CME Article

Incidental cardiac abnormalities on non-electrocardiogram-gated multi-detector computed tomography imaging of the thorax and abdomen

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ABSTRACT

Little attention is usually paid to the heart on non-electrocardiogram (ECG)-gated multi-detector computed tomography (MDCT) imaging of the thorax and abdomen. The current MDCT systems have fast scanning capabilities that render non-ECG-gated images with reduced cardiac motion artefacts due to greater temporal and spatial resolution. This has allowed for better evaluation of the cardiac structures. We present a pictorial review of incidental cardiac abnormalities found on MDCT imaging of the thorax and abdomen performed in our institution. We systematically describe abnormalities involving the pericardium, myocardium, cardiac valves, cardiac chambers, coronary artery and congenital heart disease. Some of these images have echocardiograph and magnetic resonance imaging correlation. The purpose of this pictorial essay is to draw attention to cardiac abnormalities found incidentally on non-ECG-gated MDCT imaging of the thorax and abdomen, which may or may not be related to the patient's symptoms.

Keywords: cardiac abnormalities, computed tomography, incidental

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INTRODUCTION

Little attention is usually paid to the heart on conventional computed tomography (CT) of the thorax and abdomen (where the inferior aspect of the heart is invariably imaged). Although electrocardiogram (ECG)-gated multi-detector CT (MDCT) images provide superior imaging of various cardiac diseases, non-ECG-gated MDCT images of the thorax and abdomen usually provide sufficient information to identify several incidental cardiac abnormalities, which may or may not be related to the patient's presenting symptoms. We present the imaging findings of various cardiac abnormalities that were incidentally detected on CT imaging of the thorax and abdomen, in a systematic manner.

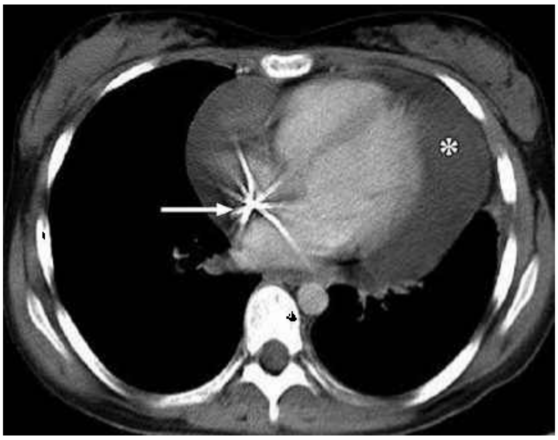

Fig. 1 A 16-year-old female patient with known B-cell mediastinal lymphoma, presenting with shortness of breath. Contrast-enhanced axial CT thorax image shows an incidental large pericardial effusion (*), which is isodense to water and indicative of a simple effusion. A central venous catheter for chemotherapy is present (arrow). Aspirated sterile pericardial fluid was negative for malignancy.

PERICARDIUM

Pericardial effusion

The common causes of pericardial effusion are heart failure, renal failure, infection, neoplasm and injury, including trauma and myocardial infarction.[1] The CT attenuation value (Hounsfield units [HU]) reflects the characteristics of the pericardial fluid; a value closer to that of water (0 HU) is likely to be a simple effusion (Fig. 1), whereas a value greater than that of water density can be seen in conditions such as malignancy, haemopericardium and purulent exudate.[1] Radiologists' awareness of CT findings of pericardial tamponade allows early diagnosis and prompt life-saving intervention. These findings include a large pericardial effusion, compression of the cardiac chambers, bowing of the interventricular septum, enlargement of the vena cavae and reflux of contrast material into the azygos vein and inferior vena cava.[2]

