Incidental findings during cardiac assessment; a suggested algorithm for countries endemic with tuberculosis.

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Abstract

Lung nodules are the commonest incidental findings during cardiac imaging. Majority of these cases were benign, but small numbers have potential malignant risk. These lead to cascade effect of unnecessary investigations especially in scarcity of specific follow-up recommendations. Furthermore, in Asian countries, these lung nodules would also represent in tuberculosis infection. In this review, we describe the approach and proposed algorithm for incidental lung nodules during cardiac assessment in countries endemic with tuberculosis. Assessment of these lung nodules should be performed using full field of view images and the malignant probability should be stratified based on clinical and radiological risk factors. In countries endemic with tuberculosis infections, the differentials for lung nodules should include infections namely *Mycobacterium tuberculosis*.

Keywords: Malignant, Recommendations, Tuberculosis, Algorithm.

Introduction

Innovative technology has progressed vastly throughout medicine field enabling non-invasive visualization of heart and its vasculature. Several cardiac imaging modalities have become essential and routine in the practice of modern cardiovascular medicine not only for diagnosis but also in aiding further interventions. These modalities cardiac Magnetic Resonance Imaging (MRI) and Computed Tomography (CT). Imaging modalities has a major role in patients' managements and as the quality of imaging examinations has improved considerably whilst access to these examinations has become wide availability. The growing number of imaging techniques performed per patient causes an increase in the number of non-cardiac incidentals findings.

Literature Review

Epidemiology: Incidental Non-Cardiac Findings in cardiovascular imaging (INCF) can be defined as abnormalities which has potential clinically relevant and identified despite being unrelated to the purpose of the investigation [1]. Coronary CTA reported to have (43-56%) incidental extra cardiac findings [2,3], and higher in cardiac MRI. Of the numbers mentioned, half were potentially clinically significant which include pulmonary nodules, emphysema, bronchiectasis, ground-glass opacities, atelectasis, focal consolidations, cysts, consolidations and abdominal pathology, however only (5-36%), radiology reports made specific follow up recommendations. Possibility of the presence of any incidental lung findings in field of view of coronary CTA increases significantly over the age of 40.5 years [5]. The prevalence significant findings reported to be (2-15%), but small number have potential malignant risk, (0.5%). Nevertheless, these findings could trigger additional investigations including unnecessary test, diagnostic procedures as well as treatments which has been called the 'cascade effect' and these needs to be identified to avoid any undesirable consequences.

Full field of view images: Assessment with limited Field of View (FOV) at cardiac scanning may result in the majority of lung cancers that could be detected on full-FOV images being missed. Use of a limited FOV at cardiac scanning led to a large majority (67-89%) of the lung cancers detected at full thoracic scanning being missed; thus, inclusion of the entire chest at cardiac CT is advisable [6]. Furthermore, the prevalence of lung cancer detected at CT was higher in patients suspected or known to have coronary artery disease compared to asymptomatic screening examined patients. These findings were due to common demographic and clinical risk factors for both coronary artery disease and lung cancer, primarily age and smoking history. In fact, majority of these cases were detected at early stage and potentially respectable [7].

Low dose CT thorax for lung nodule assessment: In the case of limited FOV images CT cardiac, a Low Dose CT (LDCT) thorax should be sought for nodule assessment in lung cancer screening [8,9]. LDCT thorax provide adequate diagnostic information while avoiding risk of contrast and minimizing radiation exposure, thus adhering to the principle ALARA (As

Low As Reasonably Achievable). LDTCT is a non-contrast CT which has lower expected radiation exposure compared to High Resolution CT (HRCT) thorax; 1-3 mSV *vs.* 3-8 mSV respectively [10]. More recently, ultra-low dose CT (<1 mSv) was been used for lung cancer screening [11] and in screening for lung nodules as a part of coronary CT [12].

