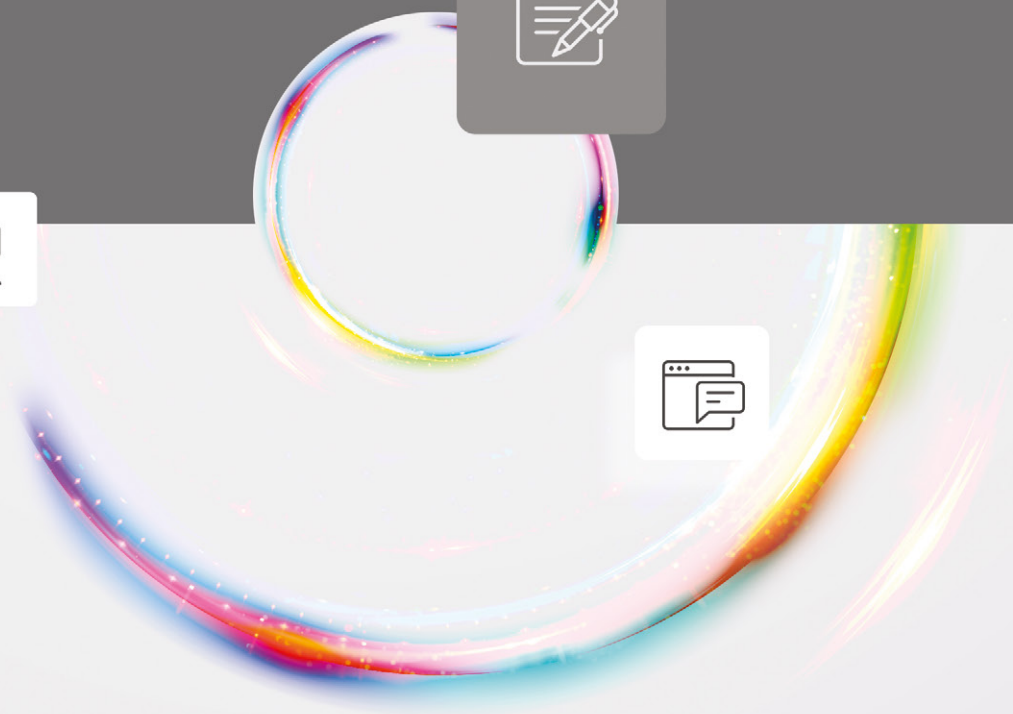
- Quantitative assessment of **fatty liver** and contrast up take in focal **hepatic lesions**
- **Renal masses** and **urothelial tumors**
- **Improved iodine sensitivity** from DECT angiography
- Reduced artifacts in patients with **orthopedic metallic implants**
- Known or suspected **pancreas neoplasms**
- Routine clinical use for **carotid/ cerebral and extremity CTA**
- Routine **pulmonary CTA**
- **Renal stones** to discriminate uric acid stones
- **Radiation doses** are reliably comparable to SECT

** White Paper of the Society of Computed Body Tomography and Magnetic Resonance on Dual-Energy CT, Part 2: Radiation Dose and Iodine Sensitivity; Part 3: Vascular, Cardiac, Pulmonary and Musculoskeletal Applications; Part 4: Abdominal and Pelvic Applications. Journal of Computer Assisted Tomography (2016).