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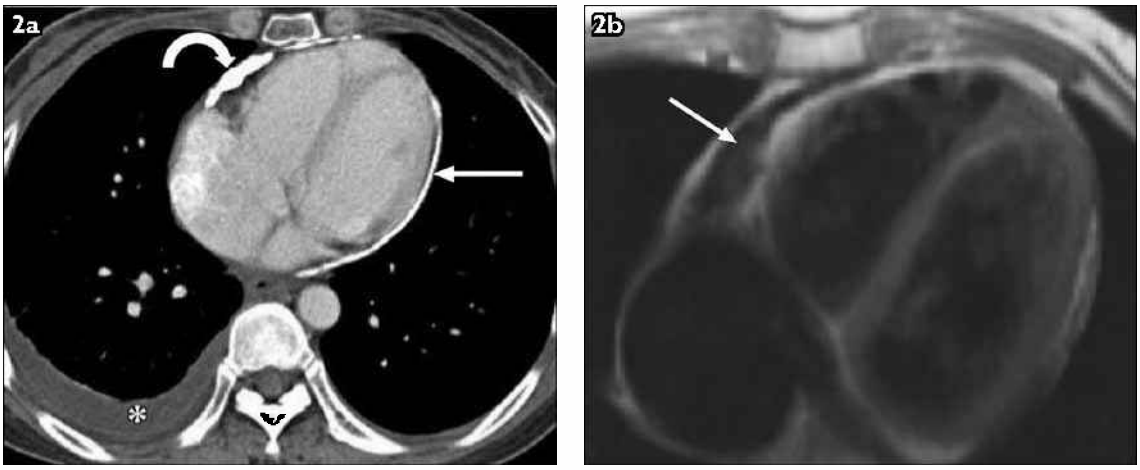


Fig. 2 A 44-year-old female patient with recurrent pleural effusion. (a) Contrast-enhanced axial CT thorax image shows diffuse pericardial calcification (arrow) and a small right pleural effusion (*). Unlike myocardial calcification, which tends to be left-sided and fine in appearance, pericardial calcification is usually diffuse in distribution and coarse in character. The pericardial calcification going around the heart (curved arrow) and not dipping into the cardiac contour, following the outline of the myocardium is seen. This is a distinguishing feature of pericardial calcification. (b) Axial T1-W spin echo MR image shows the pericardial calcification as a curvilinear low signal intensity area of thickened pericardium (arrow).

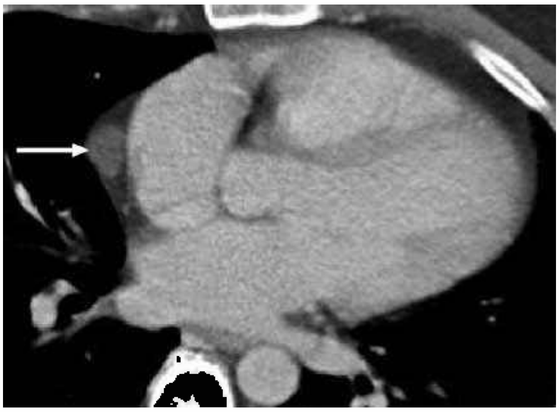


Fig. 3 A 39-year-old male patient with colon carcinoma. Contrast-enhanced axial, staging CT abdomen image shows an incidental, well-defined cyst of fluid attenuation adjacent to the right heart border (arrow). The lesion remained stable on subsequent follow-up CT images, in keeping with a pericardial cyst.

Fig. 4 A 62-year-old female patient with advanced non-small cell lung cancer. Contrast-enhanced axial CT thorax image shows incidental, extensive nodular thickening of the pericardium (arrows) due to metastases. Left-sided nodular pleural metastases (P) are also seen. There is a loculated pleural effusion with areas of high density in the left lower hemithorax (*), secondary to previous talc pleurodesis.

Pericardial calcification

Pericardial calcification is an important sign, but not pathognomonic of constrictive pericarditis, in which it may be associated with a thickened pericardium.(1) It is commonly seen within the atrioventricular grooves and in the diaphragmatic portions of the pericardium (Fig. 2). Constrictive pericarditis is now more commonly secondary to cardiac surgery and therapeutic irradiation, rather than infection, collagen vascular disease and uraemia.(1) Pericardial calcification occurs less frequently today. Ling et al from Mayo Clinic recently reported that pericardial calcification was seen in 27% of their patients with constrictive pericarditis, compared to the 40% incidence reported much earlier at the same institution.(3) Most of the constrictive pericarditis cases in these studies were idiopathic in nature, whereas tuberculosis was seen in only one patient in the recent study.(3) The occurrence of calcification despite the rarity of tuberculosis suggests that this is a nonspecific response to chronic inflammatory processes. This may also reflect disease chronicity, where tissue fibrosis and dystrophic calcification may obliterate evidence of previous infection.(3)

Pericardial masses

A pericardial cyst is the most common cause of a primary pericardial mass.(4) This is formed when a portion of the pericardium is pinched off during development. This benign lesion is usually well-defined with homogeneous low density, most commonly located in the right cardiophrenic angle (Fig. 3).(4) Pericardial metastases