Assessment of lung nodule: Lung nodule assessment is very important as majority of these cases may be benign and require no further follow-up, but some may represent early stage lung cancer, which required prompt diagnosis and definitive treatment. The assessment should be comprised by a multidisciplinary team, including pulmonologists, oncologists, radiologists, and thoracic surgeons with the aims to estimate malignancy risk and to determine the most appropriate management. Various predictive models were developed for malignant risk estimation for lung nodules utilizing both clinical risk factors and imaging features namely; mayo clinic model [13], herder model [14], veteran administration model [15], and brock's university model [16]. Among these models, brock's university model (Table 1) and herder model have the high sensitivity >90%, [17] however the later model require PET findings which may limit its utility. Management of lung nodule would be based on three categories, low risk (<15%), intermediate risk (15-65%) and high risk (>65%) [18-21]. Only those in intermediate risk and high risk may require additional invasive investigations, non-surgical biopsy and surgical resection respectively [22]. For those with low risk, surveillance imaging is recommended based on Fleisher's criteria for time interval and duration of follow-up (Table 2) [19].

Table 1. *Brock's University model.*

Clinical risk factors	**Radiological risk factors**
Age	Emphysema
Gender	Nodule size
Family history of cancer	Part solid attenuation
	Upper lobe location
	Nodule count
	Spiculation

Table 2. *Guidelines for management of incidental pulmonary nodules detected on CT Images: From the Fleischner Society 2017.*

A. Solid Nodules*				
Nodule Type	**<6 mm (<100 mm³)**	**6-8 mm (100-250 mm³)**	**>8 mm (>250 mm³)**	**Comments**
Single				
Low risk	No routine follow-up.	CT at 6-12 months, then consider CT at 18-24 months.	Consider CT at 3 months PET/CT, or tissue sampling	Nodules <6 mm do not require routine follow-up in low-risk patients (recommendation 1A).
High risk	Optional CT at 12 months	CT at 6-12 months, then CT at 18-24 months.	Consider CT at 3 months PET/CT, or tissue sampling.	Certain patients at high risk with suspicious nodule morphology upper lobe location, or both may warrant 12-month follow-up (recommendation 1A).
Multiple				
Low risk	No routine follow-up.	CT at 3-6 months then considers CT at 18-24 months.	CT at 3-6 months then considers CT at 18-24 months.	Use most suspicious nodule as guide to management Follow-up intervals may vary according to size and risk (recommendation 2A).
High risk	Optional CT at 12 months.	CT at 3-6 months, then at 18-24 months.	CT at 3-6 months, then at 18-24 months.	Use most suspicious nodule as guide to management Follow-up intervals may vary according to size and risk (recommendation 2A).
Size				
Nodule Type	**<6 mm (<100 mm³)**	**>6 mm (>100 mm³)**		**Comments**

Single			
Ground glass	No routine follow-up	CT at 6-12 months to confirm persistence, then CT every 2 years until 5 years.	In certain suspicious nodules < 6 mm, consider follow-up at 2 and 4 years. If solid component(s) or growth develops, consider resection (Recommendations 3A and 4A).
Part solid	No routine follow-up	CT at 3-6 months to confirm persistence If unchanged and Solid component remains (B mm. annual CT should be performed for 5 years.	In practice, part-solid nodules cannot be defined as such until 26 mm, and nodules <6 mm do not usually require follow-up. Persistent part-solid nodules with solid components -6 mm should be considered highly suspicious (recommendations 4A-4C).
Multiple	CT at 3-6 months If stable considers CT at 2 and 4 years.	CT at 3-6 months Subsequent management based on the most suspicious nodule(s).	Multiple <6 mm pure ground-glass nodules are usually benign, but consider follow-up in selected patients # high risk at 2 and 4 years (recommendation 5A).

Discussion

However in Asian population, some modifications were required for the risk models, mainly to cater the increased risk of lung cancer in female non-smokers [23,24] and higher prevalence of infectious lung disease especially Tuberculosis (TB) [25].

