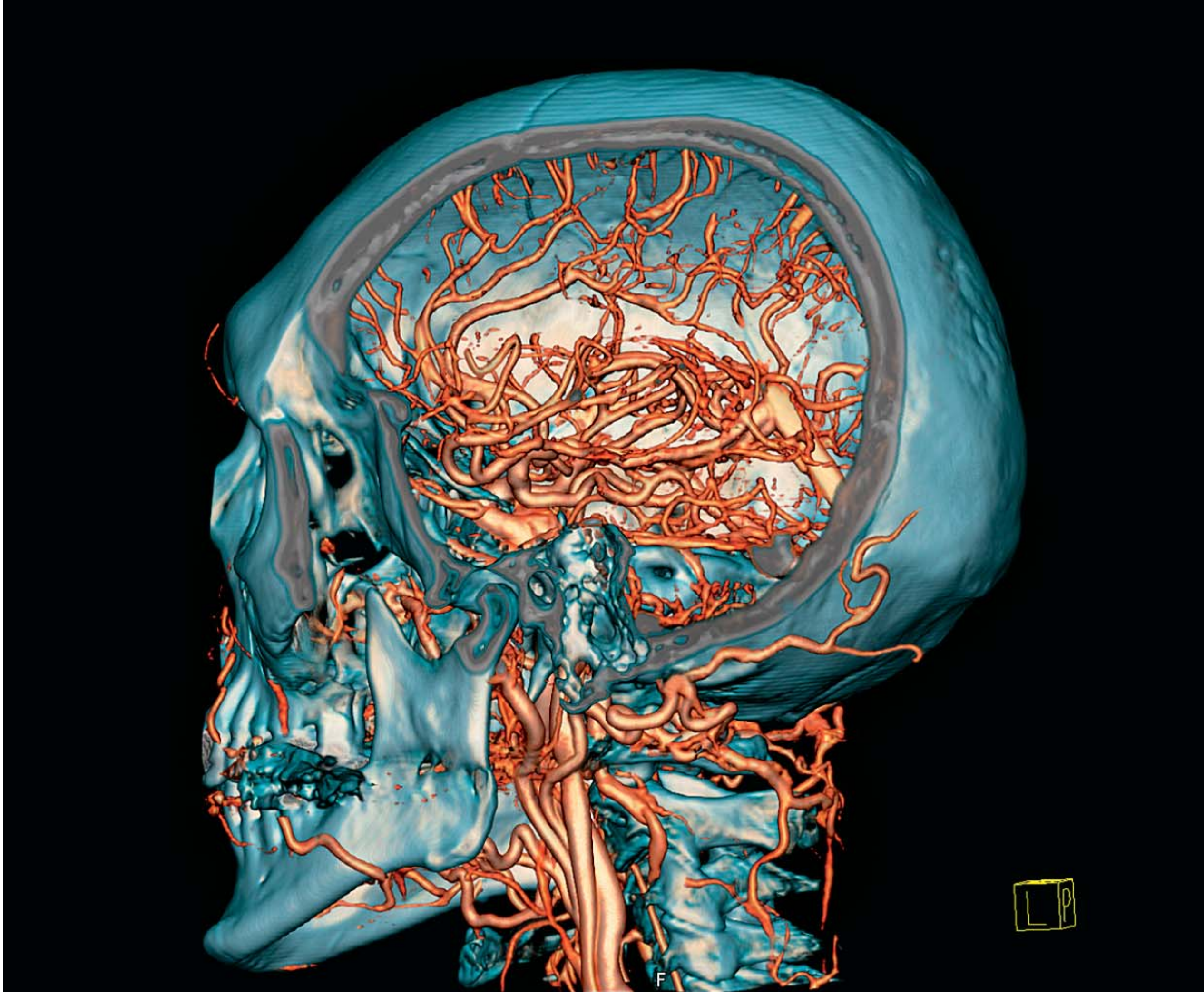

Dual Energy CT

SOMATOM Definition

Answers for life.

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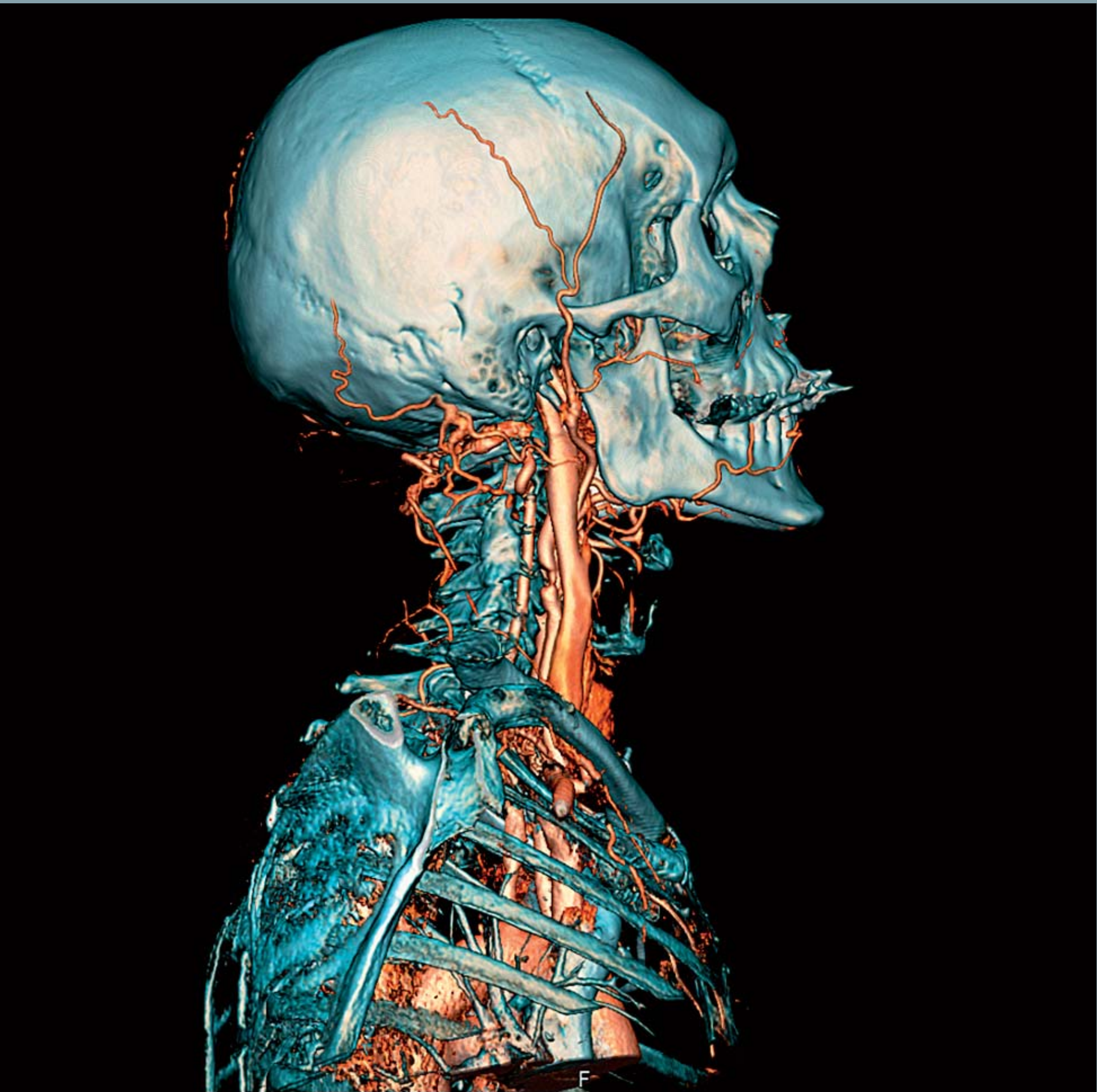
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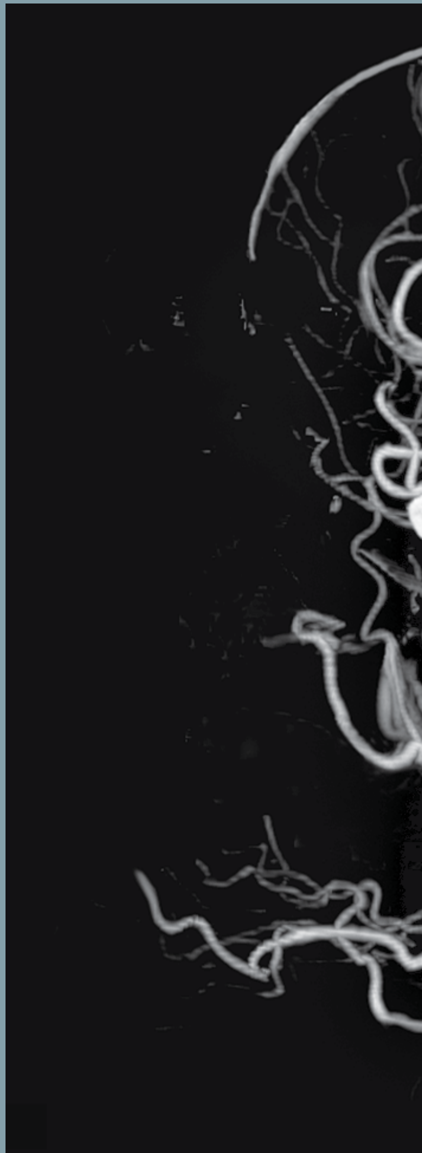
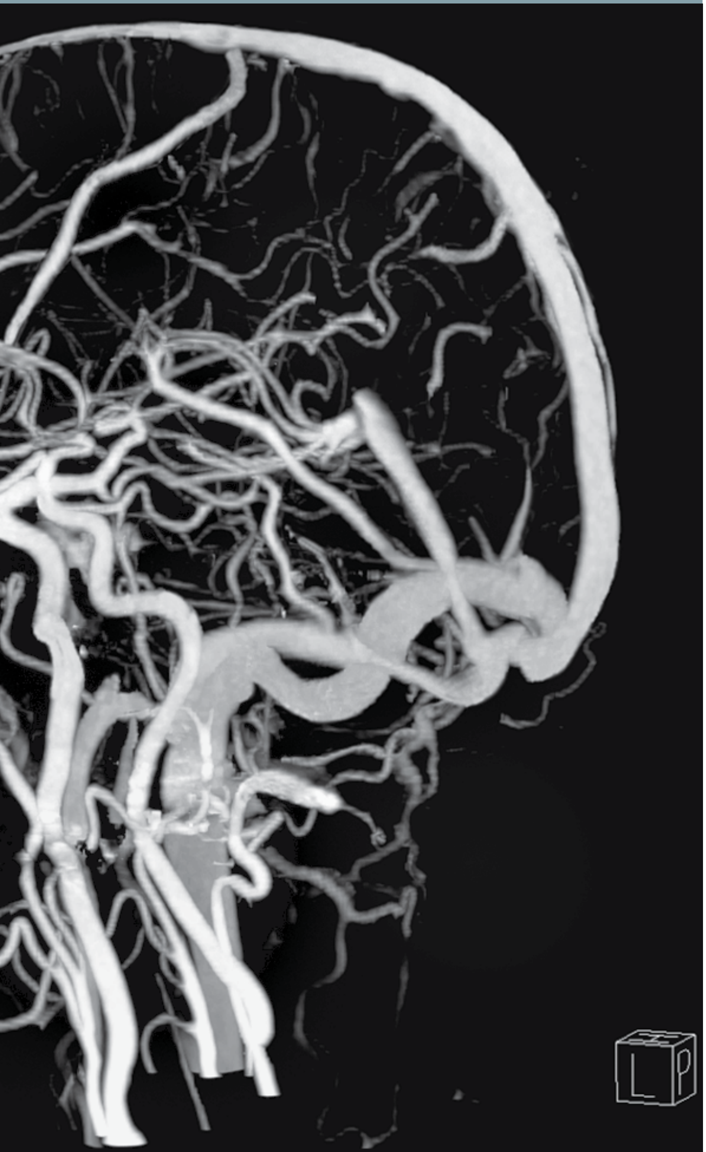




Contents

Dual Source CT with SOMATOM Definition

The idea behind Dual Source CT is as simple as it is ingenious: It is merely using two X-ray sources and two detectors at the same time. The result? You get double temporal resolution, double speed, and twice the power, while lowering dose even further. It provides images of exceptional quality and is an amazing tool to explore new clinical opportunities.

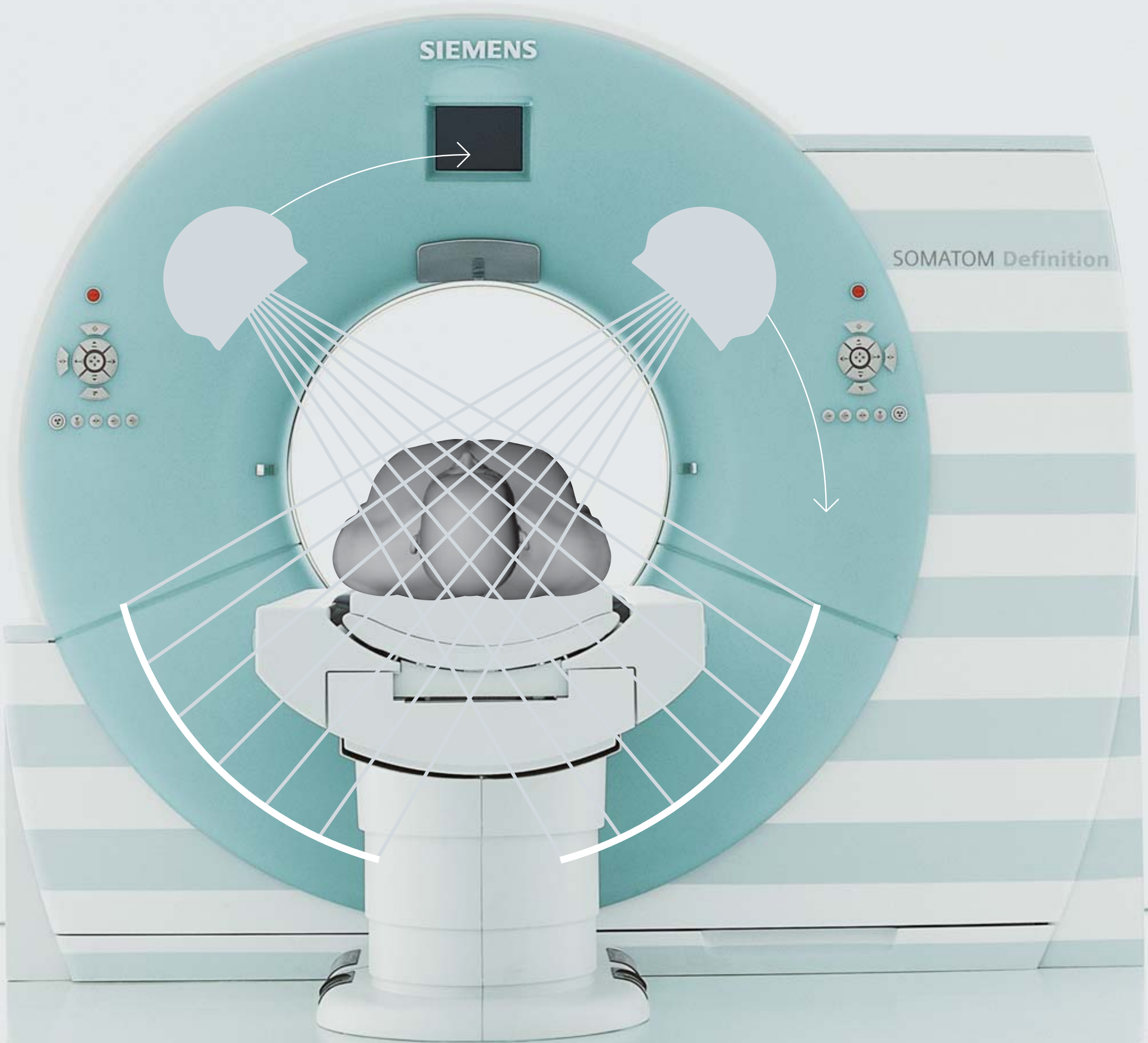
The benefits that Dual Source CT holds for you and your patients are astounding. SOMATOM® Definition allows you to scan any heart at any heart rate without the need of beta-blockers – at the lowest radiation dose ever achieved in Siemens CT.