1. Marin, D. et al. “Characterization of Small Focal Renal Lesions: Diagnostic Accuracy with Single-Phase Contrast-enhanced Dual-Energy CT with Material Attenuation Analysis Compared with Conventional Attenuation Measurements.” Radiology. 284, no. 3 (2017).
2. Liu, Qi-Yu, et al. “Application of gemstone spectral imaging for efficacy evaluation in hepatocellular carcinoma after transarterial chemoembolization.” World Journal of Gastroenterology 22, no. 11 (2016): 3242.
3. White Paper of the Society of Computed Body Tomography and Magnetic Resonance on Dual-Energy CT, Part 2: Radiation Dose and Iodine Sensitivity; Part 3: Vascular, Cardiac, Pulmonary and Musculoskeletal Applications; Part 4: Abdominal and Pelvic Applications. Journal of Computer Assisted Tomography (2016).
4. Dong, Jian, et al. “Low-contrast agent dose dual-energy CT monochromatic imaging in pulmonary angiography versus routine CT.” Journal of Computer Assisted Tomography 37, no. 4 (2013): 618-625.
5. Shuman, William P., et al. “Prospective comparison of dual-energy CT aortography using 70% reduced iodine dose versus single-energy CT aortography using standard iodine dose in the same patient.” Abdominal Radiology 42, no. 3 (2017): 759-765.
6. Reynoso, Exequiel, et al. “Periprosthetic Artifact Reduction Using Virtual Monochromatic Imaging Derived From Gemstone Dual-Energy Computed Tomography and Dedicated Software.” Journal of Computer Assisted Tomography. 2016; 40 (4): 649-657.
7. Pessis, Eric, et al. “Virtual Monochromatic Spectral Imaging with Fast Kilovoltage Switching: Reduction of Metal Artifacts at CT” RadioGraphics 2013; 33: 573–583.
8. Stolzman P. Urol Res 2008, Graser A. Invest Radiol 2008, Matlaga B. Urology 2008, Graser A . Eur Radiol 2009, Thomas C. Eur Radiol 2009, Boll D. Radiology 2009, Hidas G. Radiology 2010, Manglaviti G. AJR 2011, Kulkarni N. Journal of Computer Assisted Tomography. 2013.
9. Li, Xiaohu, et al. “Detection of uric acid depositing in tophaceous gout using a new dual energy spectral CT technology.” Journal of X-ray science and technology 22, no. 4 (2014): 541-549.
10. Forghani, R.K., et al. “Low-Energy Virtual Monochromatic Dual-Energy Computed Tomography Images for the Evaluation of Head and Neck Squamous Cell Carcinoma: A Study of Tumor Visibility Compared With Single-Energy Computed Tomography and User Acceptance.” Journal of Computer Assisted Tomography. 2017; 41: 565–571.

STUDY	# OF PATIENTS	ARTICLE CONCLUSION
Marin[1], 2017	136	The results of our study demonstrate that analysis of contrast-enhanced dual-energy material attenuation significantly improves the specificity for characterization of small (1–4 cm) renal lesions compared with that of conventional attenuation measurements. This improvement in specificity may decrease the frequency of unnecessary work-up for small indeterminate renal lesions.
Liu[2], 2016	30	Compared with conventional CT, GSI could significantly improve the detection of small and multiple lesions without increasing the radiation dose. Based on spectrum features, GSI could assess tumor homogeneity and more accurately identify residual tumors and recurrent or metastatic lesions during efficacy evaluation and follow-up in HCC after TACE treatment.
Dong[4], 2013	86	Low-contrast agent dose DECT monochromatic imaging in pulmonary angiography accommodates superior intravascular enhancement and contrast in pulmonary arteries, and improves diagnostic confidence with compatible radiation dose.
Shuman[5], 2017	21	70% reduced iodine DECT aortography may result in similar aortic attenuation, CNR, SNR, and lower although acceptable subjective image scores when compared to standard iodine SECT aortography in the same patient.
Reynoso[6], 2016	80	GSI-MARS technology demonstrated the ability to reduce periprosthetic artifacts, improving image quality and diagnostic interpretability particularly when associated with virtual monochromatic spectral images at high energy levels.
Pessis[7], 2013	Review clinical experience	The ability to obtain VMS images gives dual-energy CT potential advantages over conventional CT in reducing metal artifacts and improving image quality and diagnostic value. Evaluation of metal implants and adjacent bone or tissue is enhanced with VMS images reconstructed from dual-energy CT datasets. However, understanding principles of dual-energy CT data processing and image generation is necessary to derive maximum benefit from the dual-energy CT datasets.
Li[9], 2014	31	Dual-energy spectral CT can detect gout tophi within the peripheral joints of the patients. The quantitative measurement of the tophi concentration provides a new imaging method for quantitatively monitoring clinical outcomes of tophi.
Forghani[10], 2017	120	Using multiple lines of evidence, our results suggest that 40 keV VMIs objectively improve tumor visibility compared with SECT and, furthermore despite the increased noise levels, are preferred for targeted tumor evaluation subjectively. These conclusions seem suitable both for specialized centers as well as in general practice settings where head and neck cancer imaging is performed.