Upper lobe predominance of lung cancer was similar to TB, whilst non-smoking history did not discount malignancy risk where many of the Asian lung cancer patients were non-smokers, and the local endemicity of TB and its confounding effect on radiological features of CT scan and PET scan [26].

Furthermore, there was higher risk of lung cancer among pulmonary tuberculosis patients [27,28] and possibility of concurrent active infection [29].

Therefore, active pulmonary tuberculosis must be ascertained in lung nodules assessment among Asian population.

Suggested algorithm for countries endemic with tuberculosis: Based on these considerations and limitations, we propose the following algorithm for lung nodules detected on CT cardiac for countries endemic with tuberculosis infections (Figure 1).

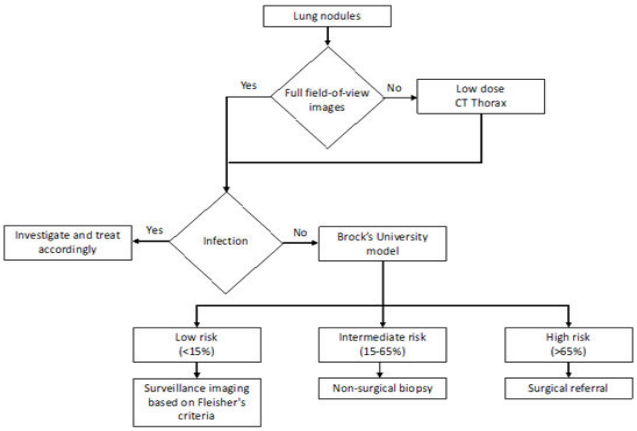

Figure 1. *Proposed algorithm for lung nodules detected in CT cardiac in countries endemic with tuberculosis***.**

Conclusion

Pulmonary nodule is the commonest INCF in cardiac CT and MRI. Majority of the nodules were benign and only small number percentages have malignant potential. Assessment of these lung nodules should be performed using full field-of-view images and the malignant probability should be stratified based on clinical and radiological risk factors. In countries endemic with tuberculosis infections, the differentials for lung nodules should include infections namely *Mycobacterium tuberculosis*.

References

1. O'Sullivan JW, Muntinga T, Grigg S, et al. Prevalence and outcomes of incidental imaging findings: umbrella review. BMJ. 2018;361.

