DUAL ENERGY CT APPLICATIONS FOR CHEST DISORDER

PULMONARY NODULES
NON-NEOPLASTIC DISEASES OF THE PLEURA,
CHEST WALL AND DIAPHRAGM
SYSTEMIC AND PULMONARY VASCULAR TECHNIQUE

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LEARNING OBJECTIVES AND OUTCOMES

**Learning Objectives:** To illustrate possible current applications of Dual-Energy CT (DECT) in thoracic abnormalities.

**Outcomes:** To familiarize the radiologists with DECT applications in chest disorders.
• Dual-energy CT (DECT) technique has permitted better material differentiation and tissue characterization compared to the traditional CT attenuation scale, modifying the noninvasive approach to chest disorders.
• Thoracic applications of DECT rely on the possibility to identify either contrast medium or specific tissue infiltration characterized by a high atomic number which cannot be precisely detected with single energy CT, providing both anatomic and functional information about the lungs
The most actively investigated principle of DECT is material decomposition based on attenuation differences at different energy levels. The use of perfusion imaging has been shown to improve the diagnosis of acute and chronic PEs, which is probably its most important current application.
The other major possibility offered by DECT is virtual monochromatic imaging that represents a new option for standard chest CT in daily routine. This technique is able to reduce the beam-hardening artifacts due to iodine contrast agent injection or metallic instrumentation. Other applications of this technique include evaluation of intra- and extracapsular silicone implant rupture.
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The more central the pulmonary artery clots are, easier is the detection.

However, in subsegmental arteries, the clots are less accurately located in multislice CT.

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35 year-old female presenting with endoluminal clots in pulmonary arteries of the posterior basal segment of the right lower lobe.

The iodine perfusion map clearly shows the corresponding segmental perfusion defect.
In this other patient, it is seen clots of acute PE in the right lower lobe artery with pulmonary infarction distally.

The typical triangular PE perfusion defect corresponds to the parenchymal abnormality area, characteristic for pulmonary infarction.
The images show a massive acute PE affecting main pulmonary arteries with signs of right ventricular overload: the ventricular septum is rectified and there is a slight enlargement in the diameter of the pulmonary artery trunk.
• Different map of colors can be used by the radiologist to depict the perfusion defects.

• The perfusion imaging may be used for prognostic assessment of acute PE. It has a good correlation between perfusion defect score, right / left ventricular diameter ratio and the angiographic obstruction score.
Multislice Pulmonary Angio-CT is the imaging exam of choice for evaluation of chronic PE. It may show the chronic findings of artery obstruction, but also signs of right ventricular overload and collateral systemic supply.

Dual-energy CT can bring new information using:

1) Low energy levels for a better analysis of small sized arteries.
2) Virtual non-contrast: detection of endovascular calcifications.
3) Perfusion imaging: show much more clearly the redistribution of blood flow in the lungs consequent to the PE, compared to the mosaic attenuation pattern that may be very subtle sometimes.
The mosaic attenuation may be very subtle or even absent, as seen in the coronal MinIP reformation.

The iodine mapping is a great tool to depicts the perfusion abnormalities, as in this case of chronic PE, with perfusion defects in the right lower lobe and left upper lobe.
Sagital reformations of the same patient depicts an endoluminal defect and narrowing of the segmentary anterior left upper lobe artery (arrows).

Perfusion shows the typical findings, triangular shaped defect in the corresponding area. Starting the evaluation by the iodine map may be very helpful to find the other signs of chronic PE.
56 year-old, male.
FIRST EXAM (04/11/2015): Right lower lobe artery occlusion with subpleural consolidations related to acute PE with pulmonary infarcts.
• Iodine perfusion map shows the perfusion defects in the right lower lobe.
SECOND EXAM (11/18/2015): Persistent endoluminal defects associated with narrowing of the arterial branches for both right and left posterior basal segments, suggesting chronic PE.
SECOND EXAM (11/18/2016)
The iodine map turns much more clear the persistent perfusion defects in posterior basal segment of both lower lobes.
It is worth to mention that the DECT perfusion has some limitations on its analysis for evaluation of PE:

1) Parenchymal abnormalities can create difficulties in the detection of typical PE defects
2) Airway diseases can create perfusion defects
3) Endoluminal clots not always cause complete arterial obstruction, therefore not always create perfusion defects.
In this case, the perfusion defects are due to ground glass opacities in posterior regions of the lungs, related to gravity-dependent atelectasis.

