Radiology Case Reports 15 (2020) 966–969

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/radcr

Case Report

Preoperative assessment of lung nodules and lobar function by spectral detector computed tomography ☆,☆☆

Amit Gupta, MD[a], *Elias George Kikano, MD*[a,*], *Aekta Gupta, MD*[a], *Christopher Di Felice, MD*[b], *Robert Gilkeson, MD*[a], *Kai Roman Laukamp, MD*[a,c]

[a] *Department of Radiology, University Hospitals Cleveland Medical Center/Case Western Reserve University, 11100 Euclid Ave, Cleveland, OH 44106, USA*

[b] *Department of Pulmonary, Critical Care and Sleep Medicine, University Hospitals Cleveland Medical Center/Case Western Reserve University, Cleveland, OH, USA*

[c] *Institute for Diagnostic and Interventional Radiology, University Hospital Cologne, Cologne, Germany*

ARTICLE INFO

Article history:
Received 14 March 2020
Accepted 20 April 2020

Keywords:
Dual energy CT
Spectral detector CT
Pulmonary nodules
Presurgical planning

ABSTRACT

Conventional computed tomography (CT) plays an important role in detection of lung nodules. However, further characterization is usually limited requiring additional imaging and invasive work up. Spectral Detector CT (SDCT) is an upcoming novel modality that not only allows morphological evaluation but also provides insight into prediction of malignant behavior of lung nodules. Additional quantification capabilities available from the same scan make it a more comprehensive imaging option in oncology patients. This is a first case report demonstrating the potential of single SDCT to provide necessary information for lung cancer diagnosis and preoperative planning, comparable to standard of care imaging.

Introduction

Lung cancer is one of the most common malignancies in the world with a high mortality rate. However, accurate imaging diagnosis remains challenging as there is considerable overlap in the appearances of malignant and benign pulmonary nodules on routine computed tomography (CT) examinations, frequently requiring costly work up and invasive tissue sampling for final diagnosis [1]. Additionally, poor respiratory function may interfere with the surgical treatment of lung cancer, which warrants preoperative lung function evaluation and additional imaging [2].

We report a case of incidental pulmonary nodules which appeared similar on conventional CT images but demonstrated completely different characteristics on iodine density

☆ This work has not been presented at any meeting.

☆☆ Disclosures: Robert Gilkeson, MD discloses research support from Philips Medical, General Electric, Siemens and consultant for Riverain Medical and Heartflow. Rest of the authors have nothing to disclose.

* Corresponding author.
E-mail address: egk8@case.edu (E.G. Kikano).

https://doi.org/10.1016/j.radcr.2020.04.049

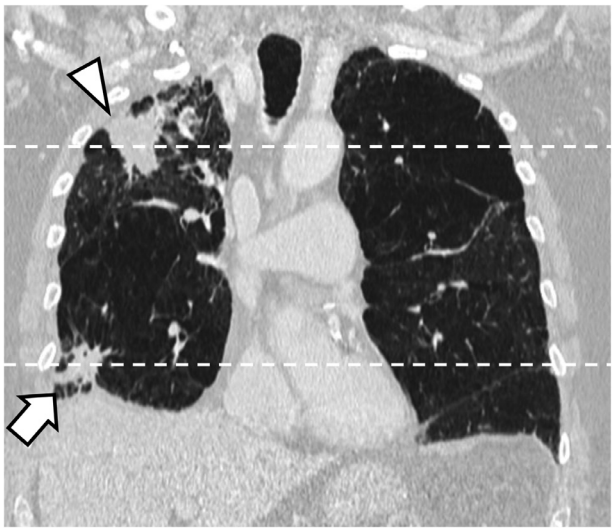


Fig. 1 – Coronal CT in lung window setting shows pulmonary nodules in right middle (Arrow) and right upper lobes (Arrowhead) which based on size and morphology appear similar and suspicious for malignancy.

maps from dual energy spectral detector CT (SDCT). Additionally, pulmonary function estimation from the same examination was also performed with comparable results to the radionuclide imaging standard.

