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ORIGINAL ARTICLE

Prevalence and clinical significance of extracardiac findings in cardiovascular magnetic resonance

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Abstract *Objective:* In cardiac magnetic resonance imaging (CMR), incidental pathological findings are frequently found outside the investigated cardiovascular system. Some of these findings might have clinical implications. The aim of this study was to determine the prevalence of incidental extracardiac findings (ECF) in CMR and their clinical significance.
Methods: A total of 4165 CMR reports from 2009-2012 were retrospectively reviewed for ECF. Two hundred-twenty reports with ECF were found. For each case, we obtained information on sex, age of the patient, reported ECF and radiologist recommendation. Follow-up data were analyzed by reviewing available electronic medical records. ECF was considered clinically significant if there was an associated diagnosis, additional treatment or further investigations in the clinical follow-up data.
Results: In total, 356 ECF were recorded in 220 (5.3%) CMR reports. Sixty (23.7%) of the 253 ECF with follow-up data available were clinically significant. The most prevalent ECF were pleural effusions (n = 54), kidney cysts (n = 54), diffuse lung parenchyma changes (n = 33) and liver cysts (n = 29). Adrenal pathology (n = 3, 100% significant), renal masses (n = 3, 100%) and pulmonary masses (n = 5, 62.5%) were the most clinically significant ECF. Although prevalence of these ECF was low, they were significant particularly frequently. When radiologist recommendations for further investigation were present in the report, the frequency of clinically significant ECF was higher compared to reports with no further investigation recommended ($p < 0.001$).
Conclusion: In this study, ECF in CMR were reported not very commonly (5.3%). A substantial part of ECF was clinically significant, changing patient diagnosis or management, with an overall prevalence of 1.3%.

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1. Introduction

Cardiac and cardiovascular magnetic resonance imaging (CMR) is increasingly used to visualize and evaluate the cardiovascular system.[1–4] Wide spatial coverage of this imaging technique, capturing anatomical regions of the thoracic and upper abdominal cavity, may lead to incidental pathological findings outside the investigated cardiovascular system, e.g., in the adjacent organs — lungs, kidneys, and so on.

Incidental findings are observed in various imaging modalities. They are particularly relevant for high resolution cross-sectional imaging, e.g., computed or magnetic resonance tomography, with their potential clinical benefits and challenges being debated.[5–8] Reported prevalence of extracardiac findings (ECF) in cardiac MRI range from 7.6%[9] to 81%.[10] Some of these ECF might have clinical implications including result in a new diagnosis, lead to further investigations or require early treatment. A few studies have sought to evaluate the prevalence of ECF in CMR;[9–14] however, information about the clinical significance is scarce. Only a few studies analyzed the clinical follow-up of the incidental findings, with a limited study population and different evaluation methods.[9,11,14]

This study aimed to determine the prevalence of ECF in a large set of clinically indicated CMR and their clinical significance by reviewing how they reflect the subsequent diagnosis, further investigations and treatment plan of the patient.

2. Methods

The study retrospectively analyzed reports of clinically indicated CMR performed at a single academic hospital from January 1, 2009, to October 2, 2012. In total, 4165 clinical CMR reports were reviewed. This study was performed in accordance with the regulations of the local ethics committee, approval Nr. 158200-13-576-178, 2013-02-12.

CMRs were performed on a 1.5 T Siemens Avanto system (Siemens Medical Solutions, Erlangen, Germany) following a standard protocol (including spin echo — black blood coronal and axial sequences, gradient ECHO sequences, dynamic images: short axis, four chamber and three chamber views, myocardial perfusion sequence and delayed contrast enhancement sequences). As a result of scanning both the heart and the major vessels, CMR scans covered the thoracic and abdominal cavities to the bifurcation of aorta. All scans were analyzed by 2 general radiologists, 10 and 20 years after completion of training, respectively, and with 7 and 10 years of cardiovascular imaging experience.

