Hong Kong J Radiol. 2018;21:271-3 | DOI: 10.12809/hkjr1816862

CASE REPORT

Ultra-low-dose Computed Tomography in Management of Pulmonary Abscess Caused by Cystic Fibrosis

R Nandurkar[1], KK Lau[2]

[1]*Department of Diagnostic Imaging, Monash Health, Melbourne, Australia*
[2]*Faculty of Medicine, Nursing and Health Sciences, Monash University, Melbourne, Australia*

ABSTRACT

Pulmonary abscess is a complication of cystic fibrosis. Model-based iterative reconstruction is a reconstructive algorithm that can substantially reduce the radiation dose of computed tomography to that of radiography while maintaining diagnostic quality. This study reports the use of ultra-low-dose computed tomography with model-based iterative reconstruction in monitoring resolution of a pulmonary abscess caused by cystic fibrosis.

Key Words: *Cystic fibrosis; Lung abscess; Tomography, X-ray computed*

中文摘要

超低劑量電腦斷層掃描管理囊性纖維化引起的肺膿腫

R Nandurkar、劉國斌

肺膿腫是囊性纖維化的併發症。基於模型的迭代重建（MBIR）算法可以顯著降低電腦斷層掃描（CT）的輻射劑量且同時保持診斷質量。本文報導超低劑量CT與MBIR在監測囊性纖維化引起的肺膿腫消退中的使用。

INTRODUCTION

Cystic fibrosis is an autosomal recessive disease that is characterised by chronic obstructive lung disease with bronchiectasis and pancreatic insufficiency.[1,2] The obstructive lung disease is secondary to mucous plugging of the airways, which is caused by a change in the tenacity and viscosity of mucus production by the epithelial surfaces.[1] Patients with cystic fibrosis sustain frequent infective exacerbations, which are usually complicated by lung abscess. Despite the use of antibiotics, lung abscess results in high morbidity and 15% to 20% mortality.[3]

CASE REPORT

In February 2013, a 36-year-old woman with a history of cystic fibrosis presented with cough, dyspnoea, and fever. Physical examination demonstrated generalised crepitation on auscultation. Her white cell count and C-reactive protein level were elevated to 17.6 (reference range, 4.5-11.0) × 10^9/L and 330 (reference range, 0-80) mg/L, respectively. A diagnosis of infective exacerbation of cystic fibrosis was made.

Initial chest radiograph revealed generalised bronchiectasis and scarring (in keeping with cystic

Correspondence: Dr R Nandurkar, Department of Diagnostic Imaging, Monash Health, Melbourne, Victoria, Australia.
Email: rohannandurkar95@gmail.com

Submitted: 20 Feb 2017; Accepted: 7 Apr 2017.

Disclosure of Conflicts of Interest: All authors have disclosed no conflicts of interest.

fibrosis) and an area of consolidation in the left lower lobe with a probable cavity (Figure 1). Ultra-low-dose computed tomography (CT) with scanning parameters of 100 kVp, 10 mA, 0.625-mm collimation, and 0.4-s rotation revealed a thick-walled pulmonary abscess with central cavitation within the area of consolidation in the left lower lobe (Figure 2). The CT images were reconstructed using model-based iterative reconstruction (MBIR). The radiation dose was 0.065 mSv, which is comparable to that of chest radiography.

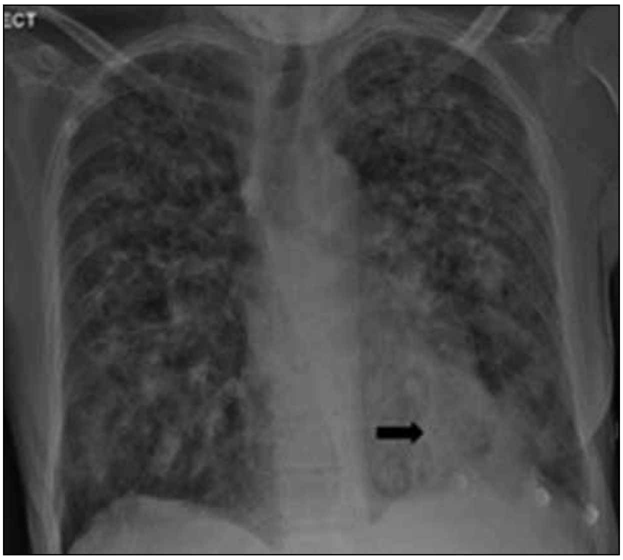

Figure 1. Chest radiograph showing diffuse bronchiectasis and scarring (in keeping with cystic fibrosis) and an area of consolidation near the left lung base with a probable cavity (arrow).

Follow-up with ultra-low-dose CT at 2 weeks, 1 month, and 3 months showed gradual improvement and resolution of the pulmonary abscess (Figure 3), which would not be easily appreciated on plain radiography due to the severe degree of overlying chronic lung changes.

