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Dual Energy CT In Clinical Practice

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Abstract: **The release of modern dual-energy CT (DECT) scanners has allowed comparison content to be recognized at imaging without the need for an individual unenhanced scan. Images of lung parenchymal comparison improvement acquired using DECT improve the recognition of problems, boosting our ability to identify lung perfusion; however, with these developments new problems are also presented. In this graphic evaluation, we present the strategy, medical programs and causes and solutions of incorrect results of dual-energy lung parenchymal improvement problems in lung perfusion.**

Objective: To evaluate the feasibility and findings of combined dual-energy computed tomography (DECT) lung ventilation/perfusion imaging in patients with congenital heart disease. And to assess perfusion patterns on a dual-energy pulmonary CT angiography.

Material and Methods: In this study Medline (pubmed) literature review and analysis for previous studies that are discussing, roles of dual-energy CT (DECT) scanners in the daily practice such lung perfusion scans and the including criteria were involving for several randomized studies that concerning patients suffering from congenital heart diseases from different ages which different perfusion patterns.

Results: DECT lung perfusion. Normal pulmonary BFI images were defined as showing homogeneous perfusion in the normal range (color-coded yellow-green or blue) with dependent symmetric lung iodine distribution. Dependent lung perfusion at DECT refers to relatively low contrast enhancement in the central regions

Conclusion: Quantitative LPS is simple, safe and widely available. Several patterns of LPS are seen in patients with CHD. But the DECT method may be considered as an alternative test in some patients due to the accuracy of performing results.

Keywords: **modern dual-energy, using DECT, dual-energy.**

1. BACKGROUND

Dual-energy computed tomography (DECT) was first presented in 4 decades ago and allows for the difference of components depending on their X-ray attenuation at different tube voltage. Different providers have re-introduced DECT and recently the strategy has become medically feasible. DECT has been examined for a variety of body systems, however, lung imaging in particular dual-energy produced iodine charts have been the focus of several past studies. Dual-energy produced iodine charts allow the creation of parenchymal iodine submission in regards to a previously described check out wait, which might be considered as a surrogate of lung perfusion and has shown good connection in comparison to atomic medication centered picture modalities. Another method that allows an assessment of lung perfusion problems is powerful comparison improved attractive resonance picture. Pulmonary perfusion imaging is conventionally performed by lung scintigraphy using technetium-labeled albumin shares that are temporarily trapped in the pulmonary capillaries and this visualized pulmonary perfusion although per definition lung perfusion is a dynamic process of pulmonary blood flow over time. Imaging of the pulmonary capillary bed or blood volume is an accepted surrogate for lung perfusion.By visualizing the contrast agent distribution in the lung parenchyma. Spiral dual energy CT angiography (CTA) provides the opportunity to assess pulmonary vessels and pulmonary perfusion within one fast examination. There is already substantial evidence that Pulmonary CTA and the dual energy CT lung perfusion visualization have complimentary roles in the diagnosis of pulmonary embolism. A simultaneous detection of a clot in a pulmonary artery in the pulmonary CTA and of the perfusion defect in DECT lung perfusion in the corresponding lung segment indicates an occlusive PE. The high spatial resolution of CTA ideally allows visualization of the pulmonary arteries down to sixth order branches, as a consequence. multidetector CTA has emerged as the diagnostic PE in the past years and has replaced perfusion scintigraphy in most institutions. Several researches have analyzed DECT for the recognition of PE. Fink et al [Fink C, 2008] revealed that both understanding and uniqueness of DECT for the evaluation of PE were 100% on per individual foundation. On a per section foundation, the understanding and uniqueness varied from 60%–66.7% and from 99.5%–99.8%; CTPA was used in this study as the conventional of referrals in 24 sufferers with alleged PE, 4 of whom actually had PE. With scintigraphy as the conventional of referrals, Thieme et al [Thieme SF ,2008] revealed 75% understanding and 80% uniqueness on a per individual foundation and 83% understanding and 99% uniqueness on a per section foundation in a small number of of sufferers with DECT. A number of 117 sufferers were analyzed by Pontana et al [Pontana F, 2008] to examine the precision of DECT in the interpretation of perfusion problems in sufferers with serious PE, finishing that multiple information on the existence of endoluminal thrombus and bronchi perfusion incapacity can be acquired with DECT.