Moreover, it provides one-stop diagnoses, regardless of size*, condition, and heart rate of the patient, saving precious time and money in acute care. And imagine all the additional clinical opportunities Spiral Dual Energy scanning offers in CT by characterizing materials in a single scan.

Reaching excellence in CT is not only about having the most innovative scanner: It is also about pushing clinical boundaries to a higher level, providing advantages nobody wants to miss. We make a difference by offering a complete and comprehensive solution dedicated to all clinical needs, by turning complex examinations into easy CT routine.

* Up to 300 kg/200 cm (660 lbs/79").


SOMATOM Definition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SOMATOM Definition

Dual Energy CT

It has always been an aim to collect as much information as possible for differentiation of tissues. Providing Spiral Dual Energy scanning, SOMATOM Definition opens the door to a new world of characterization, visualizing the chemical composition of material.

The idea of Dual Energy is not new to the CT community. Earlier approaches, including two subsequent scans at different tube voltages or two subsequent scans at the same position, failed to seamlessly align the imaged anatomy and to capture the same phase of contrast enhancement. SOMATOM Definition overcomes this limitation by permitting the use of two X-ray sources at two different kV levels simultaneously. The result is two spiral data sets acquired simultaneously in a single scan providing diverse information, which allows you to differentiate, characterize, isolate, and distinguish the imaged tissue and material.

Many applications are already available for daily clinical use, such as an accurate subtraction of bone in CTAs, assessment of pulmonary perfusion, characterization of kidney stones or iodine removal from liver scans to generate a virtual unenhanced image. What's more, new applications continuously increase the clinical value of Dual Energy CT, for example characterization of atherosclerotic plaques or assessment of myocardial perfusion.

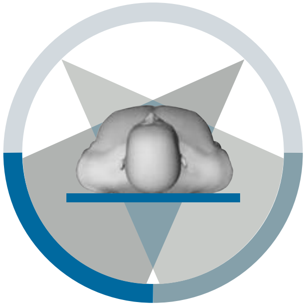
By enabling not only faster and more reliable diagnoses, but also by further broadening the application spectrum of CT, Spiral Dual Energy makes a difference for everybody's daily work.

Clinical Benefits

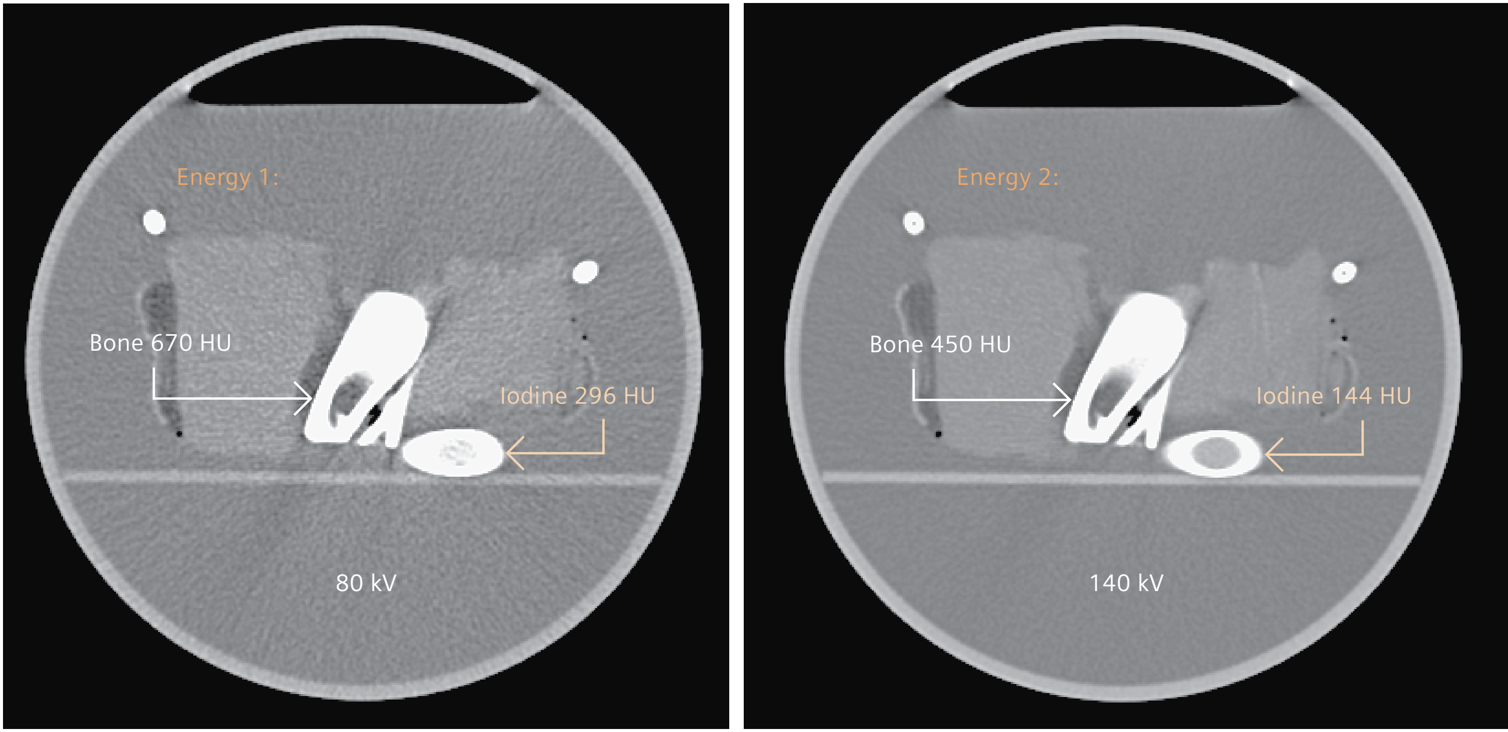
- **Direct subtraction of bone even in complicated anatomical regions.**
- **Display of atherosclerotic plaques.**
- **Virtual unenhanced images.**
- **Evaluation of lung perfusion.**
- **Display of lung vessels affected by pulmonary emboli.**
- **Visualization of tendons and ligaments.**
- **Kidney stone characterization.**
- **Visualization of iodine concentration in the myocardium.**
- **Differentiation between old and fresh intracranial bleedings.**
- **Visualization of uric acid crystals in peripheral extremities.**

How Dual Energy CT Works

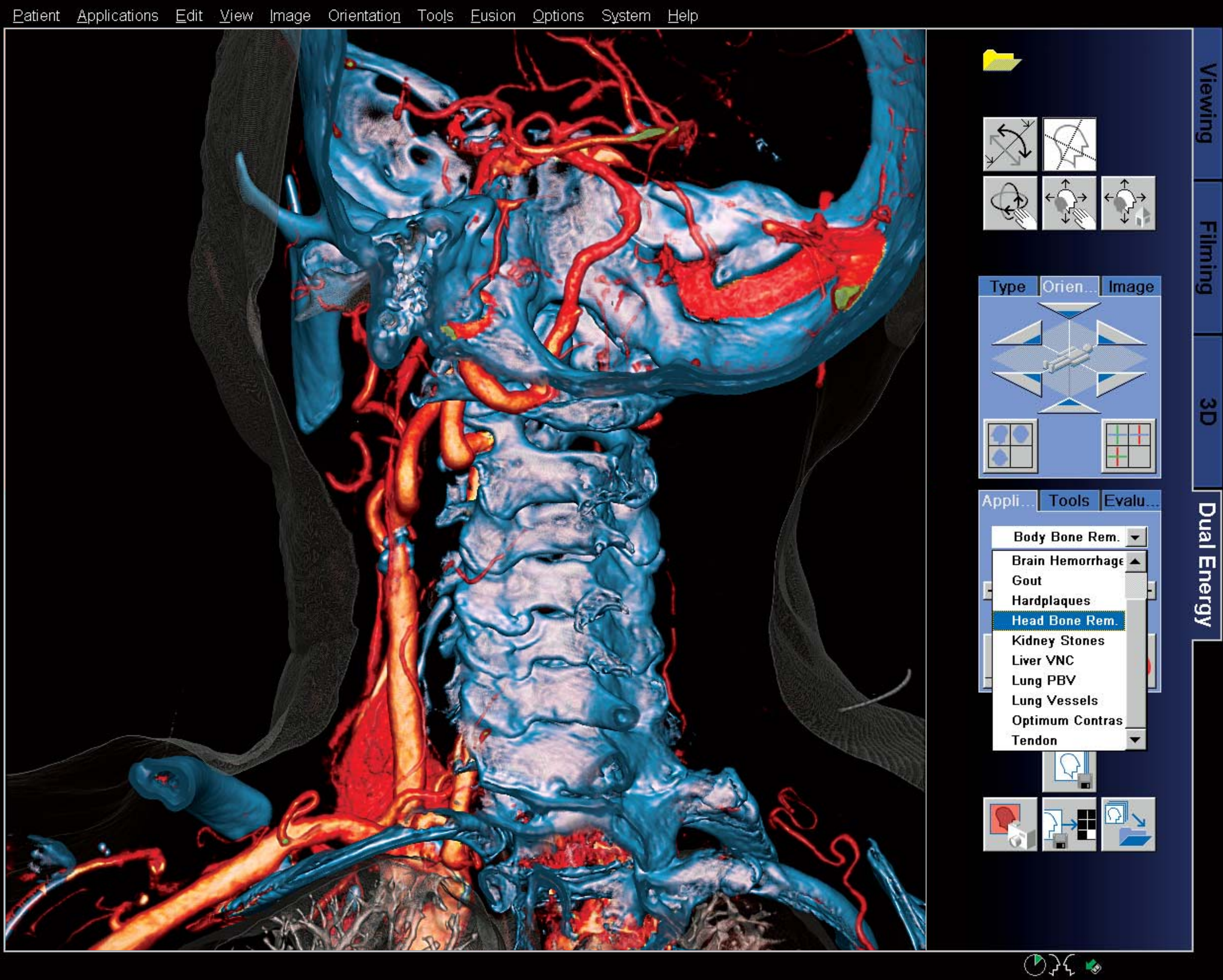
The X-ray tube's kilo voltage (kV) determines the average energy of the photons in the X-ray beam. Changing the tube potential results in an alteration of photon energy and a corresponding modification of the attenuation of the X-ray beam in the materials scanned. In other words, X-ray absorption is energy-dependent, for example, scanning an object with 80 kV results in a different attenuation than with 140 kV. In addition, this attenuation also depends on the type of material or tissue scanned. Iodine, for instance, has its maximum attenuation at low energy, while its CT-density is only about half in high-energy scans. The attenuation of bones, on the other hand, changes much less when scanned with low photon energies compared to high-voltage examinations.



Spiral Dual Energy CT exploits this effect: Two X-ray sources running simultaneously at different voltages acquire two data sets showing different attenuation levels. In the resulting images, the material-specific difference in attenuation makes a classification of the elementary chemical composition of the scanned tissue feasible. Depending on the clinical question, the images obtained at 140 and 80 kV potential are further processed with specific software algorithms implemented in the *syngo* Dual Energy software. In addition, fused images are provided for initial diagnosis. These are created as weighted average which have a low image noise and a normal attenuation like images scanned at 120 kV tube potential.



Because X-ray absorption is energy-dependent, changing the tube's kilo voltage results in a material-specific change of attenuation.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Tendon

Direct Angiography and Bone Removal with Plaque Highlighting

syngo Dual Energy Direct Angio with Bone Removal

As a minimally invasive procedure in comparison to DSA, multislice spiral CT (MSCT) has become the first-line modality for many angiographic applications. For routine practice and especially in the emergency room, CTA is the standard of care because it is less time consuming, less susceptible to motion artifacts, and much less prone to complications. Today, MSCT is the standard modality in the detection of aortic aneurysms, especially in emergencies, when pulmonary embolism, acute heart attack, and aortic dissection need to be ruled out by CT simultaneously. Visualization of the aorta is possible beyond the vessel wall, also showing, for example, intramural thrombi or periaortic infections. The latest technical evolution of MSCT to DSCT makes direct bone removal possible based on a spectral differentiation between iodine and bone in Dual Energy CT. Thus, a direct visualization of the aorta and branching vessels is feasible. Moreover, MSCT is the perfect tool for pre- and postoperative assessment and evaluation with endovascular aortic repair (EVAR), and Dual Energy CT can help to differentiate endoleaks from calcifications in the thrombosed lumen.

In neurovascular angiography, the immediate availability and fast exam in MSCT have also proven highly beneficial in the non-invasive investigation of supra-aortic extracranial and intracranial vessels for the assessment of acute stroke. Recent studies show that supraaortic CT angiography (CTA) is also ideally suited for the detection of intracranial aneurysms of 3 mm and larger in cases of subarachnoidal hemorrhage. With dual energy material differentiation, it has also become possible to perform reliable bone and calcified plaque subtraction out of CTA volume data, so that aneurysms in close vicinity to the skull base are more easily identified.

CT angiography is also gaining importance in the assessment of peripheral arterial occlusive disease. Dual Energy CT can help to cope with those huge datasets exceeding 1,000 images by generating a single maximum intensity projection without the superimposition of bones. Additionally, plaques can be identified and removed or highlighted in this image to support the grading of stenoses and to assist therapeutic planning.

Case 1 – Carotid Angiography

W. Eicher, MD
Landeskrankenhaus Klagenfurt,
Klagenfurt, Austria

History

A 79-year-old male patient was referred to CT for suspected occlusion of the right carotid artery. His past medical history included second stage PAOD (Peripheral Arterial Obstructive Disease).

Diagnosis

CT angiography revealed an occlusion of the right common carotid artery close to its origin. There was a moderate stenosis of the proximal right vertebral artery. Additionally, a high-grade stenosis of the left carotid bulb involving the common, internal, and external carotid artery was found. The left vertebral artery was occluded as well. Intracranially, the distal right internal carotid artery was supplied by collateral flow. The anterior, middle, and posterior cerebral arteries were all perfused.

Comments

With Dual Energy CT, maximum intensity projections of the extra- and intracranial arteries can be generated without superimposing bones, similar to MRA. These images make it possible to screen datasets very quickly for pathology. In complex datasets, the technique provides an excellent overview of the vasculature including occlusions, stenoses, plaques, and collateral vessels.

Examination Protocol

Scanner	SOMATOM Definition
Scan area	supraaortic vessels from aortic arch to top of head
Scan length	278 mm
Scan time	8 s
Scan direction	caudocranial
kV	140 kV and 80 kV
Effective mAs	51 mAs and 186 mAs
Rotation time	0.33 s
Slice collimation	64 x 0.6 mm
CTDIvol	9.8 mGy
Sex	M
Contrast	
Contrast material	Ultravist 370
Volume	80 ml
Flow rate	6 ml/s
Start delay	4 s after trigger
Saline chaser bolus	50 ml, 6 ml/s
Postprocessing application	
syngo Dual Energy Direct Angio with Bone Removal	

[A] VRT

[B] MIP

[C] VRT

Case 2 – Aortic Angiography

P. Rossi, MD; F. Civaia, MD
Centre Cardio-Thoracique de Monaco
Monte Carlo, Monaco

History

A 70-year-old woman with chronic hypertension was referred for follow-up aortic angiography after endovascular repair of a dissecting aortic aneurysm. She had a type B dissection of the thoracic aorta extending into the abdominal aorta and iliac arteries.