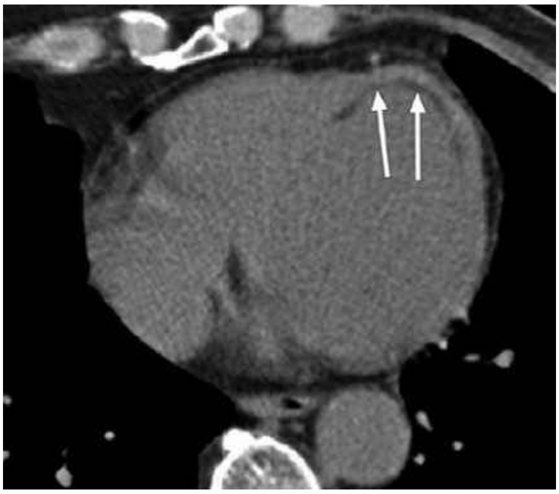


Fig. 5 A 55-year-old male patient with hepatocellular carcinoma who underwent surveillance triphasic CT liver imaging. Unenhanced axial CT image shows incidental subendocardial fatty replacement along the cardiac apex (arrows), related to previous myocardial infarction.

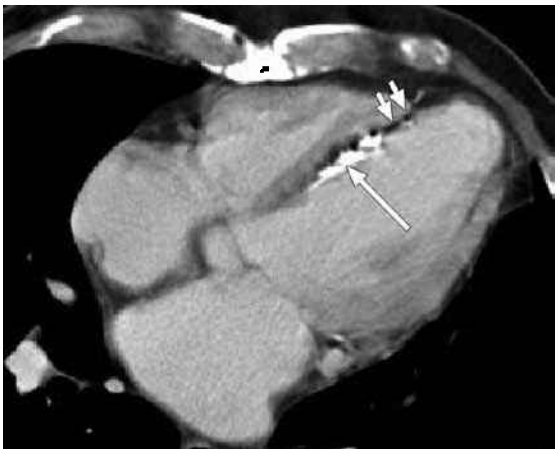


Fig. 6 A 69-year-old male patient with rectosigmoid carcinoma. Contrast-enhanced axial, staging CT abdomen image shows thinning of the interventricular septum and apex, with subendocardial hypoenhancement (arrowheads) and focal linear calcification of the interventricular septum (arrow), secondary to previous myocardial infarction. The septal involvement and regional myocardial wall-thinning helps to differentiate myocardial from pericardial calcification.

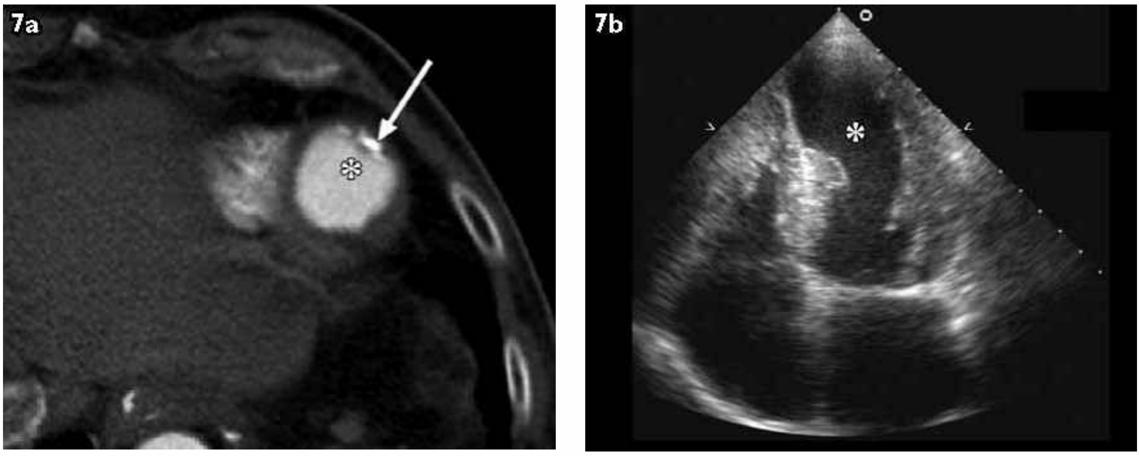


Fig. 7 An 82-year-old male patient with hypertension and an infrarenal abdominal aortic aneurysm. (a) Axial CT image shows an incidentally detected left ventricular apical aneurysm (*) with a calcified wall (arrow). This is likely due to an old left apical myocardial infarct. (b) Apical four-chamber echocardiography image of the heart shows a left apical aneurysm. The calcified left ventricular aneurysm wall is better depicted on CT. The broad ostium of the aneurysm is indicative of a true aneurysm, differentiating it from a pseudoaneurysm.

have a 40-fold increase in incidence compared to primary tumours, mainly arising from lung (Fig. 4) and breast cancers.[4] Pericardial tumours can manifest as pericardial effusions, pericardial thickening or nodular masses on CT.