DISCUSSION

Chest radiography is often the initial investigation tool of choice to evaluate patients with cystic fibrosis. Nonetheless, CT is superior to radiography in detecting and characterising lung diseases and pleural pathology, and is a valuable tool for monitoring disease progression.[4-7] CT is more sensitive than radiography for detection of pulmonary infection (89% vs. 58%).[5] In an emergency setting, only 43.5% of patients with pulmonary opacities detected on CT were also detected on radiography.[6] Nonetheless, CT has higher radiation exposure than radiography (7.00 vs. 0.05 mSv); the appropriateness of CT as a diagnostic and monitoring tool should be determined on a case-by-case basis.[7]

In low-dose CT, radiation exposure is reduced by reducing tube currents and tube voltage and increasing table pitch, although image noise is increased and affects the diagnostic efficacy.[8]

Filtered back projection is the traditional CT image reconstruction algorithm that relies on mathematical assumptions of X-ray beam attenuations from different angles. It limits the effect of dose reduction, as CT images are not consistently produced if the tube current

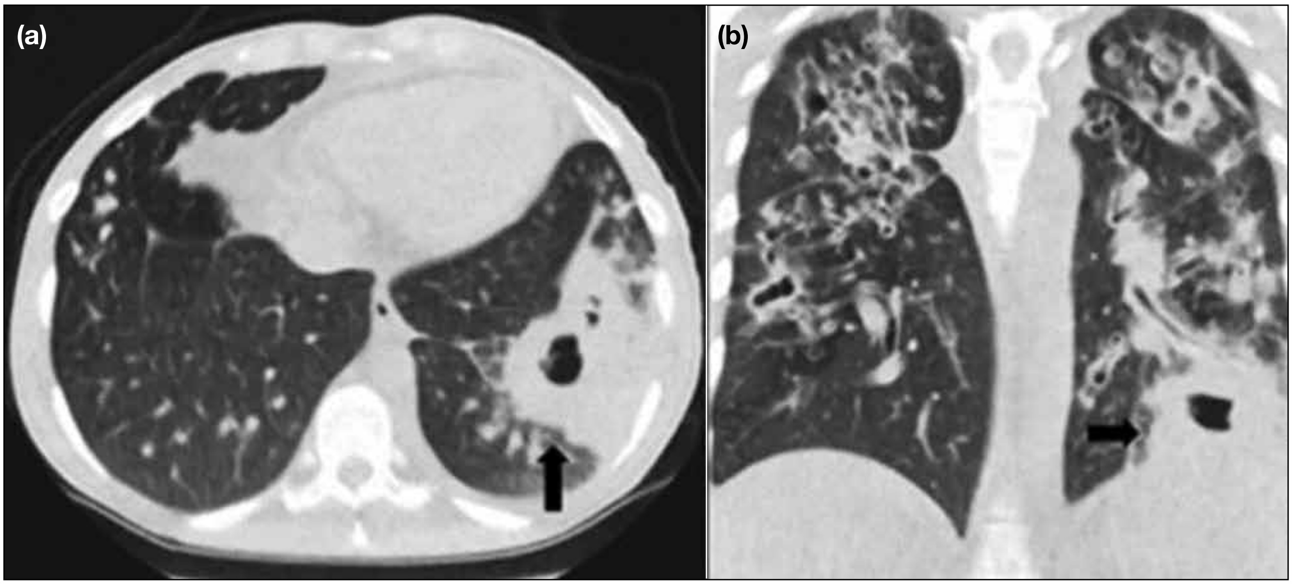

Figure 2. Ultra-low-dose computed tomography using model-based iterative construction showing a pulmonary abscess measuring 2.2 × 3.1 cm in the left lower lobe (arrows) with a central cavity.

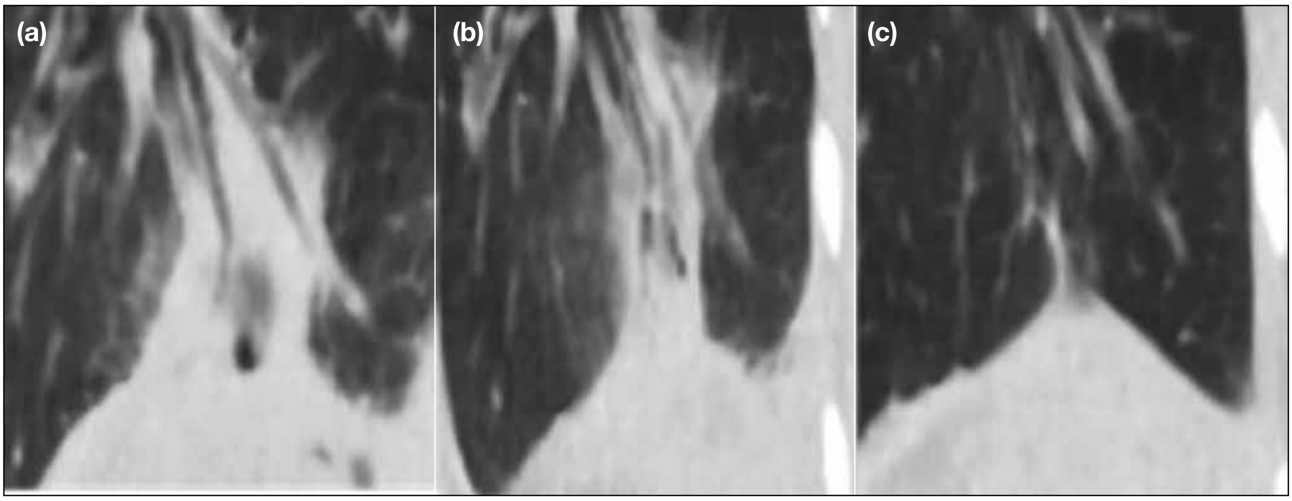

Figure 3. Ultra-low-dose computed tomography in coronal reformats showing gradual improvement of resolution of the left lower lobe abscess at (a) 2 weeks, (b) 1 month, and (c) 3 months.