Diagnosis

CTA showed the stent in the true lumen of the type B dissection in segment III of the thoracic aorta. There was a persistent entry and perfusion of the false lumen. The dissection membrane extended into the left iliac artery. The left renal artery was occluded.

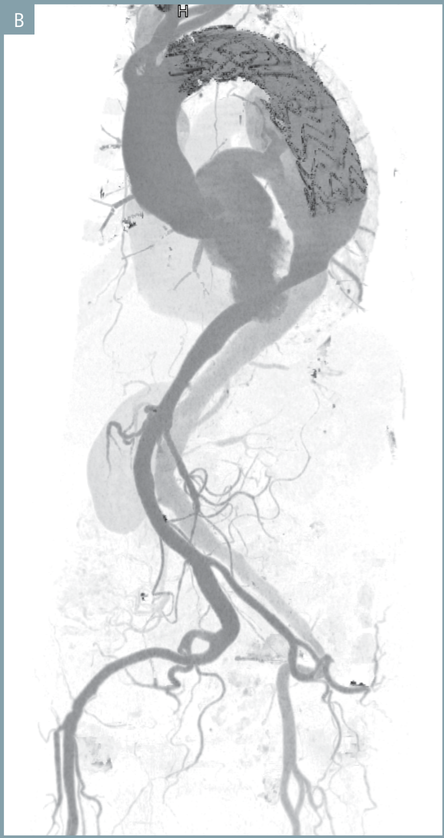
Comments

Dual Energy CTA provides an excellent overview of pathology. A stent, a perfused false lumen, a missing renal artery, and a dissection of the iliac artery are all evident in a single MIP image.

Examination Protocol

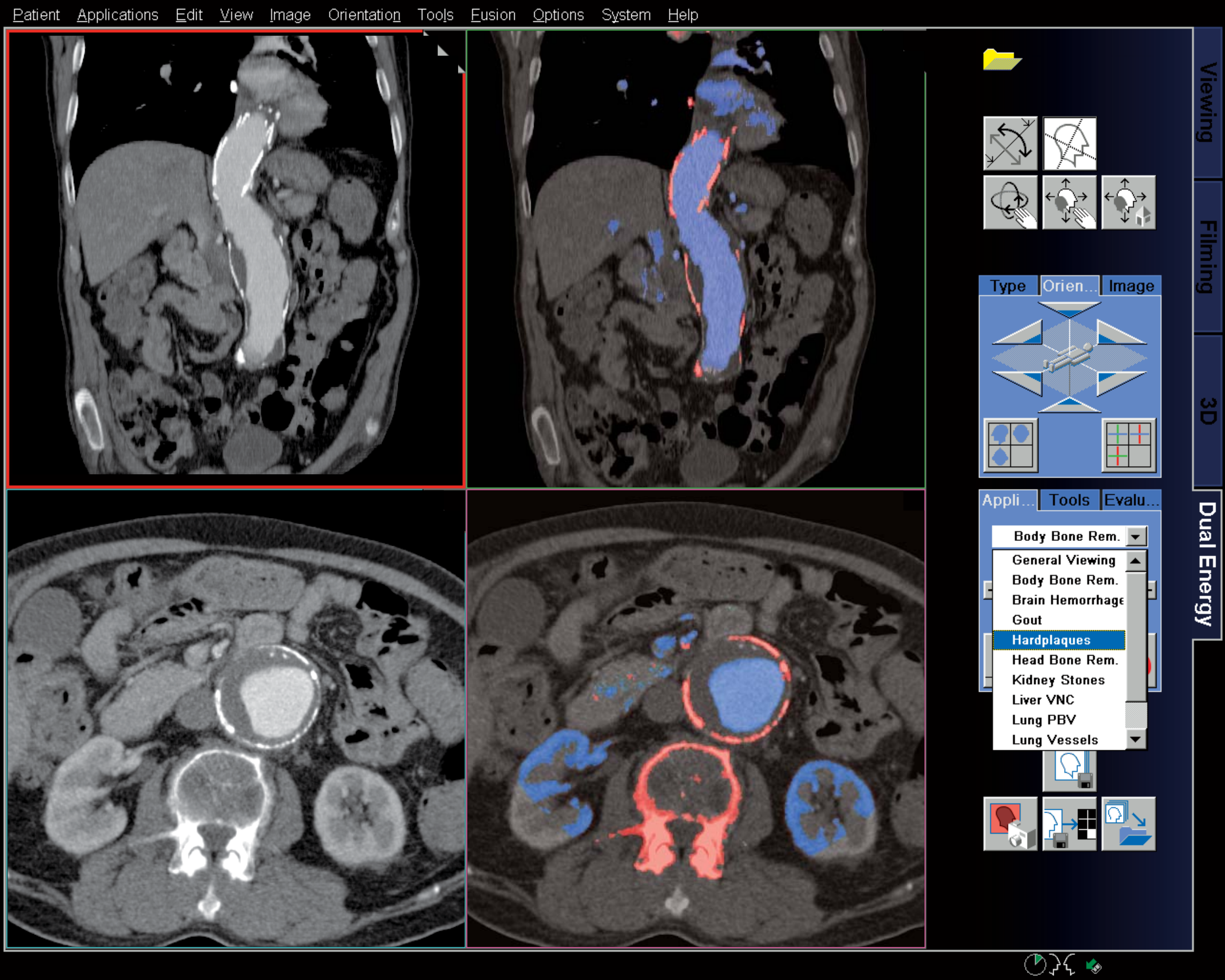
Scanner	SOMATOM Definition
Scan area	thorax and abdomen
Scan length	541 mm
Scan time	13 s
Scan direction	craniocaudal
kV	140 kV and 80 kV
Effective mAs	42 mAs and 180 mAs
Rotation time	0.5 s
Slice collimation	14 x 1.2 mm
CTDIvol	10.2 mGy
Sex	F
Contrast	
Contrast material	Ultravist 370
Volume	120 ml
Flow rate	4 ml/s
Start delay	7 s after trigger
Saline chaser bolus	50 ml, 4 ml/s
Postprocessing application	
syngo Dual Energy Direct Angio with Bone Removal	

[A] VRT



[B] Inverted MIP

[C] MIP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Kidney Stones
Liver VNC
Lung PBV
Lung Vessels

Plaque Characterization

syngo Dual Energy Hardplaque Display

With simultaneous dual energy scanning, automated plaque detection and characterization has become viable. The first step is to reliably differentiate calcified plaques from the contrast-opacified lumen of the vessel. The new *syngo* Dual Energy Hardplaques algorithm helps to differentiate plaque from iodine by color-coding both differently. This aim is accomplished better than with the bone removal algorithm, because this algorithm is designed to differentiate and mark calcium and iodine rather than completely removing calcium-containing structures from the dataset. Thus, the plaque load becomes obvious and it is possible to quantify atherosclerotic lesions, for example, to monitor treatment response to statin therapy. Also, the visual grading of calcified stenoses can be improved, because the algorithm helps to delineate plaque and lumen more exactly. Additionally, this data can be used to improve the automatic grading of stenoses by postprocessing software.

The algorithm can also be used to differentiate calcification from contrast enhancement or to visualize an additional contrast enhancement in calcified lesions. This can be helpful, for example, to identify endoleaks in a partially calcified thrombosed false lumen after endovascular repair of aneurysms or dissections. In calcified lesions of liver or spleen, for instance, metastases or parasitic cysts, the algorithm can be used to assess contrast enhancement even without an additional unenhanced scan.

Case 1 – Carotid Plaques

Centre Cardio-Thoracique
de Monaco, Monaco

History

A 63-year-old hypertensive patient presented with transient amaurosis fugax and aphasia for eight hours. MRI angiography was not possible due to a cardiac pacemaker.

Diagnosis

Abnormal anatomic findings of the carotid arteries were excluded. Fused dual energy images showed calcified plaques at both carotid bifurcations. A severe vascular stenosis due to calcified or soft plaque was ruled out.

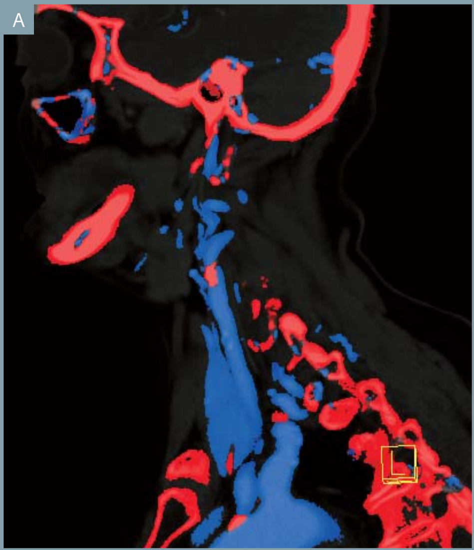
Comments

Dual Energy CTA makes a differentiation of iodine-filled vessel lumina from calcified vessel plaques feasible, making a more accurate quantification of carotid stenosis possible. Color-coded visualization further simplifies diagnosis and presentation.

Examination Protocol

Scanner	SOMATOM Definition
Scan area	aortic arch to circle of Willis
Scan length	250 mm
Scan time	4 s
Scan direction	caudocranial
kV	140 kV and 80 kV
Effective mAs	55 mAs and 234 mAs
Rotation time	0.33 s
Slice collimation	0.6 mm
CTDIvol	9.1 mGy
Pitch	0.7
Sex	F
Contrast	
Contrast material	Ultravist 370
Volume	80 ml
Flow rate	5 ml/s
Start delay	2 s after trigger
Saline chaser bolus	50 ml, 5 ml/s
Postprocessing application	
syngo Dual Energy Hardplaque Display	

A



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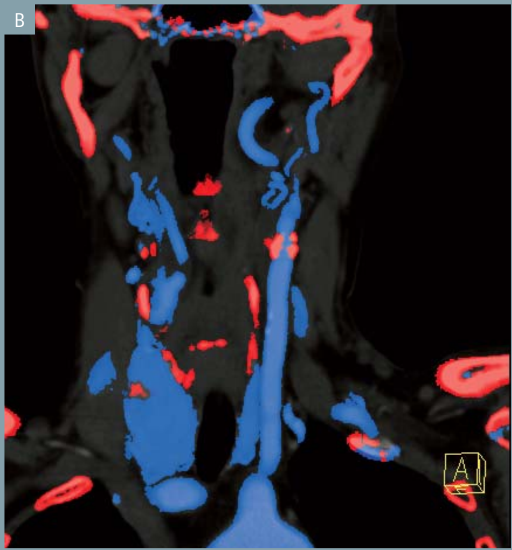

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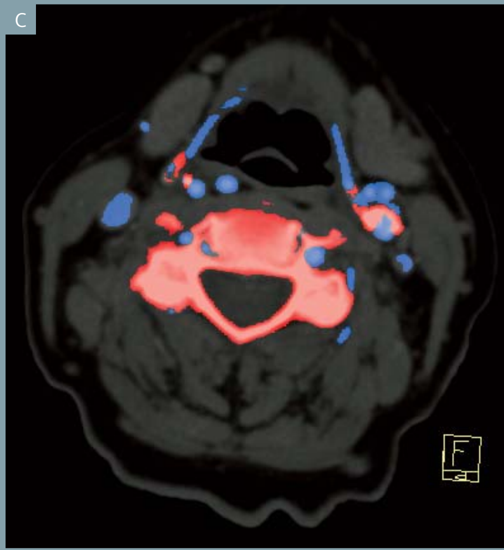


[A] Axial dual energy image of a calcified plaque at the bifurcation of the left carotid artery. Note the differentiation of iodine (blue) and calcium (red).

[B] Coronary dual energy image (MPR) of the same plaque.

[C] Sagittal dual energy image (MPR) of the same plaque.

Case 2 – Aortic Stent

T. R. C. Johnson, MD
Grosshadern University Hospital
Munich, Germany

History

A 45-year-old male patient was referred for follow-up one year after endovascular repair of an aortic aneurysm.

Diagnosis

Aortic angiography showed a stent in the descending thoracic aorta. Hyperdense material was noted in the thrombosed part of the lumen outside the stent. There was no connection to the proximal or distal end of the stent. The hardplaques algorithm color-coded these areas as iodine, confirming an endoleak type III.

Comments

The hardplaques algorithm is helpful to clearly differentiate calcifications from contrast enhancement. The single phase acquisition in dual energy technique was sufficient to make the diagnosis in this case.

Examination Protocol

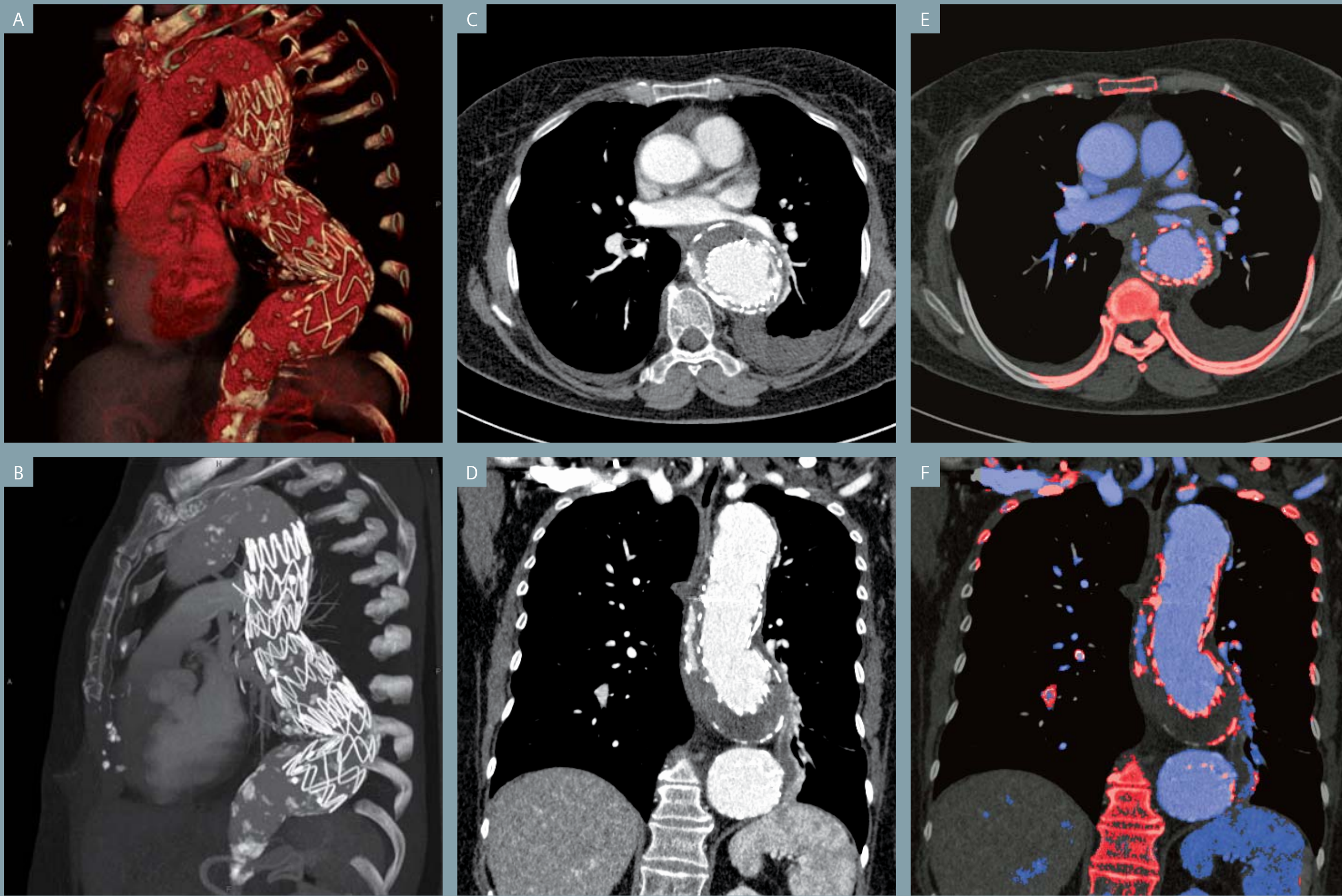
Scanner	SOMATOM Definition
Scan area	thorax
Scan length	350 mm
Scan time	8 s
Scan direction	craniocaudal
kV	140 kV and 80 kV
Effective mAs	50 mAs and 214 mAs
Rotation time	0.5 s
Slice collimation	14 x 1.2 mm
CTDIvol	11.1 mGy
Sex	M
Contrast	
Contrast material	Ultravist 370
Volume	120 ml
Flow rate	4 ml/s
Start delay	5 s after trigger
Saline chaser bolus	50 ml, 4 ml/s
Postprocessing application	
syngo Dual Energy Hardplaque Display	