MYOCARDIUM

Myocardial infarction

CT findings related to previous myocardial infarction include subendocardial fatty replacement (Fig. 5), delayed contrast enhancement, myocardial thinning and calcification in the infarcted area.[5,6] Myocardial calcification is seen in 8% of myocardial infarctions that are more than six years old.[6] It appears as a thin, curvilinear calcification on CT images, usually within the periphery of the infarct, in the distribution of the inter-ventricular septum and cardiac apex (Fig. 6).

Contrast-enhanced CT imaging usually allows the differentiation of ventricular chambers, evaluation of wall attenuation, and facilitates in the assessment of regional myocardial thinning and focal dilatation.[7] However, the thickness of normal left ventricular myocardium on non-gated CT imaging is variable, as it is scanned at variable phases of the cardiac cycle. Lee et al postulated from clinical experience that the left ventricular myocardium is thinned when the interventricular septum or posterior myocardium on axial CT image of mid-ventricular level is thinner than 10 mm, and the myocardium is thick when it is thicker than 25 mm.[8]

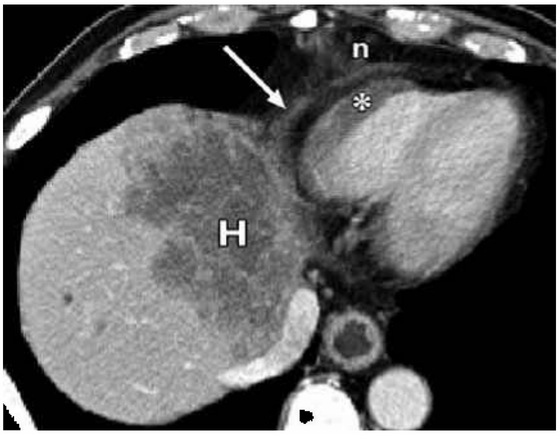
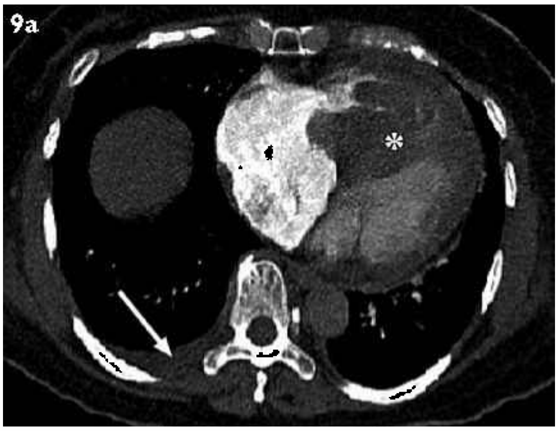


Fig. 8 A 79-year-old male patient with hepatocellular carcinoma (HCC). Contrast-enhanced axial CT abdomen image shows thickening of the right ventricular free wall, representing metastatic disease (*). Nodular thickening of the adjacent pericardium (arrow) from direct invasion of the adjacent HCC (H) and a few small-volume paracardiac lymph nodes (n) are seen.



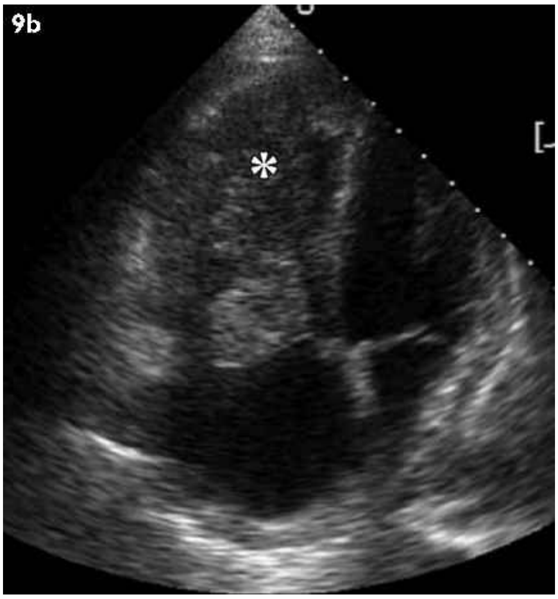


Fig. 9 A 59-year-old female patient with known retroperitoneal liposarcoma who presented with breathlessness. (a) Axial CT pulmonary angiogram image shows an incidental large filling defect in the right ventricle (*), representing metastatic liposarcoma. A small right pleural effusion is seen (arrow). (b) Apical, four-chamber echocardiography image confirms the large hypoechoic mass in the right ventricle (*).