is substantially reduced.[9] On the contrary, iterative reconstruction techniques repeatedly iterate the image reconstruction to better estimate these mathematic assumptions and therefore produce images with lower noise.[10] Iterative reconstruction algorithms consist of three key components. First, artificial object data are created from a volumetric object estimate. Second, the estimated data are then compared with the actual data. Third, the difference between the two data sets is projected back on to the volumetric object estimate for further correction.[11] This cycle is repeated until the difference between the estimated and measured data sets is within an acceptable range.[12] Compared with traditional CT, low-dose CT with iterative construction is nearly identical in terms of overall image quality and low-contrast resolution, with radiation dose reduction of 32% to 65%.[9]

MBIR uses a more complex system of prediction models. It accounts for the optics of the scanner (including focal spot and detector size) and the noise of the system (photons statistics and electronic noise).[13] Image quality of CT reconstructed with MBIR can remain diagnostic, even though the radiation dose is markedly reduced.[14] Nonetheless, MBIR is computationally expensive and needs a high level of optimisation to achieve its intended performance.[12] It requires a long reconstruction time (30-45 minutes for a single dataset).[10] Future technological advancements may help to overcome these limitations.

Ultra-low-dose CT with MBIR can produce diagnostic-quality images with a radiation level comparable to chest radiograph. It may become a diagnostic tool for cystic fibrosis patients when future technological advancements can shorten the long computational time.

REFERENCES

1. Park SH, Lee HJ, Kim JH, Park CH. Cystic fibrosis: case report. J Korean Radiol Soc. 2002;47:693-6. Crossref
2. Evans DA, Fiedler MA. Lung abscess in a patient with cystic fibrosis: case report and review of the literature. Pediatr Pulmonol. 1996;21:337-40. Crossref
3. Hirshberg B, Sklair-Levi M, Nir-Paz R, Ben-Sira L, Krivoruk V, Kramer MR. Factors predicting mortality of patients with lung abscess. Chest. 1999;115:746-50. Crossref
4. Sequeiros IM, Jarad NA. Radiological features of cystic fibrosis. In: Sriramulu D, editor. Cystic Fibrosis: Renewed Hopes through Research. Intec Publications; 2012. p 31-50.
5. Gadkowski LB, Stout JE. Cavitary pulmonary disease. Clin Microbiol Rev. 2008;21:305-33. Crossref
6. Self WH, Courtney DM, McNaughton CD, Wunderink RG, Kline JA. High discordance of chest x-ray and computed tomography for detection of pulmonary opacities in ED patients: implications for diagnosing pneumonia. Am J Emerg Med. 2013;31:401-5. Crossref
7. Mayo JR, Aldrich J, Muller NL; Fleischner Society. Radiation exposure at chest CT: a statement of the Fleischner Society. Radiology. 2003;228:15-21. Crossref
8. Remy-Jardin M, Remy J, Mayo JR, Muller NL. Acquisition, injection and reconstruction techniques in CT angiography of the chest. Philadelphia: Lippincott, Williams & Wilkins; 2001. p 1-14.
9. Hara AK, Paden RG, Silva AC, Kujak JL, Lawder HJ, Pavlicek W. Iterative reconstruction technique for reducing body radiation dose at CT: feasibility study. AJR Am J Roentgenol. 2009;193:764-71. Crossref
10. Padole A, Ali Khawaja RD, Kalra MK, Singh S. CT radiation dose and iterative reconstruction techniques. AJR Am J Roentgenol. 2015;204:W384-92. Crossref
11. Beister M, Kolditz D, Kalender WA. Iterative reconstruction methods in X-ray CT. Phys Med. 2012;28:94-108. Crossref
12. Liu L. Model-based iterative reconstruction: a promising algorithm for today's computed tomography imaging. J Med Imaging Radiat Sci. 2014;45:131-6. Crossref
13. Volders D, Bols A, Haspeslagh M, Coenegrachts K. Model-based iterative reconstruction and adaptive statistical iterative reconstruction techniques in abdominal CT: comparison of image quality in the detection of colorectal liver metastases. Radiology. 2013;269:469-74. Crossref
14. Smith EA, Dillman JR, Goodsitt MM, Christodoulou EG, Keshavarzi N, Strouse PJ. Model-based iterative reconstruction: effect on patient radiation dose and image quality in pediatric body CT. Radiology. 2014;270:526-34. Crossref