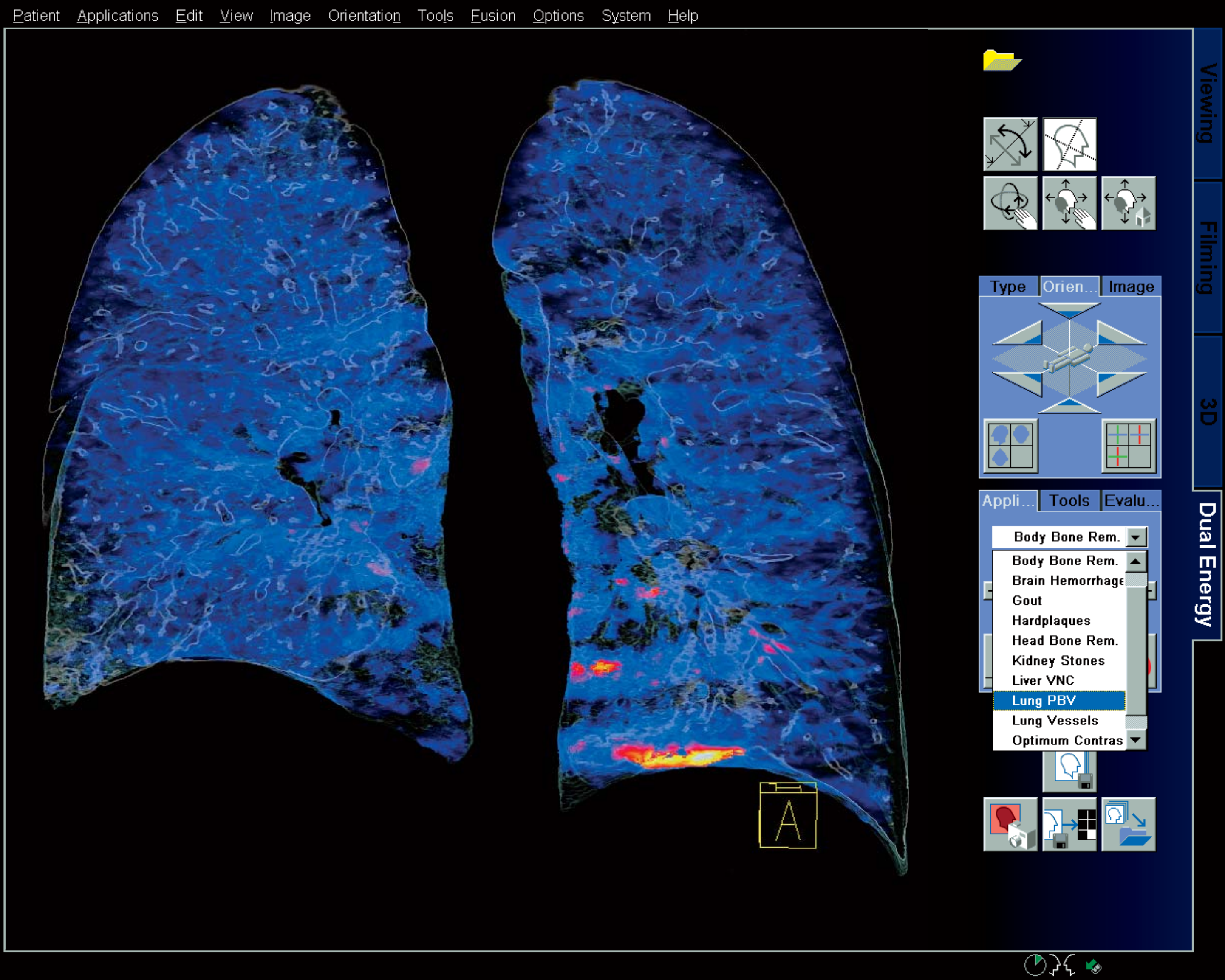
[A] Volume-rendered image showing the contrast-opacified aorta with the stent.

[B] Maximum intensity projection visualizing the struts of the stent.

[C + D] Axial and coronal images showing some hyperdense material on the right side of the stent in the thrombosed lumen.

[E + F] Axial and coronal color-coded result images of the hardplaques algorithm. The hyperdense material is identified as iodine, confirming an endoleak.

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Assessment of Lung Perfusion

syngo Dual Energy Lung PBV

CT angiography has recently become the diagnostic standard for non-invasive detection of pulmonary embolism. However, it seems that there is some discrepancy between the size or location of emboli and their clinical relevance. Therefore, additional perfusion imaging may add relevant information.

With Dual Energy CT it is possible to color-code the iodine distribution in the lung parenchyma, and thus to visualize perfusion defects caused by small emboli as areas with reduced color density. At the same time, the hemodynamic significance of larger emboli can be assessed. This method was evaluated in two clinical studies at the University of Munich. Perfusion defects were observed in the dual energy perfusion analysis in all patients with occlusive pulmonary embolism. There was also a good agreement between dual energy perfusion assessment and pulmonary perfusion scintigraphy. Hence, Dual Energy CT of pulmonary perfusion is a feasible method for detecting and assessing the functional relevance of pulmonary embolism without additional dose, contrast application, or examination time.

Case 1 – Detection of Pulmonary Embolism

J. Ferda, PhD
Fakultni Nemocnice
Pilsen, Czech Republic

History

A 19-year-old woman presented with sudden breath shortness and chest pain.

Diagnosis

The primarily reconstructed angiographic images showed subtle hypodense material in the lateral segment of the right middle lobe. With the dual-energy-based perfusion analysis, two small peripheral perfusion defects were visualized, one in the lateral and one in the medial segment of the middle lobe.

Comments

The perfusion information was helpful in confirming pulmonary embolism in the presence of the subtle angiographic finding. Additionally, a small perfusion defect was diagnosed on the basis of the perfusion information which might have been missed in normal angiography. Thus, Dual Energy CT can improve the sensitivity for pulmonary embolism and may be able to replace perfusion scintigraphy in some instances.

Examination Protocol

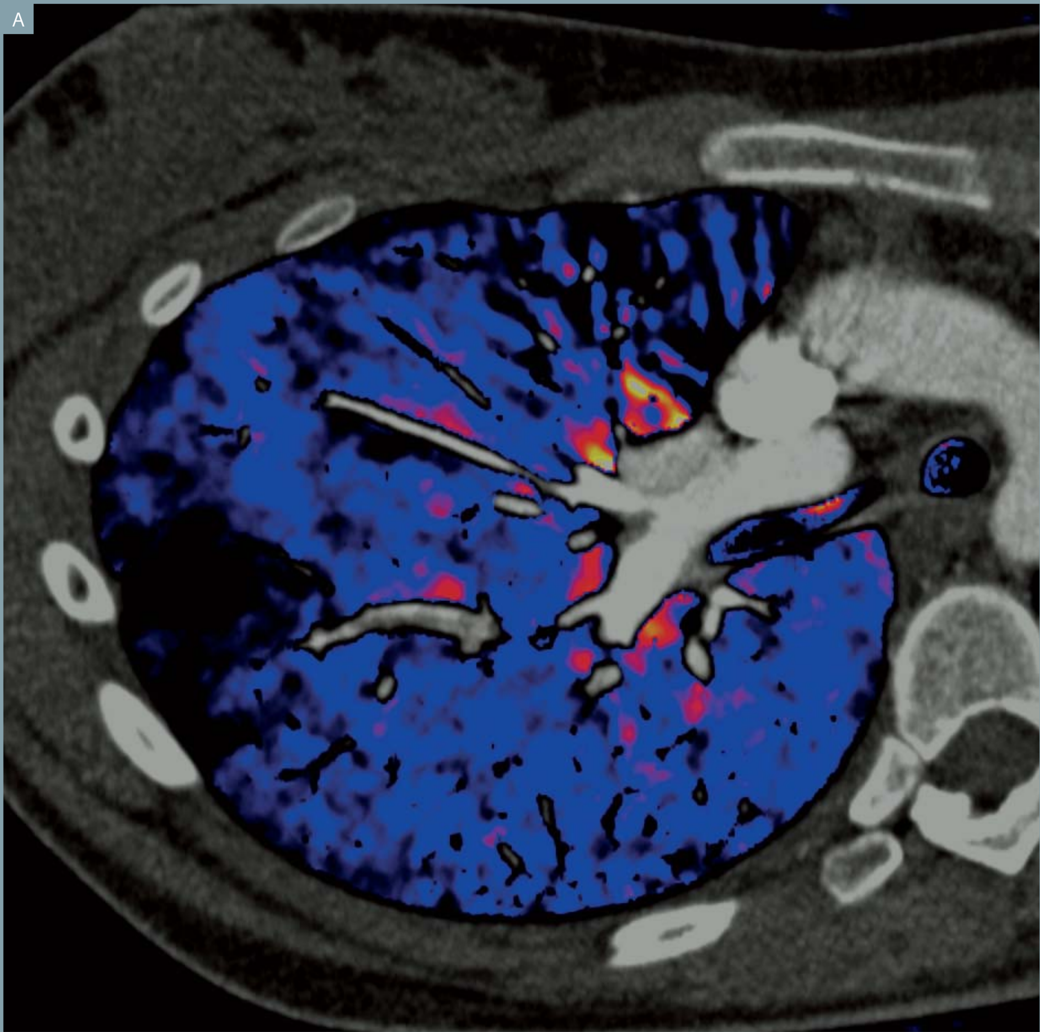
Scanner	SOMATOM Definition
Scan area	thorax
Scan length	271 mm
Scan time	9 s
Scan direction	craniocaudal
kV	140 kV and 80 kV
Effective mAs	22 mAs and 155 mAs
Rotation time	0.5 s
Slice collimation	14 x 1.2 mm
CTDIvol	5.2 mGy
Contrast	
Contrast material	Ultravist 370
Volume	80 ml
Flow rate	4 ml/s
Start delay	7 s after trigger
Saline chaser bolus	50 ml, 4 ml/s
Postprocessing application	
syngo Dual Energy Lung PBV	

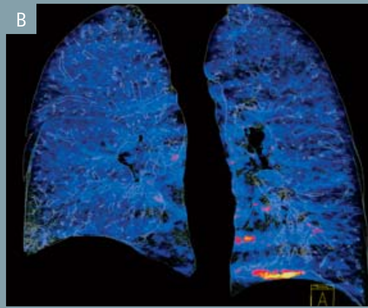
[A] Axial reconstruction with color-coded perfusion information. Note the hypodense areas in the segmental lateral middle lobe artery and the corresponding wedge-shaped subpleural perfusion defect.

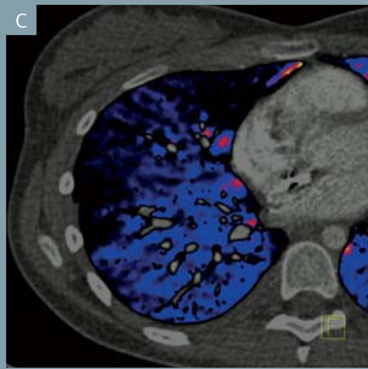
[B] Volume-rendered image showing that most of the lung parenchyma is perfused normally.

[C] Color-coded axial image showing both perfusion defects in the right middle lobe.

[D] Coronal reconstruction showing the embolic material in the right middle lobe artery. Note that the lung parenchyma has a normal density in lung window.







Case 2 – Assessment of Perfusion Defects

B. Ghaye, MD; J.-F. Monville, MD
University Hospital of Liège
Liège, Belgium

History

A 76-year-old male presented in the emergency department with sudden onset of dyspnea. Pulmonary embolism was suspected and the patient was referred for CT pulmonary angiography.

Diagnosis

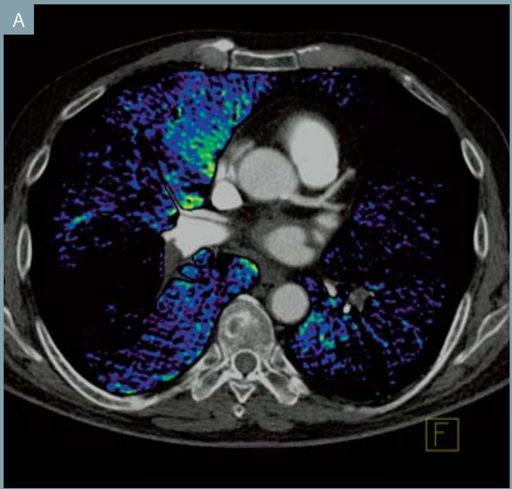
The angiographic reconstruction as weighted average images revealed massive central pulmonary embolism. The additional perfusion assessment showed large perfusion defects in the segments corresponding to the emboli. Based on the perfusion assessment, it was estimated that only about half of the lung parenchyma remained perfused and that blood oxygenization was severely impaired.

Comments

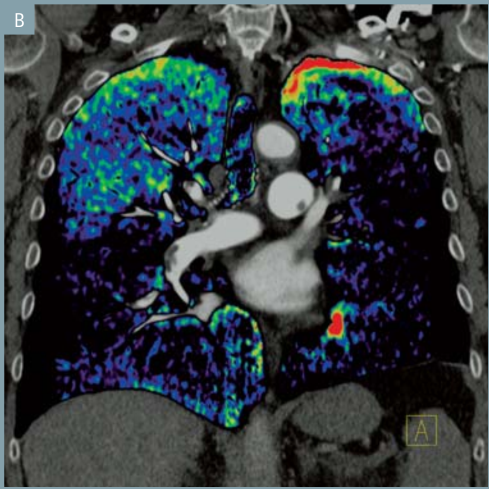
With Dual Energy CT, both morphological and functional on lung perfusion are obtained with a single exam. This can contribute to a comprehensive workup of acute conditions such as pulmonary embolism or chronic pulmonary diseases such as pulmonary hypertension, emphysematic, or fibrotic diseases. The dual energy perfusion information may even render additional perfusion scintigraphy unnecessary in some instances, thus saving time, money, and radiation exposure.