Case report

A 73-year-old male with a 50-pack-per-year smoking history, hypertension, and hyperlipidemia was found to have 2 suspicious right lung nodules on an outside hospital screening CT scan. For confirmation and further evaluation, a repeat diagnostic contrast enhanced CT of the chest was performed which confirmed 2 nodules suspicious for malignancy on conventional images in the right upper and middle lobes (Fig. 1). Since scan was done on SDCT, iodine density maps were available. These showed a pronounced uptake of iodine in right middle lobe nodule (2.5 mg/mL, Fig. 1), suspicious for malignancy, and insignificant uptake in the right upper lobe nodule (0.5 mg/mL, Fig. 2), favoring benign etiology.

Subsequent work up with positron-emission tomography/CT, CT guided biopsy, and endobronchial ultrasound and biopsy confirmed the right middle lobe nodule as poorly differentiated squamous cell cancer (T2aN0M0) while the right upper lobe nodule was consistent with a benign necrotizing granuloma. These findings were congruent with SDCT findings.

Because of severe emphysema identified on CT and poor lung function (FEV1: 42%, DLCO: 22%), the patient underwent SPECT (single photon emission computed tomography)/CT for further estimation of lobar function. This revealed several perfusion deficits, corresponding to emphysema, that matched the SDCT iodine density maps (Fig. 3A and 3B). Further, a quantitative analysis (Fig. 3C) with dedicated software (MIM Software - Version 6.7; MIM Software Inc., Cleveland, OH, USA) showed similar perfusion distribution between iodine density

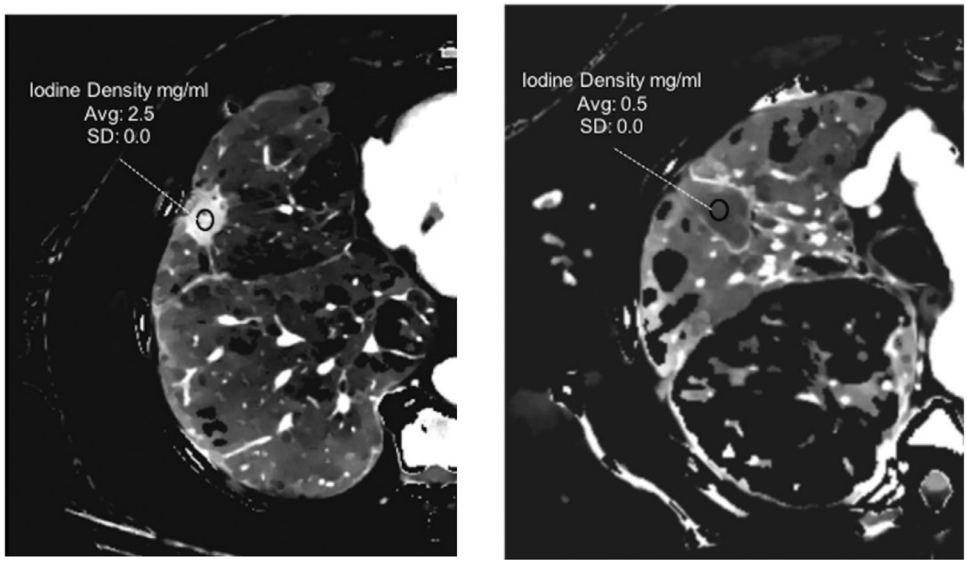
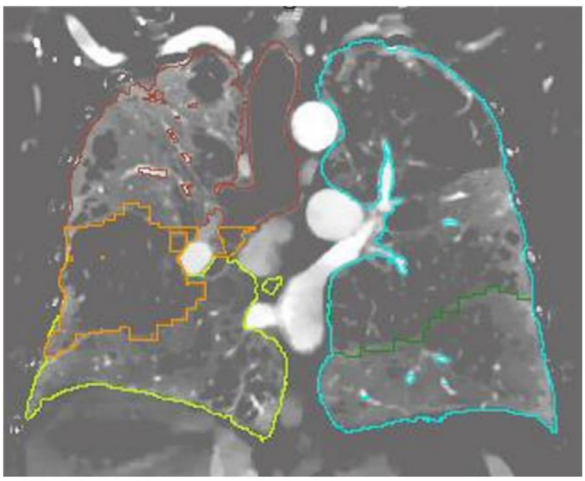
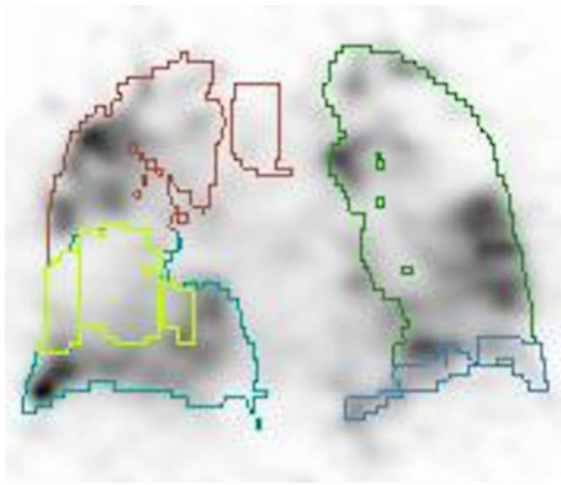


