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ORIGINAL ARTICLE

Prevalence and Clinical Significance of Incidental Extracardiac Findings during Cardiac Magnetic Resonance Imaging: a Retrospective Study

HS Abdel Rahman[1], AM Shawky[2], EM Mehana[3]

[1]Department of Radiology, Faculty of Medicine, Ain Shams University, Egypt
[2]Department of Cardiology, Al-Azhar University, Egypt
[3]Department of Radiology, Medical Research Institute, Alexandria University, Egypt

ABSTRACT

Introduction: *We sought to assess the prevalence and significance of incidental findings during cardiovascular magnetic resonance imaging (CMRI) and to investigate their impact on patient management.*

Methods: *We performed a retrospective evaluation of the CMRI images of all 131 referred patients suitable for inclusion who presented to our radiology department between July 2017 and May 2019. Their images were evaluated for any extracardiac findings beyond the pericardium detected and reported at the time of examination and classified in terms of the effects of these findings on the patients' treatment plans.*

Results: *A total of 109 incidental findings were detected in 53% of the scanned population, of which 27 (24.8%) were clinically significant and potentially significant, including pulmonary consolidation (n = 11), extracardiac vascular lesions (n = 3), and other chest and abdominal abnormalities. Among the 27 cases, four (all male; 3% of the study population) showed clinically significant extracardiac findings, namely fibrocavitary tuberculosis, lymphoma, and pericardial mesothelioma, as well as one case of patent ductus arteriosus, as patients were referred to other specialists to treat the primary disease that was causative of the secondary cardiac problem.*

Conclusions: *Incidental extracardiac findings were common in CMRI, and although the prevalence of significant lesions was low, they changed patient management. Thus, it is important to identify extracardiac findings and clarify their significance during CMRI reporting.*

Key Words: *Cardiovascular system; Heart; Incidental findings; Magnetic resonance imaging*

Correspondence: *Dr EM Mehana, Department of Radiology, Medical Research Institute, Alexandria University, Egypt*
Email: sayedmehana9@gmail.com

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Data Availability: All data generated or analysed during the present study are available from the corresponding author on reasonable request.

Ethics Approval: This study was approved by the ethics committee of Saudi German Hospital, Jeddah, Saudi Arabia. The committee identified no ethical problem and granted a waiver on patient consent as this study was a retrospective description of clinical cases and no experiments or trials were done related to this study.

中文摘要

心臟磁共振成像時意外心臟外發現的發病率和臨床意義：回顧性研究

HS Abdel Rahman、AM Shawky、EM Mehana

簡介：我們評估心血管磁共振成像（CMRI）時偶然發現病變的普遍性和重要性，並調查它們對患者處理的影響。

方法：我們對2017年7月至2019年5月期間就診於我們放射科的所有131名適合納入的轉介患者的CMRI 圖像進行了回顧性評估，評估其圖像是否存在心包結構以外的任何心臟外發現，並根據這些發現對患者的治療計劃的影響進行分類。

結果：在53%的研究族群中共檢測到109項偶然發現，其中27項（24.8%）有臨床意義或具有潛在意義，包括肺實變（n = 11）、心外血管病變（n = 3）和其他胸部和腹部異常。患者總數中有四人（全部為男性；佔研究族群的3%）顯示有臨床意義的心外發現，即纖維腔結核、淋巴瘤和心包間皮瘤，以及一例動脈導管未閉。因為有導致繼發性心臟問題的原發性疾病，這些患者被轉介至其他專科醫生治療。