Examination Protocol

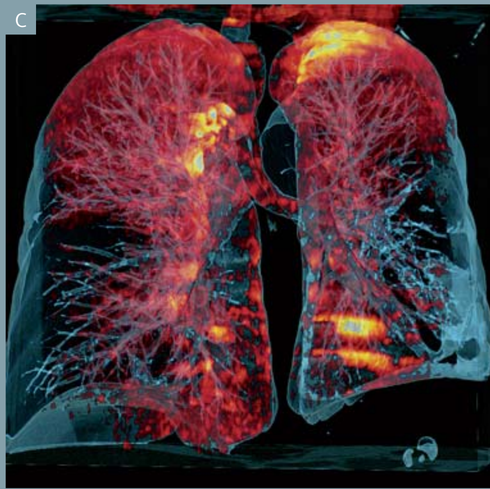
Scanner	SOMATOM Definition
Scan area	thorax
Scan length	342 mm
Scan time	8 s
Scan direction	caudocranial
kV	140 kV and 80 kV
Effective mAs	51 mAs and 213 mAs
Rotation time	0.5 s
Slice collimation	1.2 mm
CTDIvol	6.96 mGy
Sex	M
Contrast	
Contrast material	Ultravist 370
Volume	100 ml
Flow rate	5 ml/s
Start delay	6 s after trigger
Saline chaser bolus	50 ml, 5 ml/s
Postprocessing application	
syngo Dual Energy Lung PBV	



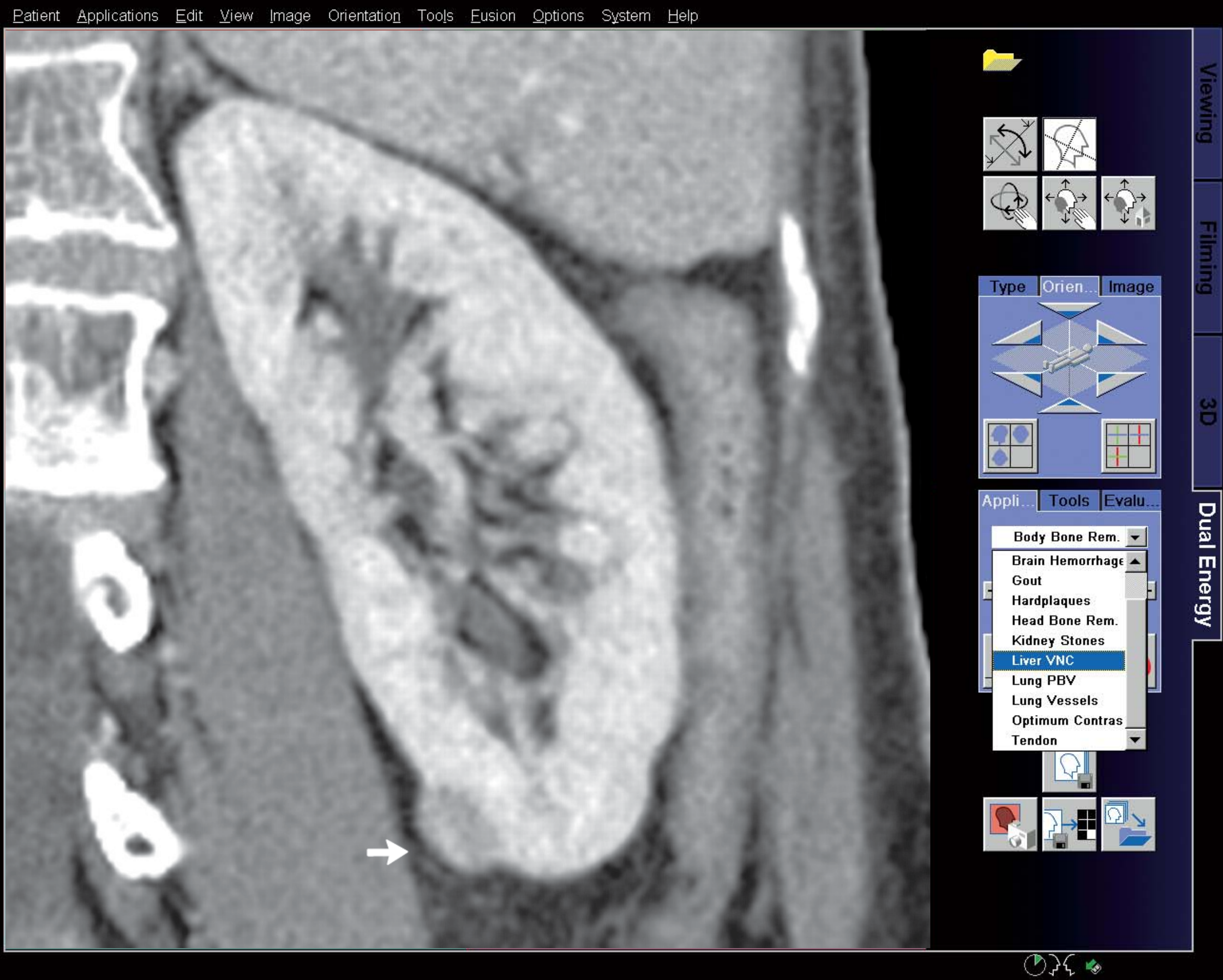
[A] Axial reconstruction with color-coded dual energy perfusion information. Note the large perfusion defects in both lungs.



[B] Coronal reconstruction. Only the apical parts show a normal perfusion.



[C] Volume-rendered image with color-coded perfusion information. There are large perfusion defects in the right middle and lower lobe and in the lingual and lower lobe on the left.



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Lung Vessels
Optimum Contras
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Virtual Non-Contrast Images

syngo Dual Energy Virtual Unenhanced

Multi-detector row CT scanners have substantially broadened the spectrum of clinical applications and examination techniques, but the basic principle of image acquisition with contrast media being used for better delineation of organs and specific structures has remained the same since the introduction of CT in the 1970s.

However, if pathology is only very subtly delineated, contrast media may mask the sought-after pathology. Such is the case with intramural hematomas in the aorta or small kidney stones. With Dual Energy CT, this clinical problem can be overcome: Thanks to the particularly stronger enhancement rate of iodine at low tube voltage, it is possible to remove the iodine content of any object in the image mathematically without removing the object itself. This results in "virtual non-contrast" images. Hence, it is possible to scan at any phase of contrast enhancement and non-contrast images can be generated afterwards. The non-contrast phase can be omitted for all imaging protocols in clinical routine, which can help to reduce dose significantly. Whenever needed for diagnosis, non-enhanced images can be generated without any further effort.

Case 1 – Differentiation of Renal Masses

R. P. Hartmann, MD
Mayo Clinic College of Medicine
Rochester, MN, USA

History

A 70-year-old female patient presented for follow-up of a suspected solid mass in the lower pole of the left kidney.

Diagnosis

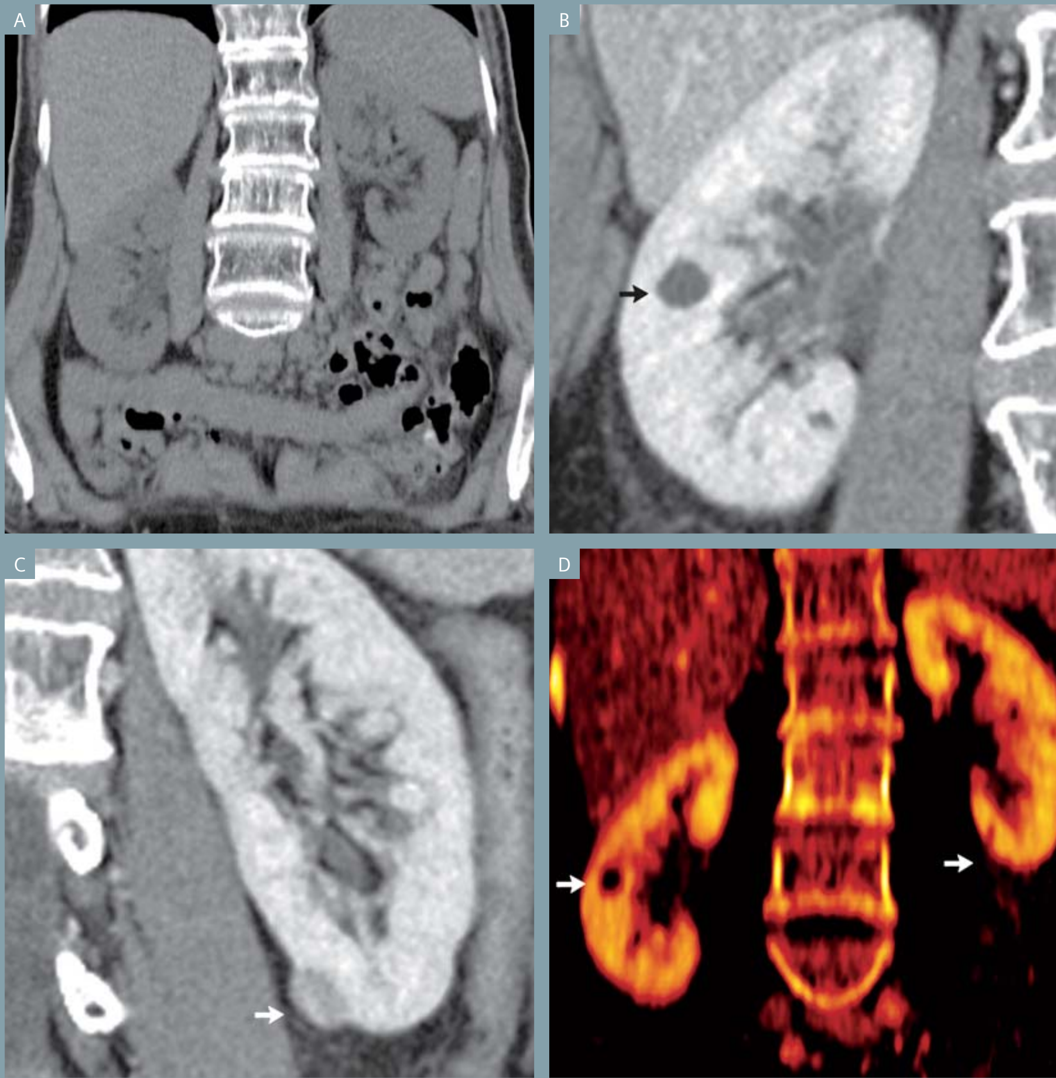
There was a 1.2 cm mass in the lower pole of the left kidney. Based on the presence of iodine signal centrally, it had to be considered a solid mass. This was also established based on an increase in attenuation from true non-contrast to post-contrast images of 70 HU. This was considered worrisome for a renal cell carcinoma. A second lesion in the mid portion of the right kidney did not have iodine signal and was considered to be a benign cyst.

Comment

The use of the iodine overlay image that can be produced from a dual energy acquisition allows for the differentiation of a renal cyst from a solid mass. It is not necessary to acquire a non-contrast scan prior to dual energy scanning, because the iodine enhancement can be identified in the color-coded overlay or in virtual non-contrast images generated with the dual energy information.

Examination Protocol

Scanner	SOMATOM Definition
Scan area	abdomen
Scan length	427 mm
Scan time	15 s
Scan direction	craniocaudal
kV	140 kV and 80 kV
Eff. mAs	50 mAs and 190 mAs
Rotation time	0.5 s
Slice collimation	14 x 1.2 mm
CTDIvol	10.2 mGy
Sex	F
Contrast	
Volume	80 ml
Flow rate	4 ml/s
Start delay	70 s
Postprocessing application	
syngo Dual Energy Virtual Unenhanced	



[A] Non-contrast coronal MPR. No stones were identified in either kidney.

[B] Coronal image of the right kidney with a low attenuation mass in the mid portion (arrow) that has a typical appearance of a renal cyst.

[C] Coronal image of the left kidney with an indeterminate lesion along the medial lower pole (arrow).

[D] Coronal iodine overlay image depicting both lesions (cyst in the right kidney with signal void and mass in the left kidney identified on average weighted series (arrows).

Case 2 – Identification of Stones in Contrast Material

R. P. Hartmann, MD
Mayo Clinic College of Medicine
Rochester, MN, USA

History

A 66-year-old male patient presented for follow-up exam of known nephrolithiasis. His prior history included bladder transitional cell carcinoma.

Diagnosis

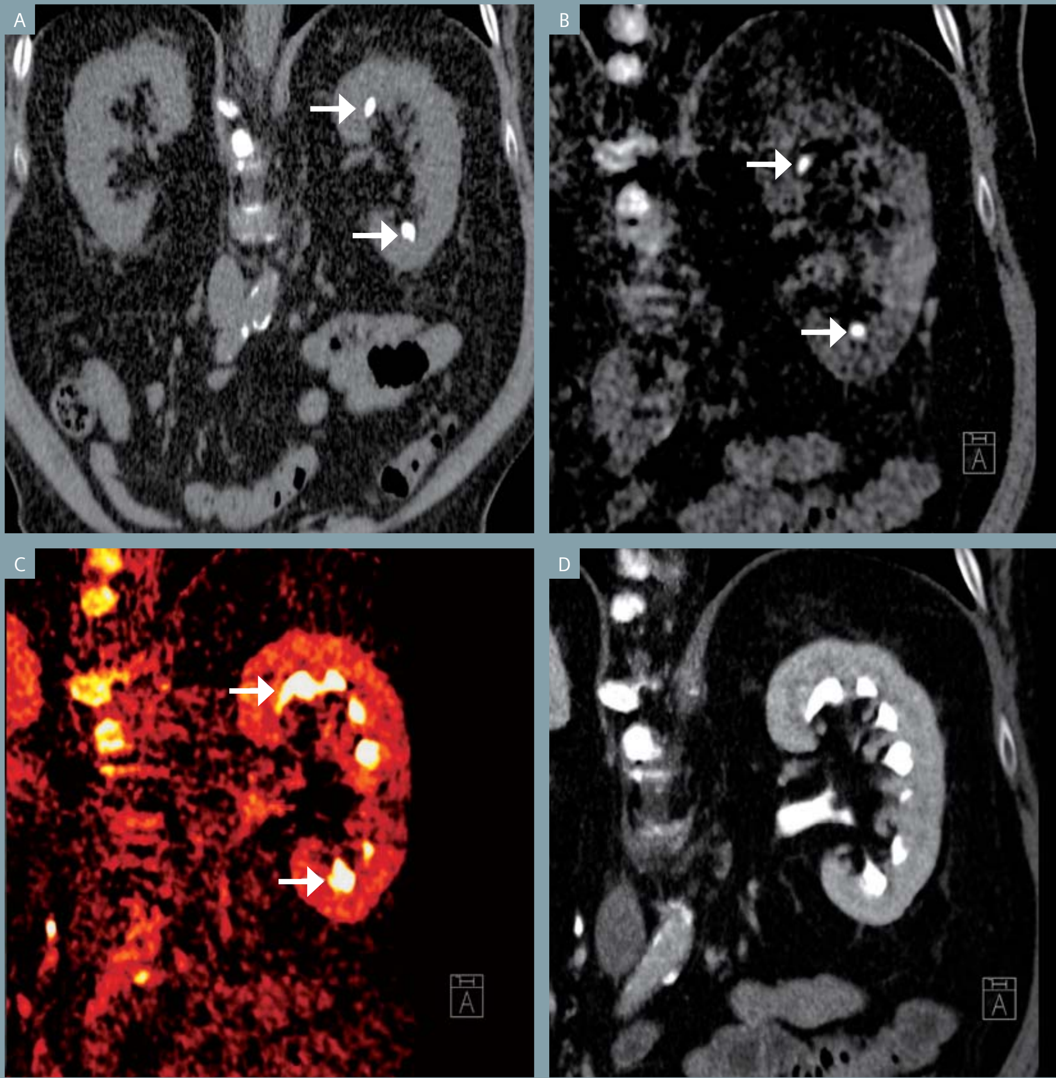
In the weighted average reconstructions, the contrast material in the renal collecting system made it impossible to identify calculi. In the calculated virtual non-contrast images, two renal calculi were identified. No other abnormalities of the kidneys, ureters, or bladder were observed. The stones were lodged within the intrarenal collecting system and were slightly larger than on previous exams.