Fig. 2 – Axial iodine density map (A) shows that the right middle lobe nodule has pronounced iodine uptake as compared to normal lung parenchyma, and further quantification reveals iodine density of 2.5 mg/ml within nodule, which points towards possible malignancy. Biopsy confirmed poorly differentiated squamous cell carcinoma. In contradistinction, the right upper lobe nodule has negligible iodine uptake (B), less than adjacent normal lung parenchyma with quantification revealing very low iodine density of 0.5 mg/ml with the nodule, pointing towards possible benign etiology. Biopsy confirmed presence of a necrotizing granuloma.



A



B

	Iodine density Map perfusion results		SPECT/CT imaging perfusion results	
(% Ratios)	Left lung	Right lung	Left lung	Right lung
Upper lobe	18%	12%	17%	7%
Middle lobe		6%		7%
Lower lobe	32%	32%	34%	35%
Total	50%	50%	51%	49%

C

Fig. 3 – Iodine density maps (A) and SPECT images (B) show qualitatively comparable perfusion deficits in bilateral lungs, although with better inherent image resolution of iodine density map. On quantitative analysis (C), iodine maps show an almost identical lobar perfusion distribution compared to the SPECT acquisition, implying that iodine maps can be used for assessment of lung function prior to lung resection and thus obviate need for additional SPECT/CT imaging.

maps and SPECT/CT (Iodine Density Map/SPECT: left-upper lobe 18/17%, left lower lobe 32/34%, right upper lobe 12/7%, right middle lobe 6/7%, right lower lobe 32/35%).

Ultimately, the patient was deemed medically inoperable based on these results combined with other medical comorbities and underwent radiation therapy to the right middle lobe nodule which demonstrated positive response on subsequent follow-up imaging.

Discussion

Lung nodules are commonly found incidentally on routine conventional chest CT scans with reported detection rates up to 51%. However, the majority are benign and only 20%-30% are malignant. Those that are malignant are mainly early stage lung cancers amenable to surgical resection with high 5-year survival rates. Therefore, distinction between benign and malignant lesions is important and generally requires additional work up, including but not limited to PET/CT and/or invasive biopsy [1]. Also, it is understood that in surgically amenable cases, there is risk of perioperative complication and long-term disability after pulmonary resection secondary to poor lung function, most commonly due to coexistent chronic obstructive pulmonary disease [3]. This necessitates preoperative lung function estimation which may be established radiologically by techniques such as quantitative radionuclide perfusion scan (SPECT/CT), the recommended standard examination in recent guidelines [4].