結論：意外的心外發現在CMRI中很常見，儘管顯著病變的發生率很低，但它們改變了患者的處理。因此，在CMRI報告中識別心外發現並闡明其意義非常重要。

INTRODUCTION

Cardiovascular magnetic resonance imaging (CMRI) has proven to be one of the most established noninvasive techniques to assess cardiac structure and performance in multiple heart diseases, and hundreds of CMRI studies have been performed subsequently.[1] During CMRI acquisition, parts of the adjacent anatomical regions within the thorax, upper abdomen, and root of the neck are also imaged, especially in initial multi-section axial and coronal images. These images can reveal a wide range of pathologies outside the cardiovascular system. Although many of these pathologies may represent benign lesions of no clinical importance, others may represent significant clues for new diagnoses, further investigations, or early treatment.[2,3]

The potential challenges and benefits associated with these incidental extracardiac findings have been investigated in multiple studies, the results of which differed in terms of the prevalence of the findings and their impact on the diagnosis and management plans for patients.[1-17] However, these studies are in agreement regarding the importance of incidental extracardiac findings. Moreover, the importance of these extracardiac findings has been recognised and implemented within the European Association of Cardiovascular Imaging core syllabus for the European Cardiovascular Magnetic Resonance certification examination.[4-7]

Extracardiac findings are also being increasingly focused on while reporting CMRI findings at our centre. Therefore, we performed this audit to retrospectively evaluate the prevalence of incidental extracardiac findings in clinically indicated CMRI examinations performed at our institution and to assess their impact on the patients' diagnosis and management. Using the obtained data, we hoped to provide recommendations for changes to reporting of CMRI studies.

METHODS

Patient Population

In this study, we performed a retrospective evaluation of the CMRI images of all patients referred to the radiology department at Saudi German Hospital, Jeddah, Saudi Arabia between July 2017 and May 2019 for clinically indicated CMRI to evaluate the prevalence of incidental extracardiac findings in these cases. We excluded patients with extended imaging, examinations with inadequate image quality, and follow-up imaging assessments and repeat scans. An incidental extracardiac finding was defined as any change found beyond the pericardium, e.g., great vessels, lung, pleural, or abdominal pathology.

Cardiovascular Magnetic Resonance Imaging Protocol

All CMRI examinations were performed on a 1.5T Avanto MRI system (Siemens Healthcare, Germany)

equipped with a 32-element cardiac coil array. All scans were electrocardiography-gated for synchronisation with the cardiac cycle and performed in end-expiration, and were performed in accordance with a local standard CMRI protocol that included the following sequences:

1. Three localising single-shot steady-state sequences in the three orthogonal planes, followed by axial, sagittal, and coronal multi-section half-Fourier acquisition single-shot turbo spin-echo (HASTE). These sequences were acquired from the top of the aortic arch to the diaphragm in the axial plane, from the sternum to the spine in the coronal plane, and from the right to left cardiac borders in the sagittal plane. The field of view (FOV) chosen was based on patient size and ranged from 340 × 233 mm^2 to 390 × 344 mm^2. Base and phase resolutions were 256 and 59%, respectively. Section thickness and section gap were 8 and 2 mm, respectively, yielding spatial resolutions from 2.3 mm × 1.3 mm × 8 mm to 2.5 mm × 1.5 mm × 8 mm.
2. Cine sequences with steady-state free precession (SSFP)–oriented 2-chamber vertical long-axis view, 4-chamber horizontal long-axis view, 3-chamber view, and short axis for studying the kinetics of the right and left ventricles (acquisition time, 7-12 s for each section; matrix, 192 × 192; flip angle, 180°; echo time, 1.69 ms).
3. Phase-contrast sequence to review valvular flow. This sequence was planned using a 3-chamber view and coronal aortic view, with one section perpendicular to the ascending aorta just distal to the valve leaflet tips, velocity encoding = 150 cm/s for normal flow (or greater for stenosis), retrospective gating, and short echo time for optimal flow sensitivity.
4. Phase-sensitive inversion recovery (PSIR) sequences for studying late gadolinium enhancement performed 10 to 15 minutes after intravenous administration of gadolinium (0.1-0.2 mmol/kg). FOV, 244 × 300 mm^2; matrix, 156 × 256.