Techniques:

Recentgenerations of DCT sareableto acquire dual-energy data by applying two X-ray tubes and two corresponding detectors at different kVp and mA settings simultaneously in a dual-source CT (Siemens Healthcare), byultra-fast kVp switching in a single source CT (GE Healthcare) or by compartmentalization of detected X-ray photons into energy bins by the detectors of a single-source CT operating at constant kVp and mA settings (Philips Healthcare). The dual-source CT scanner is composed of two x-ray tubes and two corresponding detectors. The two acquisition systems are mounted on the rotating gantry with an angularoffset of 90°/95° withregardtotheirkilovoltage and milliamperagesettings. Fordual-energy CT acquisition, the tube voltage sareset at high energy (140 kVp) for tubeA and low energy (80 kVp) for tube B. The rapid kilo voltage switching technique from GE Healthcare uses a singlex-raysource. A generator electronically switches rapidly the tube energies from low energy (80 kVp) to high energy (140 kVp) and back again to acquiredual-energy images. Each exposure takes about 0.5 msec.

2. MATERIAL AND METHODS

In this study Medline (pubmed) literature review and analysis for previous studies that are discussing, roles of dual-energy CT (DECT) scanners in the daily practice such lung perfusion scans and the including criteria were involving for several randomized studies that concerning patients suffering from congenital heart diseases from different ages which different perfusion patterns. We based our study on this sample of patients but here in using dual –energy CT scans to see whether the visualization of the lung perfusion. And also the study was assessed by different sources and articles.

Evaluation of PE severity:

In patients with acute PE, rapid risk assessment is critical because high-risk patients may benefit from life-saving thrombolytic therapy or invasive therapies, including catheter-guided thrombosuction or thrombectomy [Dogan H, 2007]. Right heart strain (RHS) has been shown to be independently predictive of 30-day mortality. In addition to use as a CT marker of RHS, the ratio between the size of the right ventricle (RV) and left ventricle (LV) has demonstrated a significant positive correlation with severity of PE and mortality [Ghaye B, 2006]. Chae et al. [Chae EJ , 2010] and Zhang et al [Zhang LJ, 2099(Acta Radio)] reported good correlation between RV/LV diameter ratio with a novel self-defined dual energy perfusion score or the number of pulmonary segments with perfusion defects, respectively.

ContrastMediuminjectionprotocols:

High-concentrationiodine-basedcontrastmaterial is recommendedfor DECT scanstoimprovethedifferentiation of iodinebythedual-energypost-processingalgorithm. Asmentionedaboveinthesection of scanningprotocols, thoracic DECT scansshould be acquiredinthecaudo-cranialdirectionsothatthechaserbolus is being injectedbythetime

Contrastinjectionprotocol of dual-energypulmonary CT angiography:

	Iodineconcentration 300 mg I ml^{-1}	**Iodineconcentration 370 mg I ml^{-1}**
Contrastmediavolume (ml kg^{-1})	1.5	1.2
Contrastmedia flow rate (ml s^{-1})	4	4
Bolustiming	Bolustracking	Bolustracking
Bolustrackingthreshold (HU)	100	100
ROI position	Pulmonarytrunk	Pulmonarytrunk
Scandelay (s)	6	6
Salineflushvolume (ml)	40	40
Salineinjectionrate (ml s^{-1})	4	4
Needlesize (G)	18	18
Injection site	Antecubitalvein	Antecubitalvein

ROI, region-of-interest. Notethisdual-energyprotocol is for a Siemens Definition 64-slice CT scanner.