Recent GSI Publications



GSI – Abdomen/Pelvis Applications

Hepatocellular nodules in liver cirrhosis: state of the art CT evaluation (perfusion CT/volume helical shuttle scan/dual-energy CT, etc.).
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Virtual monochromatic spectral imaging for the evaluation of hypovascular hepatic metastases: the optimal monochromatic level with fast kilovoltage switching dual-energy computed tomography.
Yamada, Y et al. Department of Diagnostic Radiology, Keio University School of Medicine, Shinjuku-ku, Tokyo, Japan, Invest Radiol. 2012 May;47(5):292-8, PMID: 22472797

Quantification of hepatic steatosis with dual-energy computed tomography: comparison with tissue reference standards and quantitative magnetic resonance imaging in the ob/ob mouse.
Artz, N et al. Department of Radiology, University of Wisconsin, Madison, WI 53705-2275, USA, Invest Radiol. 2012 Oct;47(10):603-10, PMID: 22836309

Initial experience with single-source dual-energy CT abdominal angiography and comparison with single-energy CT angiography: image quality, enhancement, diagnosis and radiation dose.
Pinho, D et al. Division of Abdominal Imaging and Intervention, Massachusetts General Hospital, Boston, MA, USA, European radiology 2013 Feb; 23(2): 351-359., PMID: 22918562

Assessment of hepatic fatty infiltration using spectral computed tomography imaging: a pilot study.
Zheng, X et al. Departments of Radiation Oncology and Radiology, Fudan University, Huadong Hospital, Shanghai, China, J Comput Assist Tomogr. 2013 Mar-Apr;37(2):134-41, PMID: 23493199

Hepatocellular carcinoma and focal nodular hyperplasia of the liver: differentiation with CT spectral imaging.
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Differentiating hepatocellular carcinoma from angiomyolipoma of the liver with CT spectral imaging: a preliminary study.
Yu, Y et al. Department of Radiology, Ruijin Hospital, Shanghai Jiaotong University, School of Medicine, Shanghai, China., Clin Radiol. 2013 Sep;68(9):e491-7, PMID: 23702491

Material density hepatic steatosis quantification on intravenous contrast-enhanced rapid kilovolt (peak)-switching single-source dual-energy computed tomography.
Patel, B et al. Department of Radiology, Duke University Medical Center, Durham, NC, USA, J Comput Assist Tomogr. 2013 Nov-Dec;37(6):904-10, PMID: 24270112

Dual-energy CT of the abdomen.
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Differentiation of High Lipid Content From Low Lipid Content Adrenal Lesions Using Single-Source Rapid Kilovolt (Peak) - Switching Dual-Energy Multidetector CT.
Morgan, D. et al. Department of Radiology, University of Alabama at Birmingham, JTN452 619 South 19th Street, Birmingham, AL, 35249, USA, J Comput Assist Tomogr. 2013 Nov-Dec;37(6):937-43, PMID: 24270116

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Grimm, J et al. Institute for Clinical Radiology, Ludwig-Maximilians-University Hospital Munich, Nussbaumstraße 20, 80336, Munich, Germany, Int J Legal Med. 2014 May;128(3):475-82, PMID: 24577711

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Sun, T et al. China Department of Radiology, Shanghai Ruijin Hospital, No, 197 Ruijin Er Rd, Shanghai, 200011, Front Biosci (Landmark Ed). 2014 Jun 1;19:1377-85., PMID: 24896357

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Han, S. et al. Department of Radiology, Research Institute of Radiological Science, Severance Hospital, Yonsei University College of Medicine, 50 Yonsei-ro, Seodaemun-gu, Seoul 120-752, Republic of Korea, AJR Am J Roentgenol. 2014 Oct;203(4):788-95, PMID: 25247944

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Variability of CT Attenuation Measurements in Virtual Unenhanced Images Generated Using Multimaterial Decomposition from Fast Kilovoltage-switching Dual-energy CT.
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Multimaterial Decomposition Algorithm for the Quantification of Liver Fat Content by Using Fast-Kilovolt-Peak Switching Dual-Energy CT: Clinical Evaluation
Hyodo, T et al. Departments of Radiology, Kindai University Faculty of Medicine, 377-2 Ohno-Higashi, Osaka-Sayama, Osaka 589-8511, Japan, Radiology. 2017 Apr;283(1):108-118, PMID: 28212047