Data Interpretation

Two radiologists with at least 5 years of experience in reporting and supervising cardiovascular MR imaging and without prior knowledge of the objectives of the study reinterpreted the CMRI examinations. All extracardiac findings were recorded as incidental findings and formed the basis for diagnosis. To assess the clinical implications of the incidental extracardiac findings, clinical data were analysed by reviewing the electronic medical records database of the hospital. All those findings were characterised and classified into three categories: (1) non-significant, which are findings that did not warrant further action; (2) potentially significant, which are findings with possible clinical significance that warranted further imaging or specialist consultation but did not warrant a change of the treatment plan or primary diagnosis; and (3) significant, which are findings with major clinical significance that warranted a change in the patient's treatment plan and primary diagnosis. The prevalence of incidental extracardiac findings and their sites were evaluated and reported. Evaluation of the previous radiological reports for the patients was also performed to assure that significant and potentially significant findings had not been missed and qualified for a change of the treatment plan of the patients, if any.

RESULTS

A total of 140 patients underwent CMRI examinations during the study period; of these, we included 131 patients after excluding nine patients for the following reasons: extended imaging (e.g., cardiac MR and abdominal MR in one session; 2 patients), examinations with inadequate image quality (e.g., artifacts, arrhythmia, or incomplete examination because of patient-related factors; 4 patients), and follow-up imaging assessments and repeat scans (3 patients). The patients' ages ranged from 1 to 84 years (mean, 44). The study population included 14 children (one aged 1 year and 13 adolescents aged 10-19 years). The 131 patients included 104 males (79%) and 27 females (21%).

An analysis of the clinical indications for our study cohort is presented in Table 1. Most of our patients were referred for evaluation of myocardial viability (63 patients, 48.1%), followed by non-ischaemic cardiomyopathy (25 patients, 19.1%) and myocarditis (15 patients, 11.5%); other indications included congenital heart

Table 1. Clinical indications for cardiovascular magnetic resonance imaging (CMRI) in the current study cohort (n = 131).

Indications for CMRI	No. (%)
Myocardial viability	63 (48.1%)
Non-ischaemic cardiomyopathy	25 (19.1%)
Myocarditis	15 (11.5%)
Congenital heart disease	8 (6.1%)
Right ventricular evaluation	5 (3.8%)
Pericardium	4 (3.1%)
Valvular disease	3 (2.3%)
Anatomy and function evaluation	2 (1.5%)
Ascending aorta evaluation	2 (1.5%)
Extracardiac mass	2 (1.5%)
Intracardiac mass	1 (0.8%)
Persistent atrial fibrillations	1 (0.8%)

disease, right ventricular evaluation, valvular disease, and intra- or extracardiac masses.

A total of 109 incidental extracardiac findings were recorded in 70 patients (53.4% of the study population), while 61 patients (46.6%) did not show any extracardiac findings. Of these findings, 82 (75.2% of the findings) were mild or of no clinical significance (Table 2) and 27 (24.8% of the findings) warranted further diagnostic workup or consultation since they were considered significant or potentially significant (Table 3).

Out of the 109 incidental extracardiac findings, four findings in four patients had a clinically significant impact on patient diagnosis and management (prevalence among incidental extracardiac findings, 3.7%) but were not clinically significant before imaging. These were as follows:

1. Right upper lobe consolidation and cavitation (fibrocavitary tuberculosis) in a patient presenting with dilated cardiomyopathy. This was confirmed by radiography and laboratory tests (Figure 1). The patient was referred to a pulmonologist, and the cardiac problem was treated as secondary, not primary, dilated cardiomyopathy as the dilation of the cardiac chamber was secondary to the inflammatory process caused by tuberculosis which may be reversable after treating the cause.
2. Marked mediastinal lymph node enlargement, moderate pericardial effusion, and enhancement (pericardial mesothelioma) in a patient with persistent haemorrhagic pericardial effusion. This was diagnosed by an open biopsy in cardiopulmonary surgery (Figure 2). The patient was subsequently referred to an oncologist to receive treatment for the condition in conjunction with the cardiology management.
3. Multiple left lung patchy consolidations, enlarged left supraclavicular lymph node, and marked abdominal paraaortic lymphadenopathy (B-cell lymphoma) in a patient with a large anterior mediastinal mass. This was confirmed by biopsy (Figure 3) and the patient was referred to an oncologist for treatment of the primary condition.
4. Patent ductus arteriosus in an adult patient with dilated right ventricle and pulmonary artery and suspected pulmonary hypertension. The pulmonary-to-systemic blood flow ratio was 0.6:1, while the estimated shunted blood volume through the patent ductus arteriosus was 111 mL. He was referred to undergo cardiothoracic surgery for adequate management (Figure 4).

Table 2. Non-significant incidental extracardiac findings in the current study cohort (n = 82).

Findings	No. of cases	Prevalence
Pleural effusion	28	21.4%
Mediastinal lymphadenopathy	11	8.4%
Axillary lymphadenopathy	23	17.6%
Thymus	1	0.8%
Simple renal cysts	3	2.3%
Spine degeneration	2	1.5%
Splenules	4	3.1%
Breast implant	2	1.5%
Diaphragm eventration	2	1.5%
Bovine arch	1	0.8%
Hiatus hernia	1	0.8%
Shoulder effusion	1	0.8%
Ascites	3	2.3%

Table 3. Potentially significant and significant findings in the current study cohort (n = 27).

Findings	No. of cases	Prevalence
Pulmonary consolidation	11	8.3%
Thyroid lesion	2	1.5%
Renal lesion	2	1.5%
Significant mediastinal lymph nodes	3	2.3%
Thymus	1	0.8%
Abdominal lymphadenopathy	1	0.8%
Extracardiac vascular lesions	3	2.3%
Breast mass	1	0.8%
Spine fracture	1	0.8%
Pulmonary fibrosis	1	0.8%
Large splenic cysts	1	0.8%

Among the anatomical sites where incidental extracardiac findings were detected, the chest showed the highest prevalence of findings among the whole patient population, including pleural effusion (n = 28, 21.4%), axillary lymphadenopathy (n = 23, 17.6%) or mediastinal lymphadenopathy (n = 14, 10.7%), followed by pulmonary parenchymal lesions (n = 12, 9.2%), thymus (n = 2, 1.5%), breast lesions (n = 3, 2.3%), spine abnormalities (n = 3, 2.3%), vascular extracardiac lesions (n = 4, 3.1%), and a shoulder effusion (n = 1, 0.8%). In contrast, abdominal findings were less prevalent and included ascites (n = 3, 2.3%), diaphragmatic hiatal hernia (n = 1, 0.8%), splenic lesions (n = 5, 3.8%), renal lesions (n = 5, 3.8%), abdominal lymphadenopathy (n = 1, 0.8%), and diaphragmatic eventration (n = 2, 1.5%). The site showing the lowest prevalence of findings was the root of the neck with only two thyroid nodules reported (1.5%).