These opacities appear as perfusion defects in the iodine mapping and when extensive may impair its interpretation.
The right upper image is a curved reformation that shows small and linear endoluminal defects in the right lower lobe. However, the iodine map shows multiple perfusion defects. Those are corresponding to parenchymal areas of atelectasis and consolidations, impairing therefore the perfusion analysis.
The advent of DECT technique has offered the possibility of simultaneous assessment of the regional distribution of both parenchymal destruction and pulmonary perfusion in COPD patients.

- The perfusion quantitative information correlate with several lung functional parameters.
- This may be used to improve patient selection for lung volume reduction surgery (LVRS).
- LVRS may reduce mortality in patients with a low perfusion in upper-lobe predominant emphysema.
This patient has CPOD, with emphysema predominantly located in the upper lobes.

The coronal MIP reformatations show no endoluminal clots.
The perfusion defects matches with the emphysema areas and are well delineated at the iodine map.
Virtual monochromatic images can be generated within a spectral range of 40–190 keV for dual-source CT and 40–140 keV for single-source CT.

Image series with a lower kilovoltage have higher contrast (ie. closer to the k-edge of iodine) and more noise, as a result of lower energy.

High monochromatic images have less noise and fewer streak artifacts, but they also have lower image contrast, particularly on contrast-enhanced CT images.
The images show that by increasing the kilovoltages energies there is a reduction of the streak artifacts. This may be specially usefull in the evaluation of post procedures with mettalic matherials and that usually does not need iodine contrast. The procedure as in this case was for correction of scoliosis.
Mammary implants may complicate with intra or extra-capsular ruptures.

Siliconomas may form in these cases due to a granulomatous inflammatory reaction caused by the presence of foreign body (silicone) in the tissue.

It occurs most of the time adjacent to the mammary implants or in the axillary lymph nodes.

It does not have carcinogenic effect, but may present with enlarged lymph nodes that may mimic neoplastic implants, especially when located in atypical chains, as internal thoracic and supraclavicular.

Monochromatic DECT may be an option for the evaluation of enlarged lymph nodes in patients with mammary implants, as it can give information about the material composition.

It is easily acquired and doesn’t need iodine contrast.
57 years old female presented in the emergency room with chest pain and enlarged palpable left axillary lymph nodes. A chest CT was performed with DECT.

- Enlarged lymph nodes were seen in the left axillary, supraclavicular e internal thoracic chains.

- Low density components were seen in the interior portion of the left mammary implant, as well as a subtle retraction in the most inferior aspect of the implant, findings that could represent capsular rupture.
• The color map shows that the lymph nodes presents with the same color of the silicone implants, confirming the presence of silicone within the lymph nodes representing siliconomas.

• Silicone and soft tissues have different slopes in a plot of low-energy CT number versus high-energy CT number and therefore can be differentiated.
• Above in the left, the ultrasound of the lymph nodes in the axillary chains shows the classic snowstorm sign.

• The magnetic resonance is the imaging method of choice. Specific sequences can be used to evaluate the silicone, like STIR with water or silicone suppression. As above, in the right, the enlarged lymph nodes have the same signal intensity of the mammary implant.

The left image is the one from the presented case.

At the right, a DECT image from a male patient with suspicion of rupture of the left mammary implant. The enlarged lymph nodes were not related to siliconomas.
CONCLUSION

• Radiologists should be familiarized with the ongoing technological developments of DECT techniques, enhancing the utility of this application in clinical practice.
REFERENCES


Thank You!

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