A Flexible Method for Multi-Material Decomposition of Dual-Energy CT Images.
Mendonca, P et al. GE Global Research, One Research Circle, Niskayuna, NY 12309, USA, IEEE Trans Med Imaging. 2014 Jan;33(1):99-116, PMID: 24058018

Intermanufacturer Comparison of Dual-Energy CT Iodine Quantification and Monochromatic Attenuation: A Phantom Study.
Jacobsen, M et al. Department of Imaging Physics, The University of Texas MD Anderson Cancer Center, 1515 Holcombe Blvd, Houston, TX 77030, USA, Radiology. 2017 Nov 29:170896, PMID: 29185902

Can dual-energy CT replace perfusion CT for the functional evaluation of advanced hepatocellular carcinoma?
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Development of a dual-energy computed tomography quality control program: Characterization of scanner response and definition of relevant parameters for a fast-kVp switching dual-energy computed tomography system.
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GSI – Renal Applications

Determination of renal stone composition in phantom and patients using single-source dual-energy computed tomography.
Kulkarni, N et al. Abdominal Imaging and Intervention, Harvard Medical School, Massachusetts General Hospital, Boston, MA 02114, USA, Journal of computer assisted tomography 2013 37(1): 37-45, PMID: 23321831

Determination of urinary stone composition using dual-energy spectral CT: initial in vitro analysis.
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Acknowledgements

We would like to thank all GE Healthcare CT Zone Clinical Leaders and the Scanner Europe team. We would also like to thank all the clients of GE Healthcare who contributed to making this handbook a reality through their clinical experiences.
In the order of their appearance in the book:

- **Prof. HODEL** *Head of Neuroradiology Department at the Henri Mondor University Hospital in Créteil, France*
- **Prof. LUCIANI** *Radiology Professor at the Henri Mondor University Hospital in Créteil, France*
- **Dr. TOLAN** *Consultant Radiologist at the Leeds Teaching Hospitals NHS Trust, UK*
- **Dr. FAGGIONI** *Radiologist at the University Hospital of Pisa, Italy*
- **Dr. CANO** *Radiologist at the University Hospital Quirónsalud in Madrid, Spain*
- **Dr. VAUDANO** *Head of Radiology Department at the San Giovanni Bosco Hospital in Turin, Italy*
- **Dr. EL HAJJAM** *Radiologist at the Ambroise Paré Hospital in Boulogne-Billancourt, France*
- **Dr. PROUVÉ** *Radiologist at the Saint-Augustin Clinic in Pessac, France*
- **Dr. ANTONENKO** *Radiologist at the Republican Research and Clinical Center of Neurology and Neurosurgery in Minsk, Belorussia*
- **Prof. ROUSSET** *Head of Department at the Military Teaching Hospital Clermont Tonnerre in Brest, France*
- **Dr. ZAPPA** *Radiologist at the Beaujon APHP Hospital in Clichy, France*
- **Dr. CALAME** *Radiologist at Besançon University Hospital, France*
- **Prof. MAZZEI** *Associate Professor of Radiology at the University of Siena, Italy*
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- **Prof. Dr. MÜLLER-HÜLSBECK** *Head of the Department of Diagnostic and Interventional Radiology at the DIAKO Hospital (Flensburg) Germany*
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- **Henri Mondor APH-HP university Hospital** *pages 10, 11, 12 and 33*
- **Leeds Teaching Hospitals NHS Trust** *pages 13, 15 and 16*
- **University Hospital of Pisa** *pages 14 and 28*
- **University Hospital Quirónsalud** *pages 17, 29, 30, 31, 39, 45 and 46*
- **San Giovanni Bosco Hospital** *page 18*
- **Ambroise Paré Hospital** *page 19*
- **Saint-Augustin Clinic** *page 20*
- **Clinical Center of Neurology and Neurosurgery** *page 26*
- **Military Teaching Hospital Clermont Tonnerre** *page 27*
- **Beaujon APHP Hospital** *pages 32 and 36*
- **Besançon University Hospital** *page 34*
- **University of Siena** *page 35*
- **Grenoble University Hospital** *pages 37, 47, 57 and 56*
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