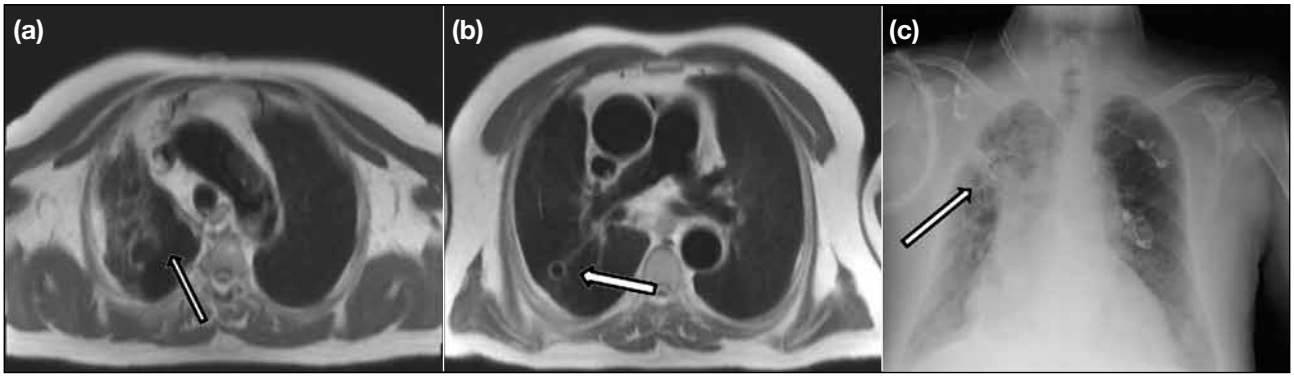

Figure 1. A 62-year-old male presented with atrial fibrillation and dilated cardiomyopathy. He was found to have viable myocardium in cardiovascular magnetic resonance imaging and normal coronaries in coronary angiography. (a and b) Axial black-blood magnetic resonance imaging showing fibrosis and cavitation in the right upper lobe (arrows). (c) Radiography of the chest confirms the diagnosis, with the arrow indicating the cavitary changes in (a) and (b). The patient was diagnosed with fibrocavitary tuberculosis by laboratory tests.