SDCT is a novel dual energy imaging technology that, unlike the conventional CT, is equipped with a dual-layer detector. This allows for separate registration of low-energy and high-energy photons enabling material decomposition and reconstruction of various spectral images, including iodine density maps [5]. These iodine density maps depict distribution of iodinated contrast media, which is a surrogate for organ perfusion and function, and allows quantification of lung function comparable to SPECT/CT, as in our case. This benefit has been already explored in cancer patients undergoing radiation therapy [6,7]. While pulmonary nodule enhancement is not always specific for malignancy over benign pathology, early studies with SDCT iodine density maps have proven reliable for nodule characterization and degree of histopathological differentiation [8–10]. Therefore, all the information starting from increased detection of lung cancer to estimation of lung function can be derived from a single imaging examination.

Conclusion

This case highlights the utility of a single SDCT scan for evaluation of patients with suspicious lung lesions. It is comparable to other diagnostic modalities for nodule characterization and lung perfusion/function prior to lung surgery planning. Thus, SDCT has the potential to obviate need of additional diagnostic exams reducing patient radiation exposure and health care costs.

Electronic Supplement 1

A clinical spectral-detector CT (IQon, Philips Healthcare, Cleveland, Ohio, USA) was used for acquisition. The patient was scanned in head-first, supine position. 120 ml of iodinated contrast media as injected in a brachial vein (Optiray, 350, Guerbet, Bloomington, IN, USA). Tube voltage was set to 120 kVp and automated tube current modulation was used (DoseRight 3D-DOM, Philips Healthcare, Best, The Netherlands) resulting in a DLP of 603 mGy x cm. The other scan parameters were set as follows: collimation 64 × 0.625 mm, rotation time 0.4 s, pitch 1.02, matrix 512 × 512, slice thickness 3 mm.

REFERENCES

[1] Wu L, Cao G, Zhao L, Tang K, Lin J, Miao S, et al. Spectral CT analysis of solitary pulmonary nodules for differentiating malignancy from benignancy: the value of iodine concentration spatial distribution difference. Biomed Res Int 2018;2018:4830659.

[2] Chae EJ, Kim N, Seo JB, Park JY, Song JW, Lee HJ, et al. Prediction of postoperative lung function in patients undergoing lung resection: dual-energy perfusion computed tomography versus perfusion scintigraphy. Investigat Radiol 2013;48(8):622–7.

[3] Choe J, Lee SM, Chae EJ, Lee SM, Kim YH, Kim N, et al. Evaluation of postoperative lung volume and perfusion changes by dual-energy computed tomography in patients with lung cancer. Eur J Radiol 2017;90:166–73.

[4] Brunelli A, Kim AW, Berger KI, Addrizzo-Harris DJ. Physiologic evaluation of the patient with lung cancer being considered for resectional surgery: diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines. Chest 2013;143(5 Suppl):e166S–e190S.

[5] McCollough CH, Leng S, Yu L, Fletcher JG. Dual- and multi-energy CT: principles, technical approaches, and clinical applications. Radiology 2015;276(3):637–53.

[6] Bahig H, Campeau MP, Lapointe A, Bedwani S, Roberge D, de Guise J, et al. Phase 1-2 study of dual-energy computed tomography for assessment of pulmonary function in radiation therapy planning. Int J Radiat Oncol Biol Phys 2017;99(2):334–43.

[7] Lapointe A, Bahig H, Blais D, Bouchard H, Filion E, Carrier JF, et al. Assessing lung function using contrast-enhanced dual-energy computed tomography for potential applications in radiation therapy. Med Phys 2017;44(10):5260–9.

[8] Lin LY, Zhang Y, Suo ST, Zhang F, Cheng JJ, Wu HW. Correlation between dual-energy spectral CT imaging parameters and pathological grades of non-small cell lung cancer. Clin Radiol 2018;73(4):412.e1–412.e7.

[9] Christensen JA, Nathan MA, Mullan BP, Hartman TE, Swensen SJ, Lowe VJ. Characterization of the solitary pulmonary nodule: 18F-FDG PET versus nodule-enhancement CT. AJR Am J Roentgenol 2006;187(5):1361–7.

[10] Swensen SJ, Viggiano RW, Midthun DE, Muller NL, Sherrick A, Yamashita K, et al. Lung nodule enhancement at CT: multicenter study. Radiology 2000;214(1):73–80.