2. Lee CI, Tsai EB, Sigal BM, et al. Incidental extracardiac findings at coronary CT: clinical and economic impact. AJR Am J Roentgenol. 2010;194(6):1531.
3. Lazoura O, Vassiou K, Kanavou T, et al. Incidental non-cardiac findings of a coronary angiography with a 128-slice multi-detector CT scanner: should we only concentrate on the heart? Korean J Radiol. 2010;11(1):60-8.
4. McKenna DA, Laxpati M, Colletti PM, et al. The prevalence of incidental findings at cardiac MRI. Open Cardiovasc Med J. 2008;2:20.
5. Eldeş T, Kara BY. Incidental lung findings in coronary computed tomography angiography. Rev Assoc Médica Bras. 2021;67:1328-32.
6. Northam M, Koonce J, Ravenel JG, et al. Pulmonary nodules detected at cardiac CT: comparison of images in limited and full fields of view. Am J Roentgenol. 2008;191(3):878–81.
7. Kim TJ, Han DH, Jin KN, et al. Lung cancer detected at cardiac CT: prevalence, clinic radiologic features and importance of full–field-of-view images. Radiology. 2010;255(2):369-76.
8. Kramer BS, Berg CD, Aberle DR, et al. Lung cancer screening with low-dose helical CT: results from the National Lung Screening Trial (NLST). J Med Screen. 2011;18.
9. Horeweg N, van der Aalst CM, Vliegenthart R, et al. Volumetric computed tomography screening for lung cancer: three rounds of the NELSON trial. Eur Respir J. 2013;42(6):1659–67.
10. Bhalla AS, Das A, Naranje P, Irodi A, et al. Imaging protocols for CT chest: a recommendation. Indian J Radiol Imaging. 2019;29(3):236.
11. Fujita M, Higaki T, Awaya Y, et al. Lung cancer screening with ultra-low dose CT using full iterative reconstruction. Jpn J Radiol. 2017;35(4):179-89.
12. Zanon M, Pacini GS, de Souza VVS, et al. Early detection of lung cancer using ultra-low-dose computed tomography in coronary CT angiography scans among patients with suspected coronary heart disease. Lung Cancer. 2017;114:1-5.
13. Swensen SJ, Silverstein MD, Ilstrup DM, et al. The probability of malignancy in solitary pulmonary nodules: application to small radiologically indeterminate nodules. Arch Intern Med. 1997;157(8):849–55.
14. Herder GJ, Van Tinteren H, Golding RP, et al. Clinical prediction model to characterize pulmonary nodules: validation and added value of 18 F-fluorodeoxyglucose positron emission tomography. Chest. 2005;128(4): 2490-96.
15. Gould MK, Ananth L, Barnett PG, et al. A clinical model to estimate the pretest probability of lung cancer in patients with solitary pulmonary nodules. Chest. 2007;131(2): 383-8.
16. McWilliams A, Tammemagi MC, Mayo JR, et al. Probability of cancer in pulmonary nodules detected on first screening CT. N Engl J Med. 2013;369(10):910-9.
17. Loverdos K, Fotiadis A, Kontogianni C, et al. Lung nodules: A comprehensive review on current approach and management. Ann Thorac Med. 2019;14(4):226.
18. Gould MK, Donington J, Lynch WR, et al. Evaluation of individuals with pulmonary nodules: When is it lung cancer?: Diagnosis and management of lung cancer: American College of Chest Physicians evidence-based clinical practice guidelines. Chest. 2013;143(5):93-120.
19. MacMahon H, Naidich DP, Goo JM, et al. Guidelines for management of incidental pulmonary nodules detected on CT images: from the Fleischner Society 2017. Radiology. 2017;284(1):228-43.
20. Baldwin DR, Callister ME. The British Thoracic Society guidelines on the investigation and management of pulmonary nodules. Thorax. 2015;70(8):794-8.
21. American College of Radiology. Lung CT screening reporting and data system (Lung-RADS).
22. Mazzone PJ, Gould MK, Arenberg DA, et al. Management of lung nodules and lung cancer screening during the COVID-19 pandemic: CHEST expert panel report. Chest. 2020;158(1):406-15.
23. Wu FZ, Huang YL, Wu CC, et al. Assessment of selection criteria for low-dose lung screening CT among Asian ethnic groups in Taiwan: from mass screening to specific risk-based screening for non-smoker lung cancer. Clin Lung Cancer. 2016;17(5):45–56.
24. Wu FZ, Kuo PL, Huang YL, et al. Differences in lung cancer characteristics and mortality rate between screened and non-screened cohorts. Sci Rep. 2019;9(1):1-7.
25. Organization WH. Global tuberculosis report 2018. Geneva: World Health Organization; 2018.
26. Phua CK, Sim WY, Tee KS, et al. Evaluation of pulmonary nodules in Asian population. J Thorac Dis. 2016;8(5):950.
27. Oh CM, Roh YH, Lim D, et al. Pulmonary tuberculosis is associated with elevated risk of lung cancer in Korea: the Nationwide Cohort Study. J Cancer. 2020;11(7):1899.
28. Abdeahad H, Salehi M, Yaghoubi A, et al. Previous pulmonary tuberculosis enhances the risk of lung cancer: systematic reviews and meta-analysis. Infect Dis. 2021;1-14.
29. Varol Y, Varol U, Unlu M, et al. Primary lung cancer coexisting with active pulmonary tuberculosis. Int J Tuberc Lung Dis. 2014;18(9):1121-5.

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