From the 4165 reports analyzed, 220 CMR reports included at least one ECF. Further data obtained from these reports included sex, age, reported ECF and subjective radiologist recommendations for additional follow-up or different imaging modality investigations. Normal anatomical variation was not considered as ECF. ECF was defined as any pathological extracardiac finding in the CMR scan. Both potentially malignant and generally benign ECF were recorded, with no exclusion criteria regarding size, location, and so on. ECF were then grouped into broader categories according to their location and appearance (focal/diffuse) (e.g., liver mass or diffuse liver disease). Renal and hepatic cysts (i.e., focal lesions with signal intensity of water) were considered separately from other focal masses due to their benign character. Rare pathologies (e.g., spinal scoliosis, other spine deformities, and hemangiomas) were grouped according to the organ or system affected (e.g., spinal pathology).

To assess the clinical implications of ECF, follow-up data were analyzed by reviewing the electronic medical records database of the hospital. According to the follow-up data, ECF (for which data were available) were classified as clinically significant or insignificant. ECF were considered clinically significant if in the follow-up data there was an associated clinically relevant diagnosis, planned or completed treatment or further investigation of the ECF. Findings that were for some reason noted in the diagnosis but did not require any clinical attention (e.g., simple renal cyst) were considered insignificant.

2.1. Statistical analysis

Statistical analysis was performed with commercially available software (SPSS Inc., version 18.0, Chicago, IL, USA). Averages are presented with ±1 standard deviation (SD). Categorical variables are presented as frequencies and percentages and compared using the chi-square test. Continuous variables were compared using two tailed Student's *t* test. Associations were considered significant at *P* value <0.05.

3. Results

3.1. Prevalence

A total of 4165 unique CMR cases were reviewed. ECF were reported in 220 (5.3%) cases, including 135 men and 85 women (age range from 9 to 86, mean age 44.7 ± 20.8 years). In 97 (44.1%) of these cases, more than a single ECF was reported. In total, 356 ECF (on average 1.62 ± 0.85 for a patient) were found. Examples of ECF are shown in Figures 1, 2 and 3.

The most frequent ECF were pleural effusions, kidney cysts, diffuse lung changes, and liver cysts (Table 1). ECF were most frequently localized in lungs and pleura n = 107 (30.1%), kidney and adrenal glands n = 89 (25.0%) and the liver n = 57(16.0%). These localizations are consistent with the spatial extent of CMR imaging in this study — thoracic and upper abdominal cavities.

3.2. Clinical Significance

Clinical follow-up was available for 253 (71.1%) ECF, or for 151 patients in total. From these, 60 (23.7%) ECF proved to be clinically significant. For 37 (24.5%) patients with follow-up, at least one ECF was clinically significant, resulting in an overall prevalence of 1.3%. The most common clinically significant ECF were pleural effusion (n = 11, 18% of all significant ECF), diffuse lung changes (n = 7, 12%), hepatic mass (n = 6, 10%), hepatic cyst (n = 6, 10%) and pulmonary

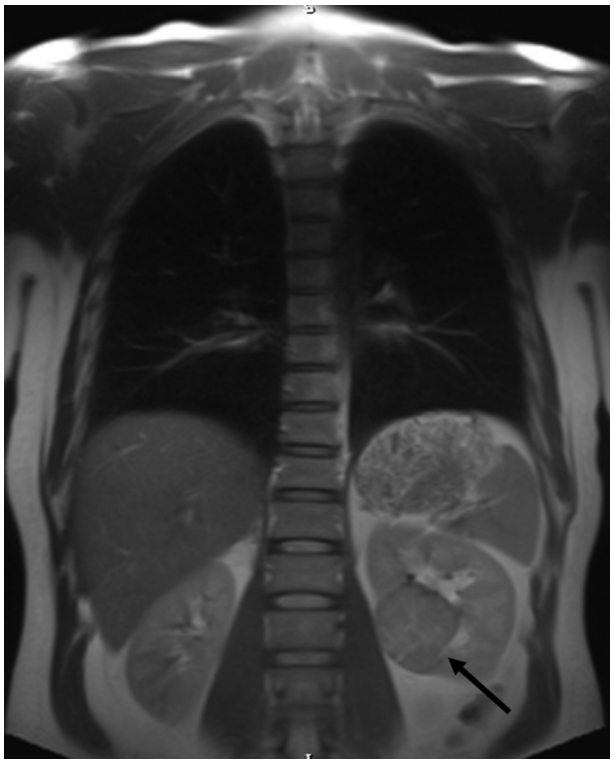

Figure 1 An extracardiac finding in CMR — renal mass (black arrow). T2_haste coronal view.