Myocardial aneurysm

Left ventricular aneurysm can be subdivided into true and false aneurysms.[9] True aneurysms have a continuous wall of thinned, scarred myocardium, whereas false aneurysms arise from interruption or rupture of the myocardium. Both can be complicated by thrombus formation. True aneurysms are most commonly located at the anterior wall of the left ventricle or cardiac apex, usually secondary to transmural myocardial infarction (Fig. 7).[9] They are seen in 8%–12% of patients after acute myocardial infarction.[8] Rarer causes include trauma, Chagas disease, sarcoidosis and congenital causes.

False left ventricular aneurysms are uncommon and potentially fatal, usually requiring prompt surgical repair due to a 30%–45% lifetime risk of rupture.[9] They commonly arise from the inferior wall of the left ventricle, secondary to myocardial rupture 5–10 days post infarction.[9] False aneurysms in a sub-mitral location following replacement of the mitral valve and resection of the mitral valve apparatus have also been reported.[9] It is important to differentiate between true and false aneurysms due to the differences in management. In addition to the typical inferior locations, other CT features suggestive of a false aneurysm include narrow ostium (orifice to aneurysm diameter ratio < 0.5), discontinuity of the myocardium at the neck of the aneurysm and absence of coronary arteries overlying the aneurysm.[10]

Myocardial masses

Metastases to the myocardium are more common than primary tumours.[11] 12% of oncology patients are reported to suffer from cardiac or pericardial metastases, frequently through direct invasion from adjacent structures, haematogenous or lymphatic spread.[11] They may manifest as filling defects within the cardiac chambers, multiple masses, nodules or diffuse infiltration of the myocardium on CT imaging (Figs. 8 & 9). Non-ECG-gated MDCT with intravenous contrast media usually provides adequate localisation and definition of the tumour extent.[11]

CARDIAC VALVES

Valvular heart disease/calcification

The limited temporal resolution and complex orientation of cardiac valves are the limitations of non-gated CT imaging in demonstrating the morphologic abnormalities of each cardiac valve. However, the dilatation and hypertrophy of the cardiac chambers secondary to haemodynamic adaptations in valvular heart disease can sometimes be interpreted on routine CT images.[8] Under normal circumstances, the ventricles appear roughly equal in size

Fig. 10 An 86-year-old male patient with oesophageal carcinoma underwent contrast-enhanced, staging CT thorax, which showed incidental findings of aortic and mitral valvular disease due to rheumatic heart disease. (a) Axial CT image at the level of the mitral valve shows calcification involving the chordae tendinae and papillary muscle (arrowhead) and valve leaflets (which are thickened)(arrow). Calcified pleural plaques from previous asbestos exposure are seen. (b) Axial CT image of a slice superior to Fig. 10a shows calcification of the aortic valve (arrow), a finding related to the severity of aortic stenosis, but the dynamic function of the aortic valve cannot be demonstrated and assessed directly on a non-gated CT image. Asbestos-related calcified pleural plaques are again seen.

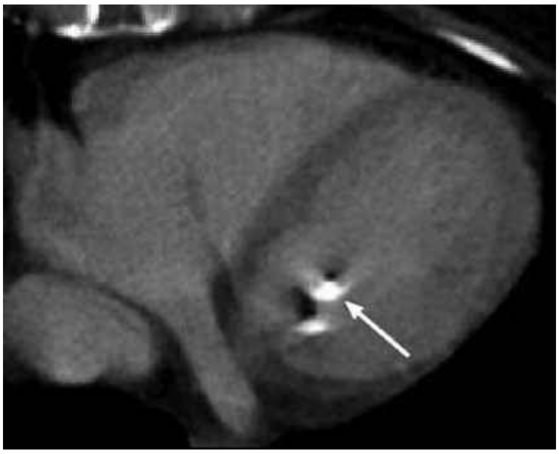


Fig. 11 A 62-year-old female patient presenting with weight loss. Contrast-enhanced axial CT abdomen image shows incidental findings of papillary muscle calcification (arrow). Calcification of the papillary muscle is most commonly located at the apex of the muscle, as was seen in this case.