Image post-processing:

From the raw manage projector screen information of both pipes, pictures were instantly rebuilt to three individual image sets: 80 kVp, 140 kVp and regular calculated exclusive 120 kVp pictures with 80:140 kVp straight line weighting of 0.3 (i.e. 30% image details from the 80 kVp image and 70% details from the 140 kVp image). For each image set, the piece width was 0.75 mm and period was 0.50 mm. The only currently from the commercial perspective available program (syngo DE Bronchi PBV by Siemens HealthCare) for DECT lung perfusion image research is aspect of the double power post-processing program available for the Siemens syngo Multimodality Office. For the computation of iodine submission in the lung parenchyma, the program category is developed for iodine removal, and the content factors for iodine removal are as follows: -1,000 HU for air at 80 kVp, -1,000 Hounsfield device (HU) for air at 140 kVp, 60 HU for smooth cells at 80 kVp, 54 HU for smooth cells at 140 kVp, 2 for comparative comparison improvement, -960 HU for lowest value, -200~- 300 HU for highest possible value, and 4 for variety (Figure 1A).The lung parenchyma is shade written using greyish variety 16-bit or hot steel 16-bit shade programming (default setting) with different optionally available shade machines available. The program allows a multiplanes perspective of the lung parenchyma image. The program also allows customers to set a combining rate between a non-color-coded exclusive 120 kV dataset and color-coded lung parenchyma. This combining rate can be with complete confidence set between 0% displaying a structure image and 100% displaying a blood vessels circulation image (BFI) pictures where only the color-coded, segmented lung parenchyma is shown. Windowing performance for the unique and color-coded dataset, primarymeasurement tools, and a few dual-energy-specific measurements are also available. The fused images are obtained by mixing the anatomy image and BFI images with different ratios. The fused images are used for visualization of CT pulmonary angiography and the lung perfusion.

3. RESULTS AND DISCUSSION

It is very important to recognize the normal findings or artifacts at DECT lung perfusion. Normal pulmonary BFI images were defined as showing homogeneous perfusion in the normal range (color-coded yellow-green or blue) with dependent symmetric lung iodine distribution. Dependent lung perfusion at DECT refers to relatively low contrast enhancement in the central regions (color coded yellow-green) and relatively higher enhancement in the dorsal regions (color coded blue - black) with the patient in the supine position

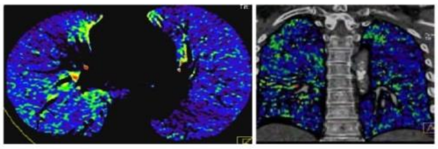
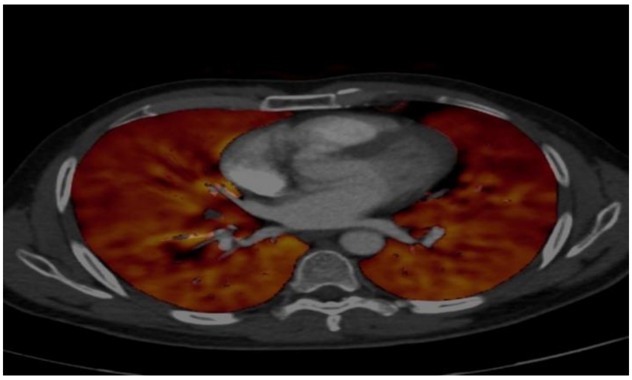


Image Analysis: Based on the clinical features and image findings, the patients were classified as:

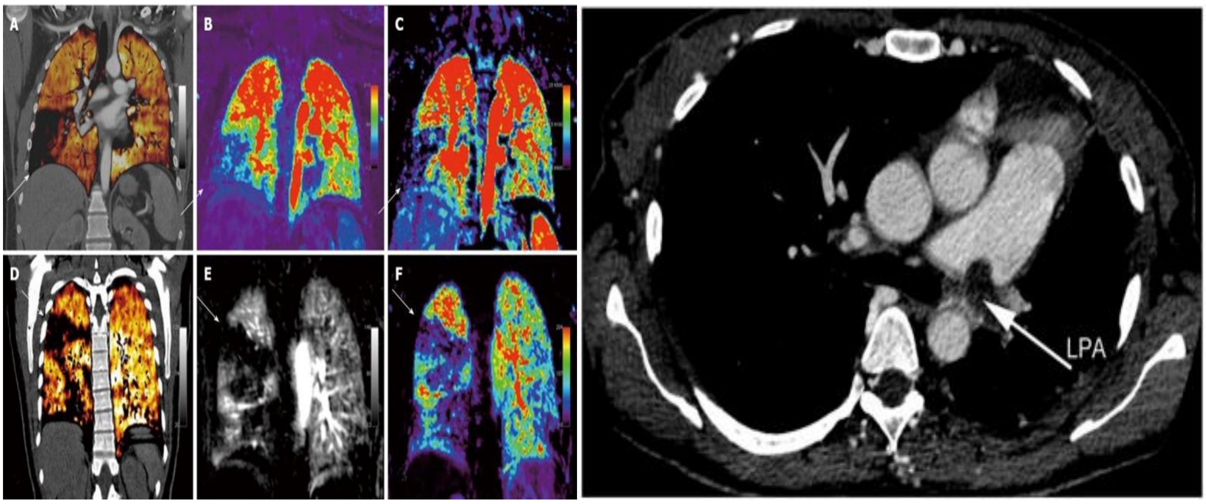
Normal perfusion lungs DECT scan:

In the following figurePatients with CHD with normal pulmonary artery have normal perfusion with essentially equal perfusion to both lungs through the DECT.



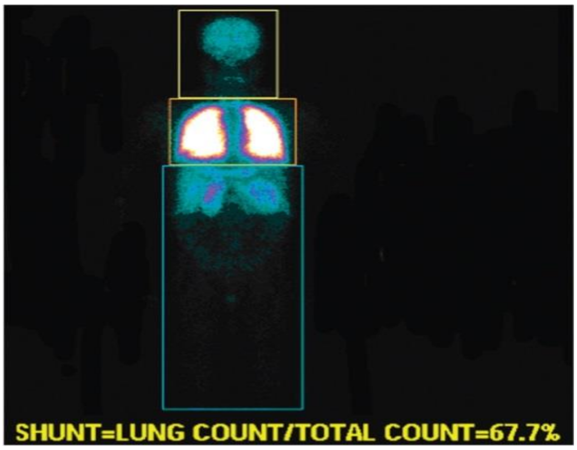
Unilateral absence of lung perfusion:

Unilateral lack of bronchi perfusion is seen in patients with genetic lack of lung artery, where in the ipsilateral bronchi perfusion happens through collaterals from bronchial blood vessels that cannot be evaluated by bronchi perfusion except in patients with performing right to remaining shunt, here Total absence of the left lung perfusion in a 35-year-old female with severe pulmonary hypertension. Pulmonary computed tomography angiography (CTA) reveals complete occlusion of LPA with thrombus and next to it a 7-year-old female with the left lung contributes to 33% and the right lung contributes to 67% of the total lung function



Right to left shunt:

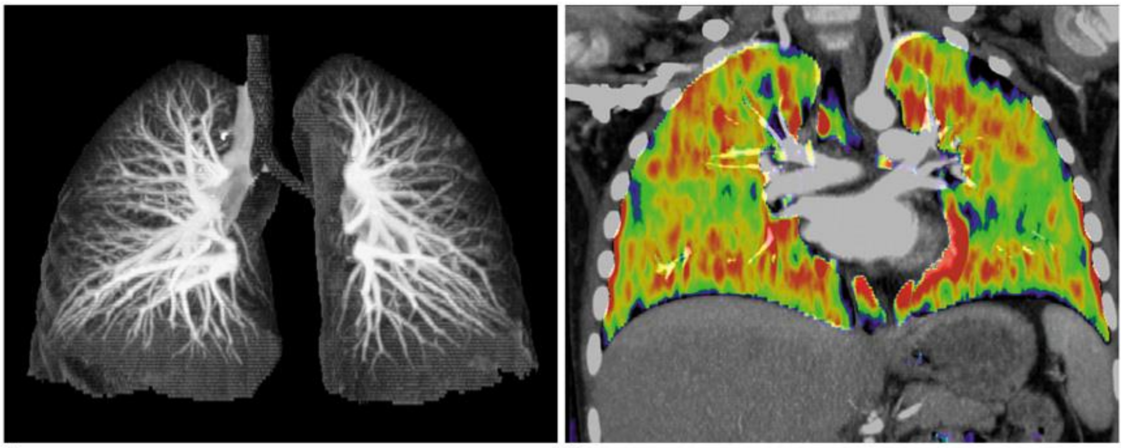
Where there is a right to left shunt, some of the MAA escape from the pulmonary circulation and lodge in the systemic capillaries. By estimating the counts in the lungs and in the systemic circulation, it is possible, after an intravenous injection of MAA, to estimate the size of the right to left shunt. Presence of aortopulmonary collaterals blood vessels (APCs) may cause significant systemic to pulmonary shunt.