Comments

The virtual non-contrast images produced from the excretory phase of a CT urogram are capable of detecting the stones that are evident on a true non-contrast acquisition. Given this capability of Dual Energy CT, a separate non-contrast acquisition is not needed.

Examination Protocol

Scanner	SOMATOM Definition
Scan area	upper abdomen
Scan length	274 mm
Scan time	10 s
Scan direction	craniocaudal
kV	140 kV and 80 kV
Effective mAs	40 mAs and 200 mAs
Rotation time	0.5 s
Slice collimation	14 x 1.2 mm
CTDIvol	10.1 mGy
Sex	M
Contrast	
Volume	80 ml
Flow rate	4 ml/s
Start delay	300 s
Saline chaser bolus	50 ml, 4 ml/s
Postprocessing application	
syngo Dual Energy Virtual Unenhanced	

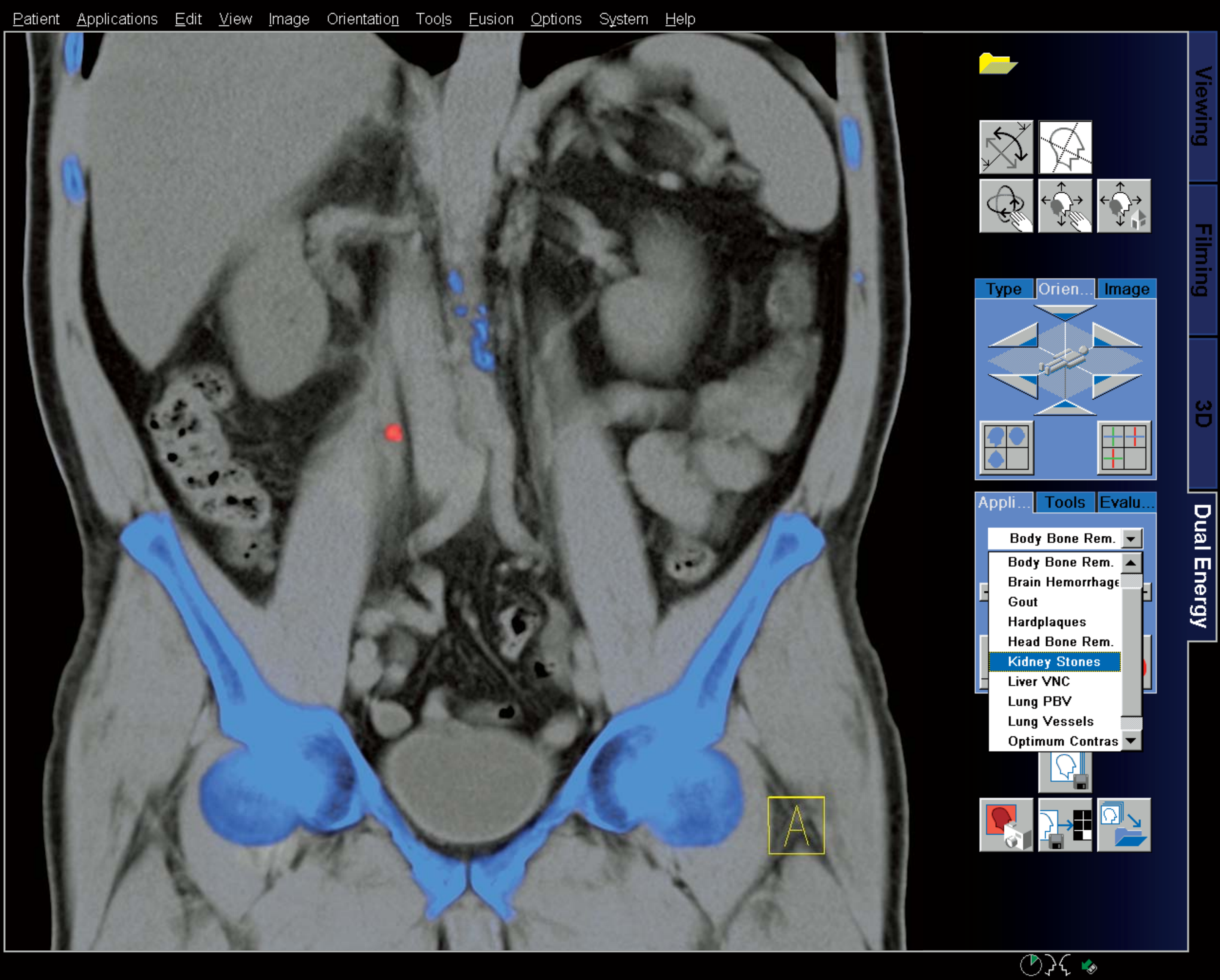


[A] Coronal MPR image from a non-contrast CT acquisition demonstrates stones in the upper and lower poles of the left kidney (arrows).

[B] Coronal MPR image after iodine subtraction from the excretory phase. The stones previously obscured by the surrounding iodinated contrast are now easily visible (arrows).

[C] Coronal MPR from dual energy data acquired in the excretory phase. The areas determined to be iodine are depicted with color. The stones are not visible (arrows).

[D] Coronal MPR from the dual energy mixed images acquired during the excretory phase. The stones shown on the non-contrast acquisitions are now obscured.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Lung PBV
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Optimum Contras
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Characterization of Renal Calculi

syngo Dual Energy Calculi Characterization

In recent years, the ability of MDCT to provide rapid contiguous thin-slice imaging through the abdomen has led to the supersession of traditional techniques in the detection of nephrolithiasis, urolithiasis, renal masses, and urothelial neoplasms such as transitional cell carcinoma. Improved CT acquisition techniques have led to increased sensitivity and speed. They also require less radiation dose than traditional X-ray urograms.

To date, a contrast and a non-contrast scan were required in multislice CT Urography (CTU) for the safe detection of stones and calcifications, and the characterization of renal masses. Spiral Dual Energy CT, with its potential for delivering a virtual non-contrast image set, makes the acquisition of an initial non-contrast scan obsolete. Saving dose and time, a virtual non-contrast image set can be produced from a CT acquisition performed during an excretory phase, when the intrarenal collecting systems and ureters are opacified with iodinated contrast.

Studies at the the Mayo Clinic College of Medicine have shown that Spiral Dual Energy CT also provides a highly accurate method of predicting stone compositions on the basis of the various materials' specific X-ray attenuation characteristics. After the Spiral Dual Energy CT data acquisition, detailed stone characterization was performed using micro CT. For all stones, micro CT confirmed the major mineral compositions as determined by infrared spectroscopy. This opens up an interesting perspective in the therapy of patients with uric acid stones. The expensive and somewhat risky shock wave lithotripsy procedure can be avoided. Instead, such patients may be treated through urinary alkalization, which is likely to dissolve uric acid stones. Studies at the University of Munich using the SOMATOM Definition have confirmed that Dual Energy CT is able to reliably differentiate uric acid calculi from other types of renal stones, both in vitro and in vivo.

Cases 1 and 2 – Differentiation of Uric Acid and Calcified Stones

A. Graser, MD; T. R. C. Johnson, MD;
C. R. Becker, MD
Grosshadern University Hospital
Munich, Germany

History

A 34-year-old male (1) and a 55-year-old male (2) patient were both referred for MDCT evaluation of known urolithiasis.

Diagnosis

The red color-code of the kidney stone shown in patient 1 indicated a uric acid calculus. Approximately 12 hours after the Dual Energy CT scan, the stone passed spontaneously and was analyzed. The chemical analysis confirmed that the calculus consisted entirely of uric acid. The blue color-code shown in patient 2 characterized a calcified stone. Based on this dual energy study, the stone was removed by ureterorenoscopy. The lab analysis of the removed stone confirmed that the stone consisted of calcium oxalate.

Comment

The dual-energy-based differentiation of renal calculi makes it possible to treat patients with uric acid stones medically and to initiate mechanical removal in patients with other types of calculi.

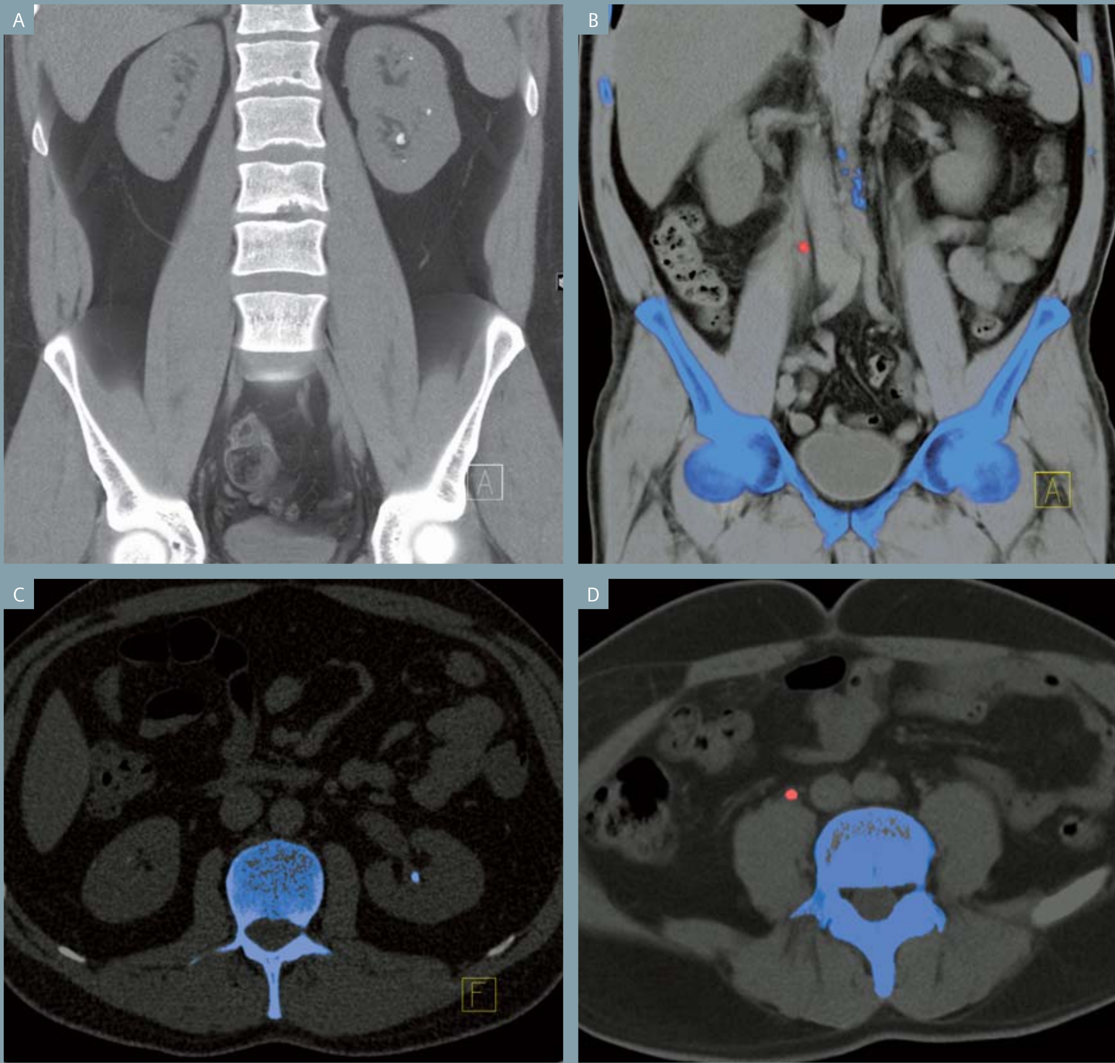
Examination Protocol

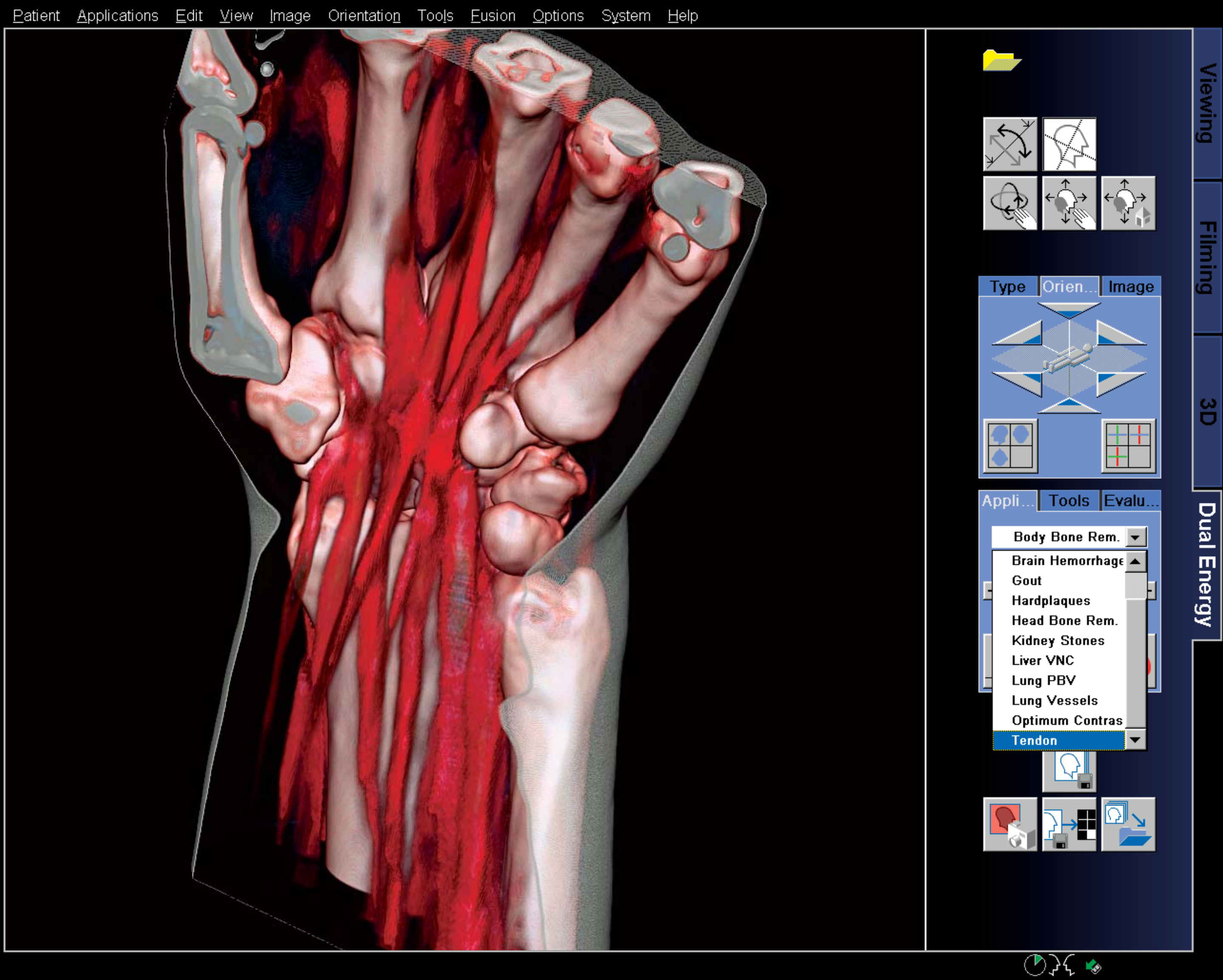
Scanner	SOMATOM Definition	SOMATOM Definition
Patient	**Patient 1**	**Patient 2**
Scan area	abdomen	lower abdomen
Scan length	377 mm	215 mm
Scan time	14 s	8 s
Scan direction	craniocaudal	craniocaudal
kV	140 kV and 80 kV	140 kV and 80 kV
Effective mAs	64 mAs and 352 mAs	69 mAs and 351 mAs
Rotation time	0.5 s	0.5 s
Slice collimation	1.2 mm	1.2 mm
CTDIvol	11.7 mGy	11.7 mGy
Sex	M	M
Postprocessing application		
syngo Dual Energy Calculi Characterization		

[A] Using conventional CT imaging the kidney stones (arrows) can clearly be visualized; however, its composition cannot be characterized.