at the level of the mid-interventricular septum, with the interventricular septum bowing toward the right side.[7]

CT is highly sensitive in detecting the presence of calcium in chronic valvular disease. This is seen in conditions such as rheumatic fever, congenital malformations and previous endocarditis.[7] Mitral valve (MV) leaflet calcification is characteristic of rheumatic mitral stenosis.[12] MV annular calcification, located at the outer ring of the valve, is due to a degenerative process and associated with normal valve function (Fig. 10a).[12]

Rheumatic heart disease can affect any cardiac valves, but most commonly involve the MV. Primary calcification of the left atrial wall is almost always due to rheumatic disease.[7] In chronic rheumatic MV disease, the slowly progressive process of reactive fibrosis results in scarring and calcification of the valve, leading to chronic mitral stenosis. This causes dilatation of the left atrium and appendage in the presence of a normal left ventricle. The resultant chronic left atrial hypertension results in pulmonary vein dilatation, leading to pulmonary hypertension. The right ventricular myocardium subsequently hypertrophies, and this is seen on CT imaging as thickened right ventricular free wall and septal myocardium. Further progression to right atrial hypertension follows, causing flattening and posterior bowing of the interatrial septum. Signs of right heart failure may be seen on non-gated CT, which include dilatation of the coronary sinus, vena cavae, hepatic and azygos veins.

In chronic mitral regurgitation, there is dilatation of the left atrium and ventricle secondary to volume overload, followed by thickening of the left ventricular myocardium. However, in acute mitral regurgitation, the cardiac chambers are usually not dilated in the presence of interstitial pulmonary oedema and signs of severe left atrial hypertension on CT imaging.[7]

Aortic valve calcification seen on CT imaging (Fig. 10b) is proportionately related to the severity of aortic stenosis,[13] but the reference ranges of the calcium scores are probably dependent on the imaging protocol and CT equipment used. The common causes of aortic valve calcification are congenital bicuspid valve before the fourth decade and acquired valve degeneration after the sixth decade.[6] Cowell et al opined that poorly defined or diffuse segments of calcium on CT imaging usually represent a minor aortic valve gradient, while coalescent calcium centred on the aortic valve likely represents moderate stenosis, and very heavy calcification almost invariably represents significant valvular stenosis.[13] Other CT findings of aortic stenosis include left ventricular hypertrophy and post-stenotic dilatation of the ascending aorta.

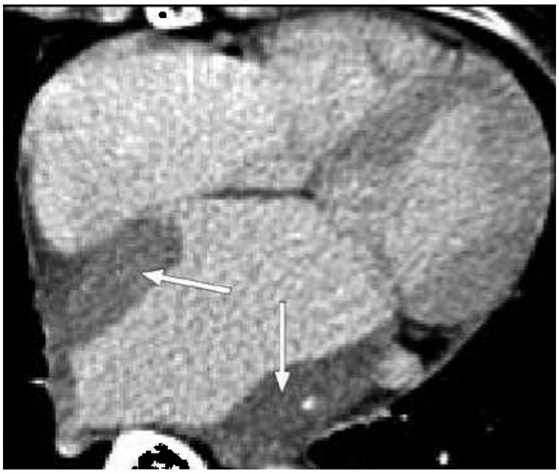


Fig. 12 A 59-year-old female patient with atrial fibrillation presenting with abdominal pain. Contrast-enhanced axial CT abdomen image shows chronic left atrial thrombus adjacent to the inter-atrial septum and along the posterolateral wall (arrows), related to atrial fibrillation. The presence of calcification within the thrombus is suggestive of chronicity. The patient was treated with anticoagulation.