Right to left shunt in a 10-year-old female with ASD and VSD To quantify right to left shunt, region of interests were drawn around the entire body and around the lung. Right to left shunt is determined by subtracting the count in the pulmonary region from the whole body region. In this case, the right to left shunt was 32%

Multiple segmental perfusion abnormalities (Pulmonary embolism):

Thrombosis and thromboembolism can be an important cause of deaths and death rate after Fontan function. The possible risks that may promote thrombosis in sufferers with CHD consist of low circulation state. Perfusion defects that are consistent with acute PE include those that are peripherally located, wedge-shaped, and in a segmental or lobar distribution. All other perfusion defects, such as patchy or band-like defects without segmental distribution, or complete loss of color-coding (indicating lack of air-containing voxels due to consolidation), were considered to be inconsistent with PE. For the Lung Vessels application, while color-coded red soft tissue around PAs was discarded.



A B

Chronic PE:

DECT pulmonary angiography can also allow for the depiction of perfusion defects in patients with chronic PE or patients with chronic thrombembolic pulmonary hypertension (CTEPH). A typical imaging characteristic of chronic PE can be mosaic patterns of lung attenuation, that is, areas of ground-glass attenuation mixed with areas of normal lung attenuation, suggesting a redistribution of blood flow.These perfusion defects in BFI beyond chronic clots, similar to what is achievable for acute PE, and these changes closely mirror the mosaic attenuation pattern which is very suggestive of blood flow redistribution in CTEPH. Mosaic attenuation can sometimes be subtle, and BFI appears to accentuate regional differences in parenchymal attenuation, which become very conspicuous when displayed as a color map. In CTEPH, DECT can identify matched defects (i.e., occluded pulmonary arteries to lobe and negligible residual blood flow), mismatched defects (i.e., occluded lobar artery and demonstrable residual blood flow), and normal lung regions (i.e., unobstructed pulmonary arteries with demonstrable normal or increased flow). Perhaps of most interest are areas of mismatch where there is blood supply maintained beyond the occluded pulmonary arteries.

4. CONCLUSION

DECT can provide both anatomical and iodine mapping information of the whole lungs in a single contrast-enhanced CT scans. After recognition of some artifacts in DECT pulmonary angiography, this technology has the capacity to improve the detection and severity evaluation of acute and chronic PE through comprehensive analysis of BFI and CT pulmonary angiography obtained during a single contrast-enhanced chest CT scan in a dual-energy mode. DECT pulmonary angiography can be used as a one-stop-shop technique for the evaluation of PE.DECT with different dual energy CT hardware (dual source CT and rapid kV switching technique) became available to simultaneously provide the functional and morphological information, overcoming the limitations of the above-mentioned CTperfusion techniques. Iodine, shows a proportionally larger increase of CT values with decreasing X-ray tube voltage compared to other materials, e.g., to soft tissue, iodinated contrast medium enhanced DECT provides the opportunity to assess pulmonary parenchyma iodine maps (i.e., lung perfusion). Compared with the previously developed CT perfusion techniques, DECT technique eliminates registration problems and allows selective visualization of iodine distribution with high spatial resolution and no additional radiation exposure to the patient compared with the conventional CT pulmonary angiography technique.

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