[B] + [D] In patient 1 the kidney stone can be characterized as uric acid stone, color-coded in red.

[C] The dual energy characterization shows that the calculus of patient 2 is a calcified stone, color-coded in blue (as cortical bone in the image).

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Head Bone Rem.
Kidney Stones
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Lung PBV
Lung Vessels
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Tendon

Visualization of Tendons and Ligaments

syngo Dual Energy Musculoskeletal

Dual energy techniques based on the recently introduced Dual Source CT with Spiral Dual Energy capabilities promise to offer additional diagnostic information regarding the integrity of ligaments, tendons, and potentially cartilage. However, MRI remains the imaging modality of choice in many cases.

Dual Energy CT makes it possible to differentiate and visualize tendons and ligaments. This can be of great value in trauma patients where CT is performed to evaluate fractures. If the CT scan is performed in dual energy technique, bones can be assessed as well as tendons and ligaments in the same dataset. Although MRI is necessary to detect minor abnormalities, such as edema in a tendon, dual energy evaluation is available with the dataset obtained for the initial evaluation, and it is generally sufficient to exclude tendon ruptures or to display dislocations. Also, the differentiation of cartilage may be of interest, for example, to weigh the possibility of joint reconstruction against the necessity of replacement in elderly trauma patients.

Case 1 – Tendons of Foot and Ankle

C. Sun, MD
ASAN Medical Center
Seoul, Korea

History

After a bicycle accident, a 27-year-old man was referred for CT to rule out bony extensor hallucis longus tendon avulsion.

Diagnosis

On the anterior aspect of the right foot there was a defect and proximal retraction of the extensor hallucis longus tendon. There was no bony avulsion and no evidence of fractures or other injuries.

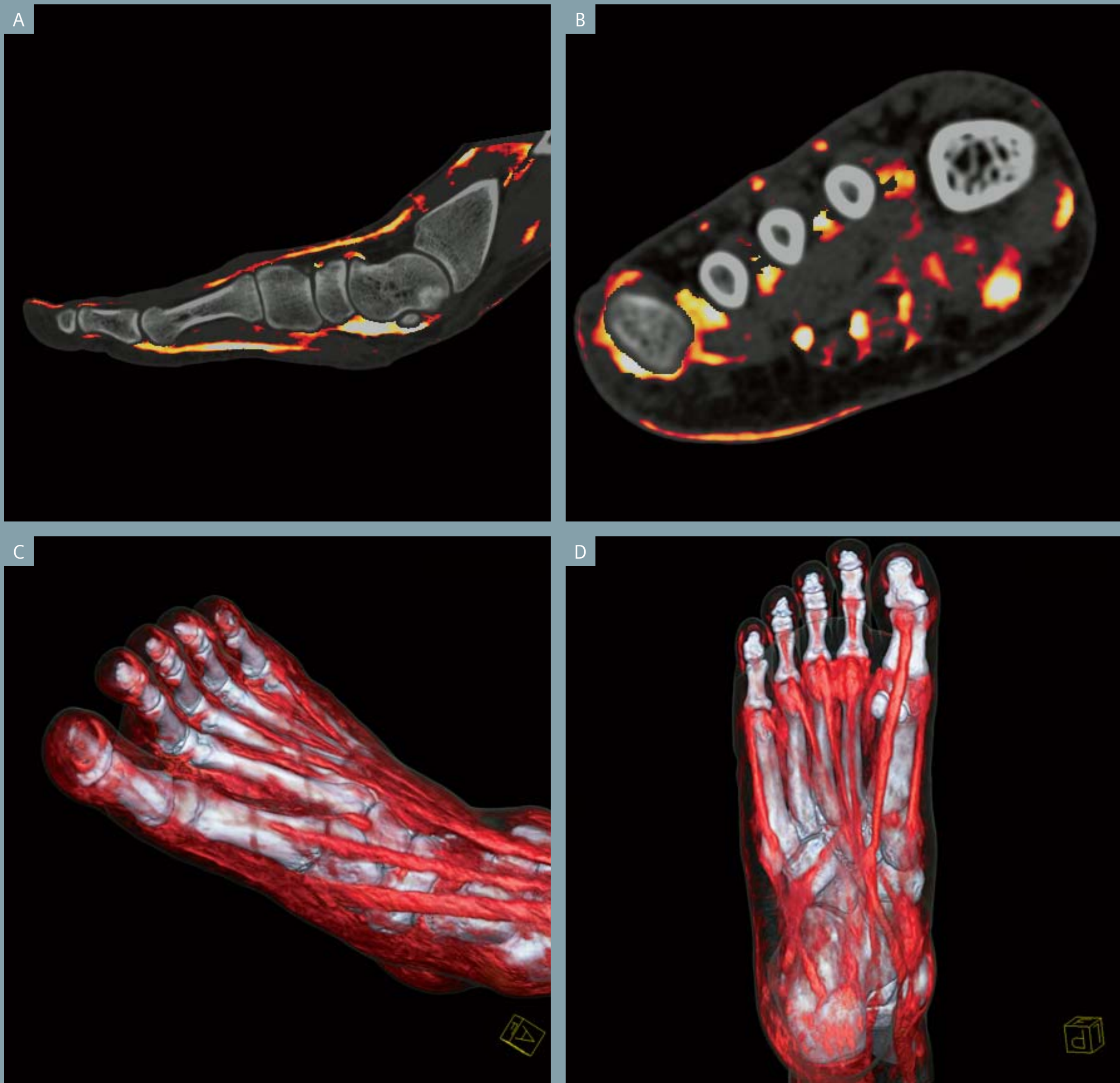
Comments

With Dual Energy CT it is possible not only to exclude a fracture or bony avulsion but also to evaluate the tendons and ligaments directly. Without Dual Energy CT, the relevant diagnosis would not have been made in this patient.

Examination Protocol

Scanner	SOMATOM Definition
Scan area	foot and ankle
Scan length	274 mm
Scan time	55 s
Scan direction	craniocaudal
kV	140 kV and 80 kV
Effective mAs	50 mAs and 90 mAs
Rotation time	1.0 s
Slice collimation	20 x 0.6 mm
CTDIvol	9.2 mGy
Sex	M

Postprocessing application
syngo Dual Energy Musculoskeletal



[A] Sagittal MPR image with color-coded tendons. Note the interruption of the extensor hallucis longus tendon.

[B] Axial MPR image. Note the color-coded flexor and extensor tendons and the absent first extensor.

[C] Volume-rendered image from a superior view showing the extensor tendons and the interrupted hallux tendon.

[D] VRT in a plantar view showing the flexor tendons.

Case 2 – Tendons of Hand and Wrist

T. R. C. Johnson, MD
Grosshadern University Hospital
Munich, Germany

History

A 45-year-old female patient was referred for diagnostic workup of chronic pain in the wrist six years after an intraarticular fracture of the radius.

Diagnosis

The SL joint space showed a triangular configuration, and the color-coding of the ligaments and tendons showed no signal in the area of the scapholunate interosseous ligaments. Rupture of the ligaments with scapholunar dissociation was suspected. Additionally, there was severe radiocarpal arthrosis with an uneven articular surface as remnant of the previous fracture. Joint space to os lunatum was noticeably narrowed.

Comments

Dual Energy makes it possible to visualize both bones and ligaments in a single exam. Although Dual Energy CT cannot replace MRI for a detailed evaluation, it can be useful to assess the presence and continuity of ligaments and tendons without additional radiation exposure. Considering that CT is mostly performed as primary modality to rule out fractures, this technique can help to route the further diagnostic workup.

Examination Protocol

Scanner	SOMATOM Definition
Scan area	wrist
Scan length	133 mm
Scan time	4 s
kV	140 kV and 80 kV
Effective mAs	38 mAs and 100 mAs
Rotation time	1.0 s
Slice collimation	64 x 0.6 mm
CTDIvol	9.1 mGy
Sex	F
Postprocessing application	
syngo Dual Energy Musculoskeletal	

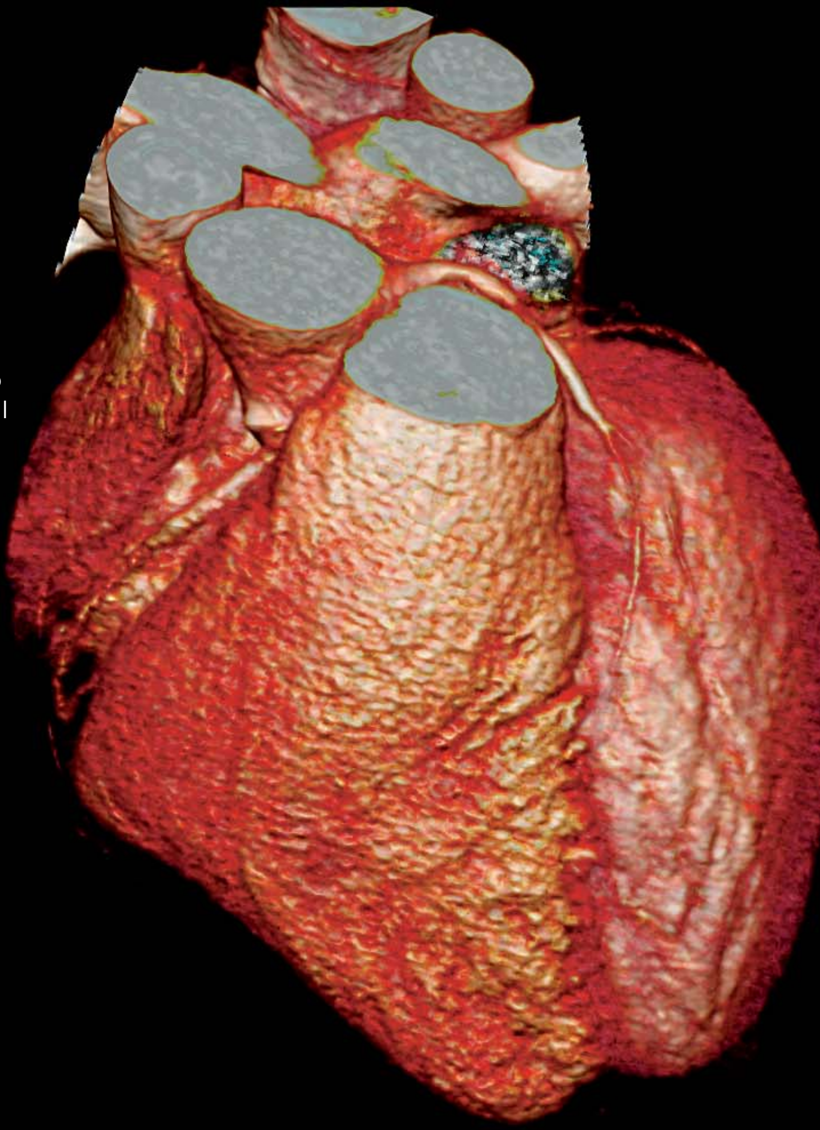
[A] + [B] Volume-rendered images showing the continuity of the flexor tendons.

[C] + [D] Color-coded reconstructions in coronal and sagittal orientation.

New Applications

Dual Energy CT is very young. As early as two years after the first dual energy applications were invented, they have been fully integrated in the DSCT system and provide clinically useful additional information without additional effort in daily clinical routine at many hospitals.

Additionally, Dual Energy CT has opened up a whole new field of research and science. Many academic centers worldwide work with this new technology and identify further clinical applications. As a manufacturer Siemens has taken this opportunity to integrate these new applications into the *syngo* Dual Energy software as fast as possible. Therefore, the group of postprocessing applications selectable in the menu of the software is growing continuously, and Siemens is proud to present several new and already FDA cleared application classes.

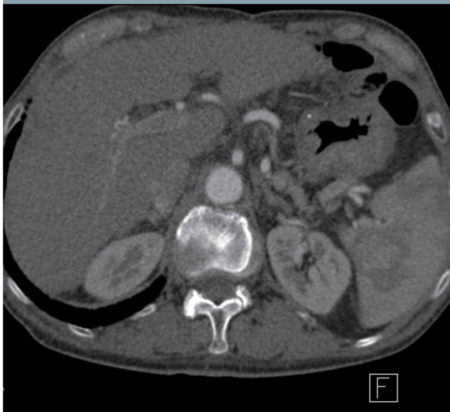


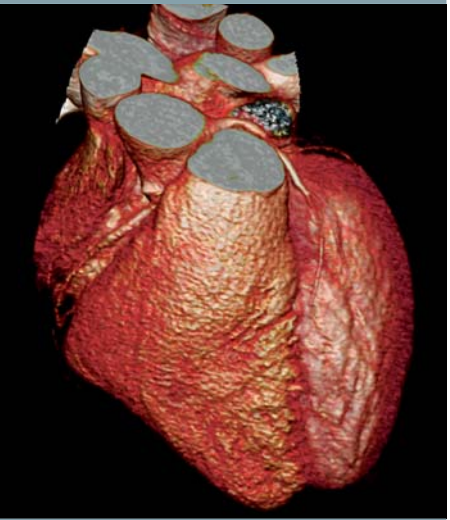
Optimum Contrast Blending

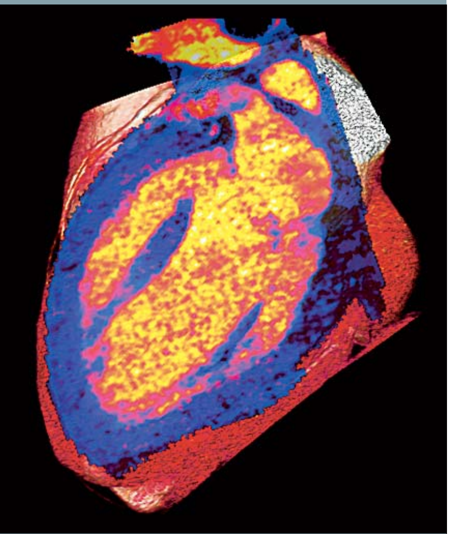
syngo Dual Energy Optimum Contrast

Dual Energy datasets usually consist of images obtained at 80 and 140 kVp. The different postprocessing algorithms exploit the spectral behavior of certain materials or tissues to identify or quantify them. Additionally, average images can be calculated to provide a ”normal” CT image with a low noise and normal attenuation properties, because the 140 kVp images lack contrast, while the 80 kVp images are very noisy. However, special, non-linear blending algorithms can provide a better image than mere averaging.

By adding more of the contrast information from the 80 kVp images in areas of homogeneous soft tissue, and more of the detail from the 140 kVp images in high-contrast areas such as lung or bone, an optimized image can be calculated. This image provides less noise and more contrast than linear average images.







Assessment of Myocardial Perfusion

syngo Dual Energy Heart PBV

With its high temporal resolution, Dual Source CT has greatly improved coronary CT angiography, because it is less sensitive to high heart rates or arrhythmia than other types of scanners. With Dual Energy CT, it is now possible to color-code iodine content to visualize organ perfusion.