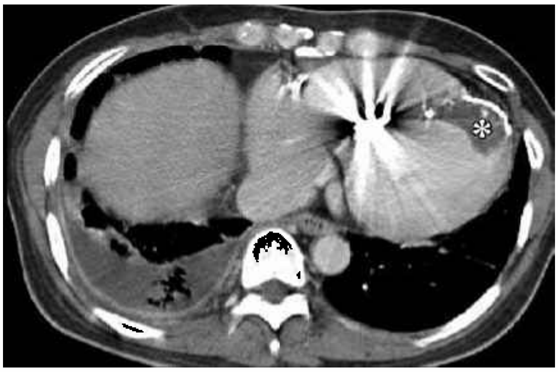


Fig. 13 A 46-year-old male patient with diabetes mellitus presenting with chest infection. Contrast-enhanced axial CT thorax image shows an incidental thrombus (*) within a left ventricular apical aneurysm due to previous myocardial infarction, which are known associations. A cardiac pacemaker lead causing streak artefacts is noted. There is a right pleural effusion with right lung base atelectasis.

Aortic regurgitation may be suggested on CT imaging by the presence of left ventricular and aortic dilatation. However, a milder form of the disease may be overlooked.

Papillary muscle calcification

Left ventricular papillary muscles are vital to left ventricular and MV function. Papillary muscle calcification is most frequently seen at the apex of the muscle (Fig. 11).[14] It is associated with coronary artery disease and dilated cardiomyopathy.[14]

CARDIAC CHAMBERS

Filling defects

Filling defects within the cardiac chambers are more commonly due to thrombi than tumours.[8] Thrombus typically occurs along the posterolateral wall of the left atrium or within the left atrial appendage, as a nonenhancing filling defect (Fig. 12).[8] It is usually associated with cardiomyopathy and dysrhythmia. Thrombus in the left ventricular apex is associated with previous myocardial infarction and ventricular aneurysm (Fig. 13).

Left-sided cardiac thrombi are potential sources of systemic embolisation, whereas right-sided lesions are associated with deep vein thrombosis and pulmonary thromboembolism. Cardiac thrombus related to tumours, such as renal cell carcinoma with invasion of the inferior vena cava, shows relative good enhancement and are located in the right heart chambers.[8] Cardiac myxoma, the most common primary cardiac tumour, is usually located within the atrium and more likely in the left atrium.[11] It tends to arise from the fossa ovalis as a heterogeneously low attenuation filling defect.[11]

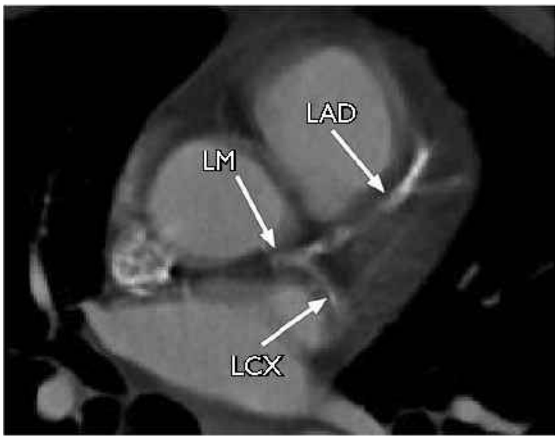


Fig. 14 An 84-year-old male patient with abdominal aortic aneurysm. Contrast-enhanced CT aortogram shows incidental calcification of the left main (LM), left anterior descending (LAD) and circumflex coronary arteries (LCX), indicative of coronary artery disease.

CORONARY ARTERIES

Coronary artery calcification

Calcified coronary arteries strongly correlate with coronary artery disease.[15] The left anterior descending artery is most commonly involved (Fig. 14). Patients with calcified coronary arteries have a higher frequency of cardiac complications, including arrhythmia, ischaemia, hypotension and myocardial infarction.[15]

CONGENITAL HEART DISEASE

Some cases of isolated congenital heart disease may be detected incidentally on CT imaging performed for non-cardiac-specific symptoms such as unexplained dyspnoea, or for evaluation of pulmonary hypertension or bilateral hilar enlargement on chest radiograph in adulthood.