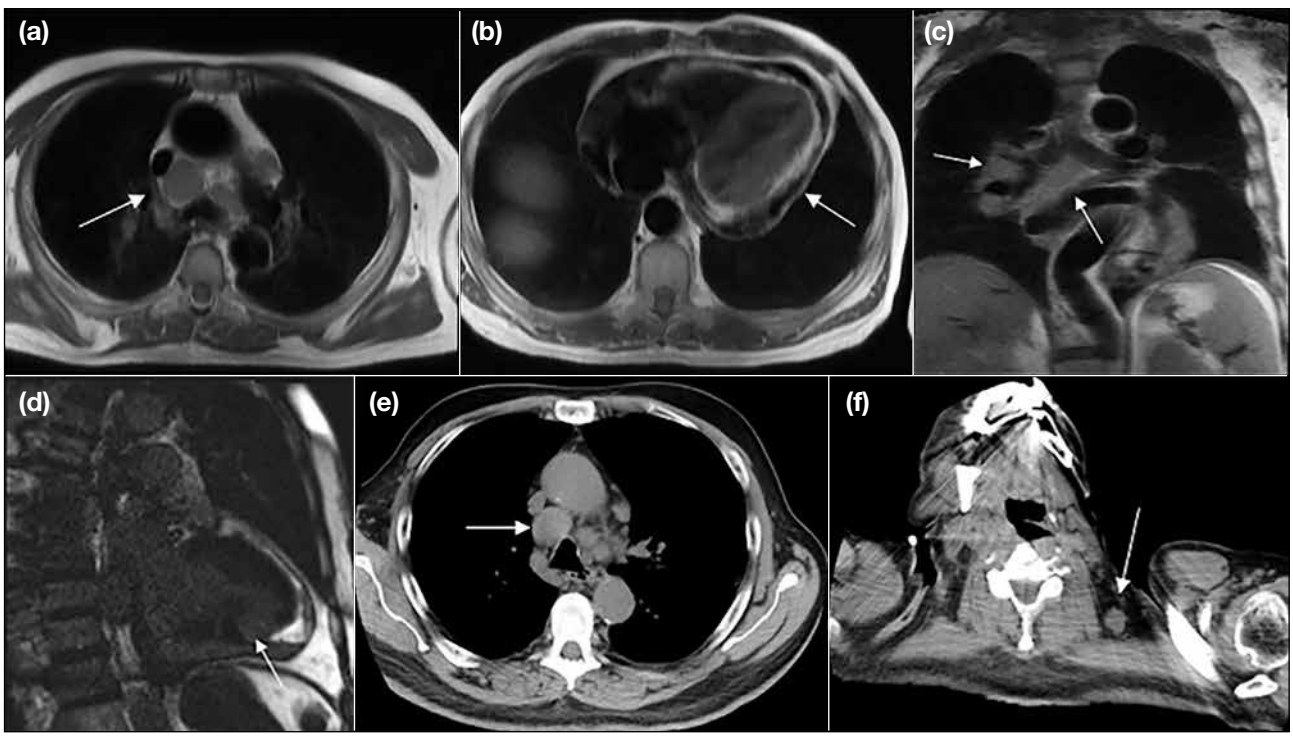

Figure 2. A 61-year-old male presented with dysarthria and facial weakness, pericardial effusion, and tamponade. (a) Axial black-blood image showing significant mediastinal lymphadenopathy (arrow). (b) Axial black-blood image showing pericardial thickening and collection (arrow). (c) Coronal black-blood image showing subcarinal and right hilar lymphadenopathy (arrows). (d) Long-axis phase-sensitive inversion recovery image with abnormal inferior wall myocardial enhancement (arrow). (e and f) Axial computed tomography images confirm the pathological lymph nodes (arrows). The patient underwent an open biopsy that revealed pericardial mesothelioma.

The most relevant sequences that detected extracardiac findings were the initial localiser sequences (HASTE) within the three orthogonal planes that allowed a global view, with all incidental extracardiac findings visualised in this sequence. Other relevant sequences were the morphological post-contrast PSIR sequences in which 10 out of 109 of the findings were visualised, and cine-SSFP sequences in which five findings were visualised.

DISCUSSION

CMRI is a highly reproducible tool to assess cardiovascular diseases. In CMRI examinations, an

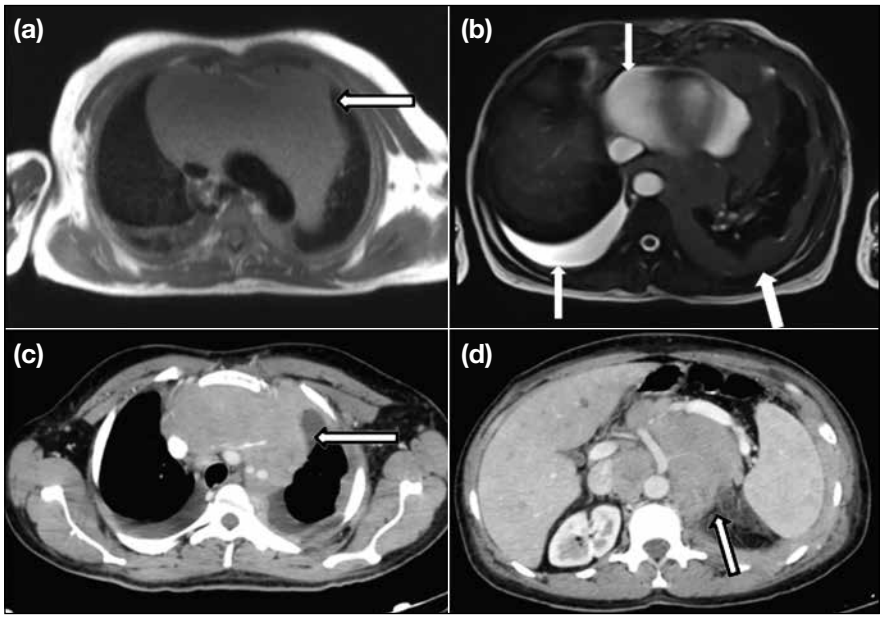

Figure 3. A 36-year-old male with B-cell lymphoma. (a) Axial black-blood cardiovascular magnetic resonance imaging showing a large anterior mediastinal mass surrounding and displacing the great vessels (arrow). (b) True fast imaging with steady-state free precession magnetic resonance imaging axial image showing lobulated soft tissue thickening of the left pleural cavity with pericardial and right pleural effusion (arrows). (c) Axial computed tomography (CT) image at the level of the chest confirms the findings in (a) [arrow]. (d) Axial CT image at the abdomen shows prominent paraaortic lymphadenopathy (arrow).