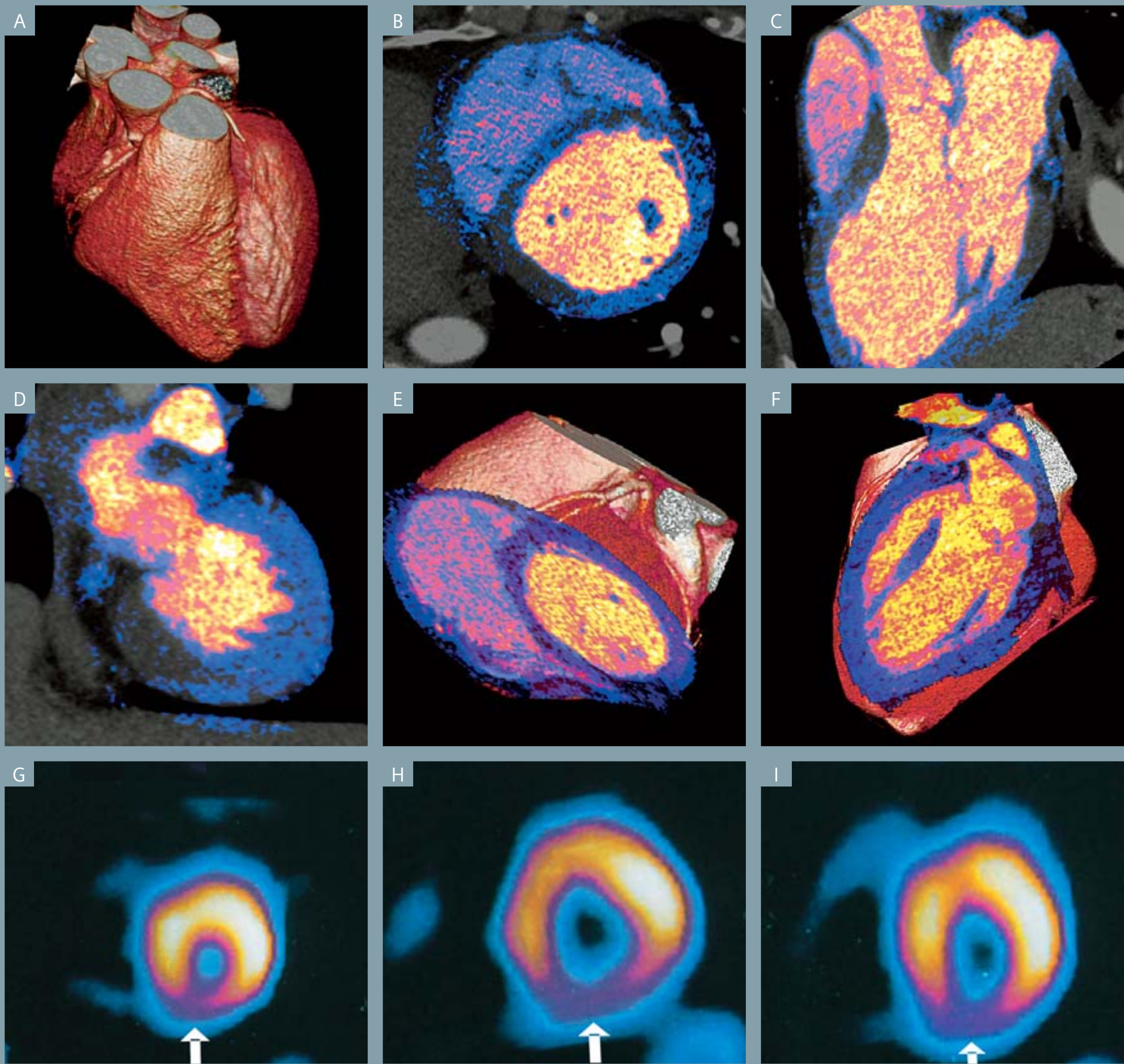
A new protocol now offers an ECG-gated dual energy scan to assess myocardial perfusion. The corresponding *syngo* Dual Energy Heart PBV software color-codes myocardial perfusion, so that both coronary artery morphology and myocardial perfusion can be assessed in a single CT scan.

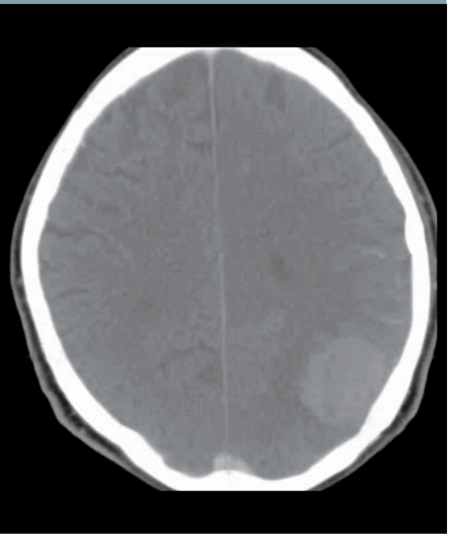
[A] Volume-rendered image of the heart scanned in dual energy technique.

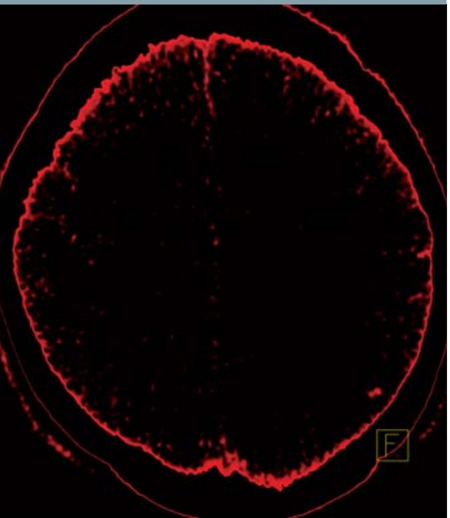
[B] – [D] MPRs with color-coded perfusion information in short axis, two chamber, and coronal orientation. Note the perfusion defect of the basal posterior left ventricular wall.

[E] + [F] Cut volume-rendered images showing the perfusion defect of the posterior wall in short and long axis.

[G] – [I] Short axis SPECT images in an apical, mid-ventricular, and basal plane confirming the posterior perfusion defect.





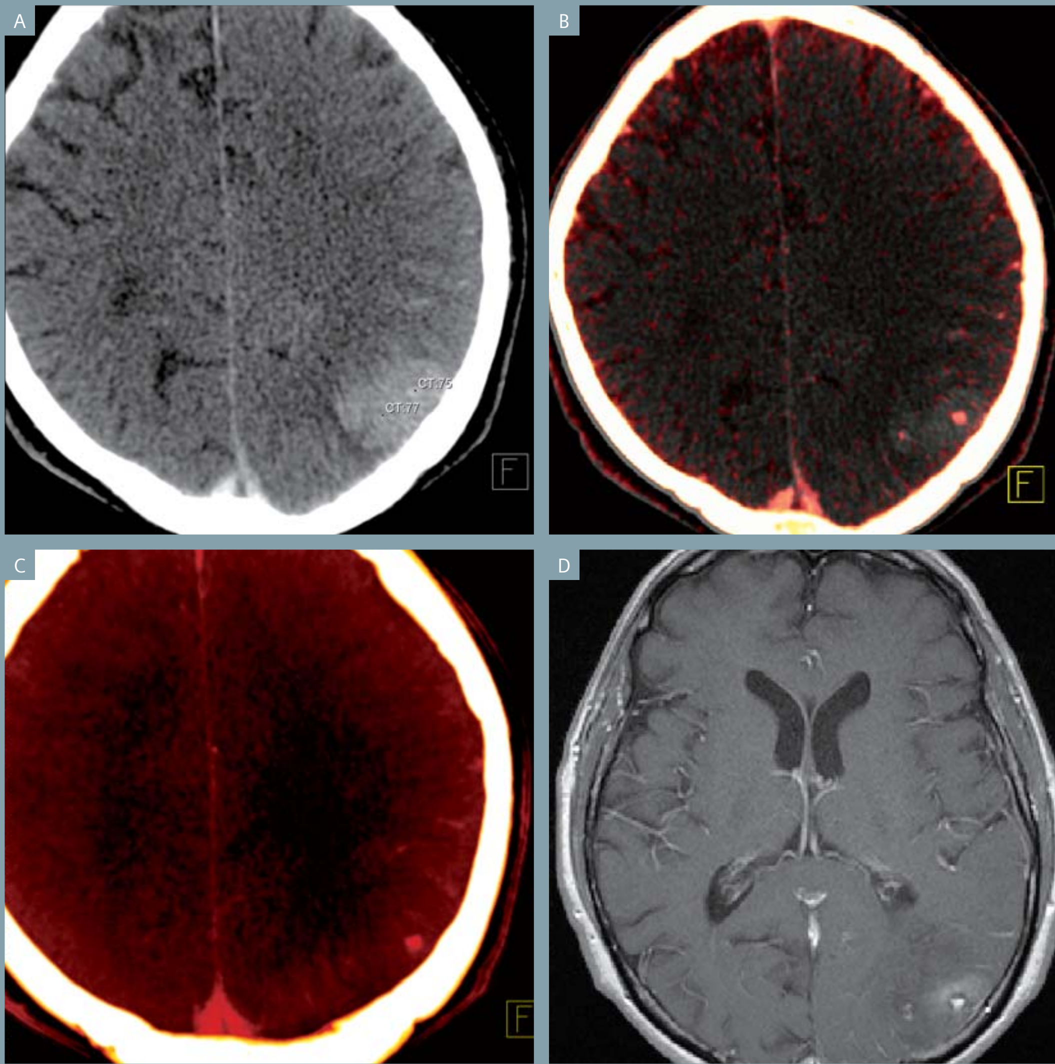


Differentiation of Brain Hemorrhage and Contrast Enhancement

syngo Dual Energy Brain Hemorrhage

A primary task of cranial CT is to rule out hemorrhage, and this is why an unenhanced scan is usually obtained even in other clinical questions in which a contrast-enhanced scan is necessary, for example to rule out neoplasms.

With *syngo* Dual Energy Brain Hemorrhage, a virtual non-contrast image can be generated from a contrast-enhanced dual energy scan. This application may make it possible to discard the pre-contrast scan in some instances.

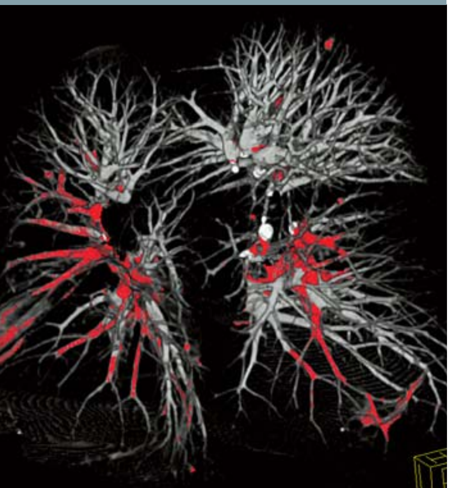


[A] The normal reconstruction of the contrast-enhanced Dual Energy CT scan shows a hyperdense area at the left parietal lobe, suggestive of subarachnoidal hemorrhage.

[B] The *syngo* Dual Energy Brain Hemorrhage application color-codes the center of the lesion to indicate iodine enhancement.

[C] The color-coding alone shows a distinct spot of enhancement.

[D] T1-weighted MRI after administration of gadolinium contrast confirms the central enhancement, either due to neoplastic tissue or active bleeding.

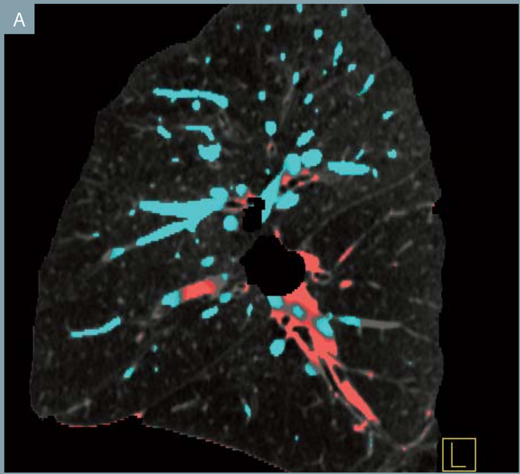


Detection of Pulmonary Embolism in Lung Vessels

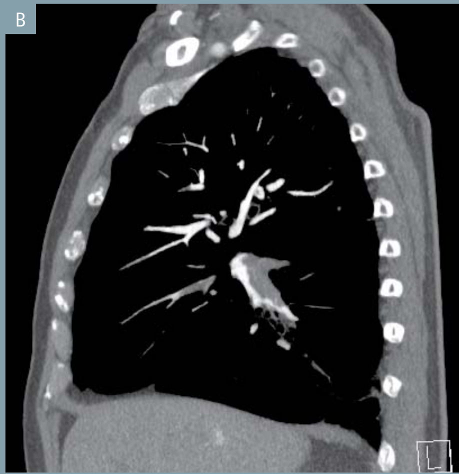
syngo Dual Energy Lung Vessels

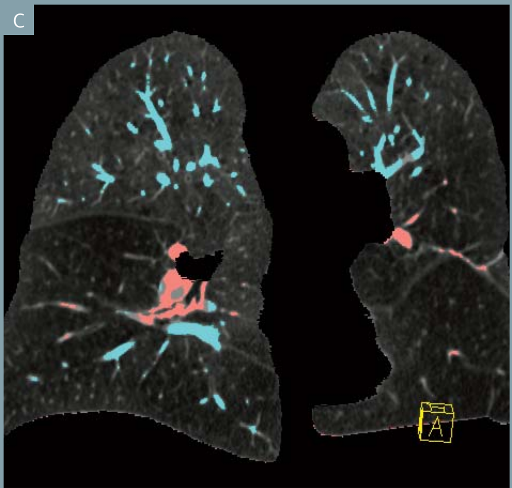
syngo Dual Energy Lung Vessels color-codes the iodine content of lung vessels. Vessels that are affected by pulmonary embolism and, therefore, show a significantly lower iodine concentration than non-affected vessels are assigned a different color than those with a high iodine content. With the color-coding, the affected vessels are much easier to identify. In this manner, Dual Energy CT can improve the sensitivity for pulmonary embolism by demonstrating perfusion defects in the parenchyma and additionally by highlighting affected arteries.

[A] Color-coded sagittal MPR of the right lung showing normally perfused vessels in turquoise and embolized vessels in red.

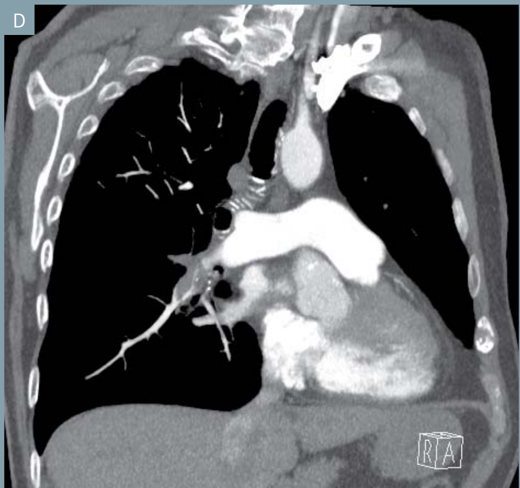


[B] Corresponding angiographic image reconstructed from the same scan. There is embolic material in the lower and middle lobe arteries.





[C] Color-coded coronal MPR showing embolism to both lower lobes.



[D] Angulated coronal angiographic image showing the emboli in the lower lobe arteries.

[E] Color-coded volume-rendered image of the pulmonary vessels demonstrating the emboli in the arteries.

Characterization of Gout Tophi

syngo Dual Energy Gout

The *syngo* Dual Energy Gout application visualizes deposits of uric acid crystals which are characteristic for gout tophi. Additionally, the application color-codes iodine enhancement so that tophi with active inflammatory changes can be differentiated from stable ones. This way, both the molecular cause and the activity of the disease can be shown in a single scan.

[A] Axial image of both feet showing massive deformities and calcified masses.

[B] The red color-coding confirms uric acid in the masses, identifying them as gout tophi.

Courtesy List

- ASAN Medical Center, Seoul, Korea
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