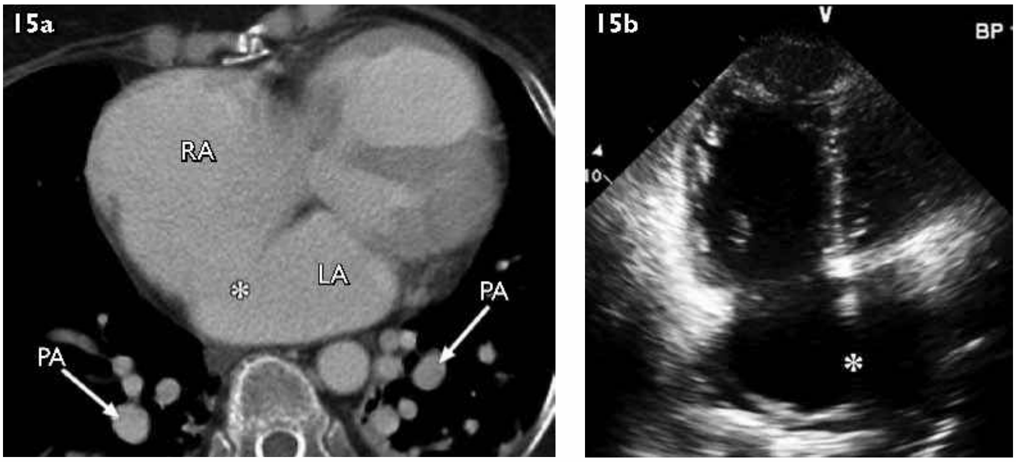


Fig. 15 A 61-year-old female patient with cholangitis. (a) Contrast-enhanced axial CT abdomen image shows biatrial dilatation (right atrium > left atrium) and dilated pulmonary arteries (PA), representing secondary pulmonary hypertension. An atrial septal defect (ASD) was suspected from a probable defect in the inter-atrial septum (*), but diagnosis of ASD should be carefully made on non-gated CT imaging. (b) Apical, four chamber echocardiography image confirmed an ostium secundum atrial septal defect (*), the most common subtype.

Of all the congenital heart diseases, atrial septal defects (ASDs) account for about a third of cases in adults.[8] As the interatrial septum in the region of the fossa ovalis may be too thin to be delineated on non-ECG-gated CT imaging, the diagnosis of ASD should be made cautiously (Fig. 15). However, in the presence of increased curvature of the right atrial cardiac border due to right atrial enlargement, intracardiac shunts should be suspected in addition to pulmonary arterial hypertension and tricuspid valve abnormalities.

CONCLUSION

Various cardiac abnormalities can be identified incidentally on MDCT images of the thorax and abdomen. Hence, it is important to review the cardiac findings, and if present, mention this in the radiology report, as some of these findings could be relevant to the patient's presenting complaints. With greater awareness and by using a systemic approach to assess the heart in CT imaging of the thorax and abdomen, radiologists would be better able to identify cardiac lesions on non-ECG-gated MDCT images.

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SINGAPORE MEDICAL COUNCIL CATEGORY 3B CME PROGRAMME
Multiple Choice Questions (Code SMJ 201112B)

	True	False
Question 1. The following are CT features of cardiac tamponade:		
(a) Dilatation of the vena cavae.	☐	☐
(b) Reflux of contrast into the inferior vena cava.	☐	☐
(c) Right atrial dilatation.	☐	☐
(d) Large pericardial effusion.	☐	☐
Question 2. The following are CT features of myocardial infarction:		
(a) Subendocardial fatty replacement.	☐	☐
(b) Early contrast enhancement.	☐	☐
(c) Myocardial thinning.	☐	☐
(d) Myocardial calcification.	☐	☐
Question 3. The following are characteristics of true left ventricular aneurysms:		
(a) They are commonly located at the left ventricular apex.	☐	☐
(b) They can be complicated by thrombus formation.	☐	☐
(c) The cause is that of transmural myocardial infarction.	☐	☐
(d) Prompt surgical intervention is required.	☐	☐
Question 4. Cardiac valvular calcification is associated with:		
(a) Rheumatic fever.	☐	☐
(b) Previous endocarditis.	☐	☐
(c) Malignancy.	☐	☐
(d) Congenital malformations.	☐	☐
Question 5. The following are characteristics of constrictive pericarditis:		
(a) Pericardial calcification is pathognomonic for constrictive pericarditis.	☐	☐
(b) Constrictive pericarditis is rarely secondary to radiotherapy.	☐	☐
(c) Constrictive pericarditis is associated with a thickened pericardium.	☐	☐
(d) Uraemia is a cause of constrictive pericarditis.	☐	☐

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SUBMISSION INSTRUCTIONS:

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RESULTS:

(1) Answers will be published in the SMJ February 2012 issue. (2) The MCR numbers of successful candidates will be posted online at www.sma.org.sg/cme/smj by 13 January 2012. (3) All online submissions will receive an automatic email acknowledgment. (4) Passing mark is 60%. No mark will be deducted for incorrect answers. (5) The SMJ editorial office will submit the list of successful candidates to the Singapore Medical Council. (6) One CME point is awarded for successful candidates.

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