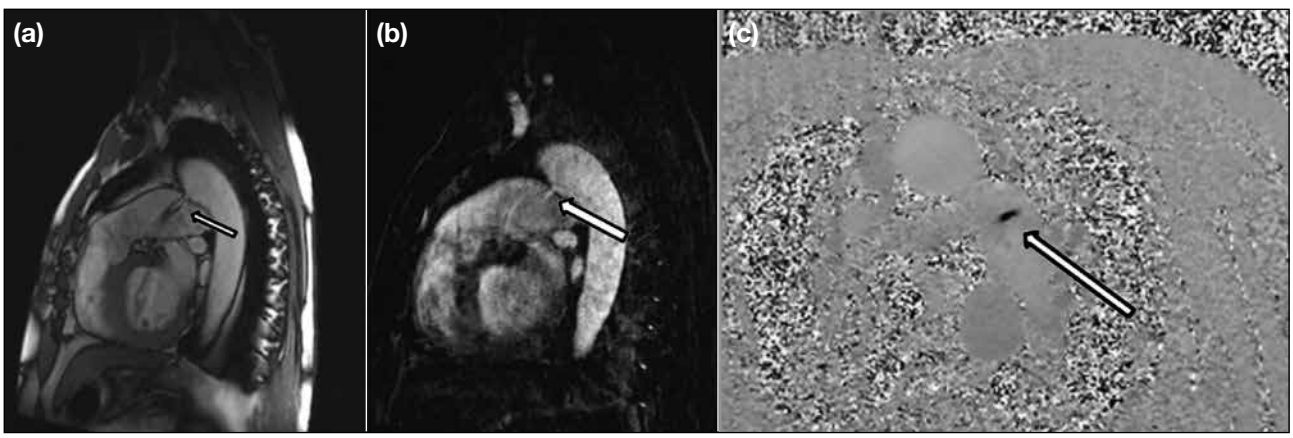

Figure 4. A 61-year-old man presented with wheezing and was suspected to have an aortic valvular disease. (a) Sagittal true fast imaging with steady-state free precession localiser magnetic resonance imaging (MRI) showing a 3-mm patent ductus arteriosus jet flow (arrow). A dilated pulmonary artery and ascending aorta can also be seen. (b) Sagittal post-contrast dynamic MRI with flow across patent ductus arteriosus (arrow). (c) Axial phase-contrast image marking the flow across the patent ductus arteriosus (arrow).

informed assessment of extracardiac structures can help detect multiple non-cardiac diseases. However, few studies in the literature have reported the prevalence and nature of incidental extracardiac findings on CMRI; although the comparisons of these studies are difficult because of different study designs (i.e., the study cohorts, clinical setting, sequences applied, and reading session format), the general agreement is that missing these incidental extracardiac findings can result in a significant delay in the appropriate management of the patients, which may be associated with progressive morbidity, as well as legal consequences and costs.[3,8,9]

For the classification of incidental extracardiac findings, we adopted the scheme proposed by Gravina et al,[3] who divided incidental extracardiac findings into three groups: (1) findings with mild or no clinical significance; (2) findings with possible clinical significance; and (3) clinically significant findings that required further diagnostic workup or the initiation of a new specific treatment different from the current treatment or ended by a non-cardiac diagnosis of the disease process of the patient. However, some other studies categorised incidental extracardiac findings as relevant if they required further diagnostic workup or the initiation

of a new specific treatment different from the current treatment or clinically irrelevant/insignificant if they necessitated no change in the patient's management.[1,9-11] Previous studies have also differed in their considerations for relevant findings. For example, Jacobs et al[12] considered pleural effusion as a potentially relevant finding, whereas other studies[10,13,14] performed a separate assessment in each case to classify the significance of the findings. In our study, we also assessed the patients individually and found that pleural effusion in all the patients was non-significant and was related to their cardiac condition since a large group of our patients had ischaemic heart disease.

Our study is consistent with other studies with regard to the significant lesions. However, the difference between our study and those of other studies was rooted in the non-significant lesions, which did not influence patient management. In our retrospective cross-sectional study with a focused review of 131 CMRI examinations (based on an image review), extracardiac abnormal findings were prevalent in 53% of the study population. Similar studies reported the rates of extracardiac abnormal findings from 10 to 62%.[7,8,15] This great variability may be attributed to differences in study designs, the use of different definitions of incidental extracardiac findings, as well as the differences in the number of patients included within the studies. In this study, we found that 3.7% of incidental extracardiac findings were clinically significant, which was comparable to other studies with reported rates of 2 to 5%.[3,10] However, a much lower prevalence of 0.9% was reported.[7] This variation could be attributed to the larger patient population included in their study, the differences in the study protocols, variations in the FOV coverage, and, possibly, the differences in the number of sections per sequence.[9]

In our evaluation of the site of prevalence of extracardiac findings either in the lower neck, chest, or upper abdomen, we found that most were localised in the chest, such as pleural effusion; this may be because most of our patients were referred for ischaemic cardiomyopathy (48.1%). Sokolowski et al[7] also reported a high association between vascular and congenital heart disease indications and a high prevalence of vascular findings and a low prevalence of major findings. Despite a male predominance in our study compared with other reports,[1,3] the overall prevalence of incidental extracardiac findings was higher in female patients (77.8% vs. 47.1%).

With regard to the influence of MRI sequences on detection of incidental extracardiac findings, we found that while the lesions could be detected in multiple sequences, 100% of such findings were identified in the HASTE sequence due to its large FOV and tissue coverage, despite the lower spatial resolution, while the single-section cine-SSFP and multi-section post-contrast PSIR sequences were useful in confirming some of these findings or limiting the differential diagnosis on the basis of signal intensity and enhancement characteristics. This is in agreement with other reports[3,16] but with the difference that they used multiplane SSFP localisers instead of HASTE. Another study[17] compared these two large-FOV sequences and stated that the transaxial balanced SSFP (bSSFP) sequence with a wide FOV is more accurate in the detection of incidental extracardiac findings than the HASTE localiser images due to its better spatial resolution. In our study, we depended on HASTE localiser images for evaluation of incidental extracardiac findings since all of these were detected in these large-FOV images, with confirmation or clarification of some of the findings in other sequences such as late post-contrast images, as a result of the poorer resolution of HASTE localiser images.

One limitation of our study and a potential source of bias is its small size, which hindered evaluation of the incidental extracardiac finding prevalence by age-group. Another limitation was the absence of histologic confirmation since many lesions were managed on the basis of suspected imaging diagnoses alone. We should also mention that our routine localised large-FOV sequence was the HASTE sequence, and we would have preferred to compare these findings to those obtained with the large-FOV bSSFP sequence, which has a higher spatial resolution and provides greater coverage in a very short time.

We recommend adding a subtitle to CMRI reports to include the extracardiac findings encountered during reporting and their significance or the further recommended management. We also recommend the use of bSSFP sequences with a wide FOV during routine CMRI in the axial and coronal planes to replace the HASTE localising sequences at the beginning of the CMRI study owing to their better resolution.

CONCLUSION

Incidental extracardiac findings are common in cardiac MRI, and, despite the low prevalence of significant

lesions (around 3% of patients), they changed patient management and facilitated the delivery of an accurate diagnosis. Hence, it is important to identify incidental extracardiac findings and clarify their significance during CMRI reporting.

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