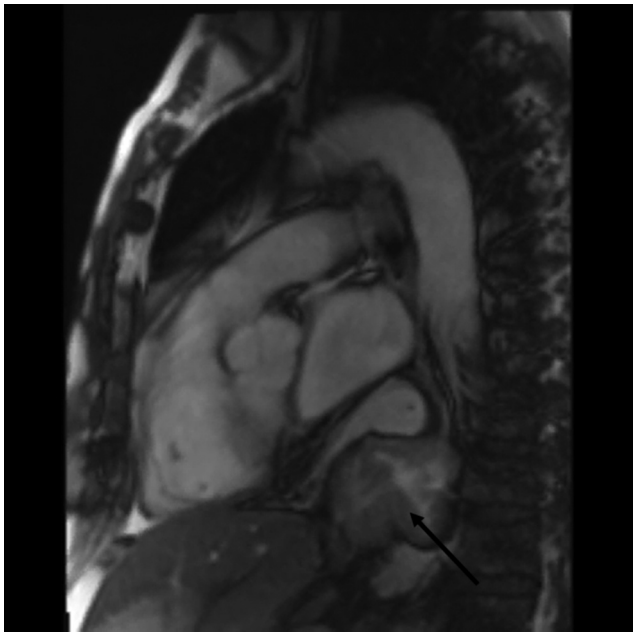

Figure 2 An extracardiac finding in CMR — hiatal hernia (black arrow). GRE sagittal view.

nodule (n = 5, 8%). Clinical significance of ECF did not correlate with patient age (p = 0.755) and did not vary based on sex (p = 0.626).

Relative clinical significance for a particular ECF was defined as the proportion of the significant to total ECF

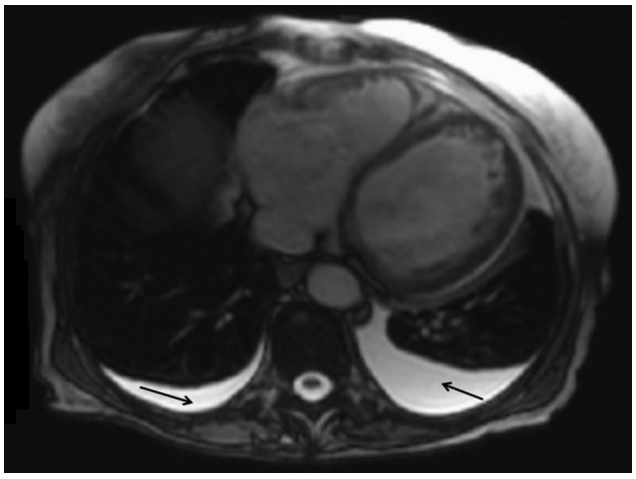

Figure 3 An extracardiac finding in CMR — bilateral pleural effusion (black arrows). SSFP axial view.

Table 1 Prevalence of extracardiac findings in CMR (n = 356).

ECF	Total, N	% of all ECF
Pleural effusion	54	15.2
Renal cyst	54	15.2
Diffuse lung changes	33	9.3
Hepatic cyst	29	8.1
Accessory renal artery	21	5.9
Mediastinal lymphadenopathy	19	5.3
Hepatic mass	16	4.5
Pulmonary nodule	16	4.5
Gallstones	16	4.5

(e.g., clinically significant pleural effusions to total pleural effusions). Relatively, the most clinically significant ECF were adrenal pathology (100%, i.e., all cases proved to be clinically significant), renal mass (100%) and pulmonary nodule (62.5%). Thus, although the prevalence of these ECF was rather low, they were clinically significant particularly frequently (see Table 2).

Radiologist recommendations for follow-up investigations (e.g., with a different modality or after a certain period of time) in CMR reports were included for 101 (28.4%) ECF or 55 (25.0%) patients. From the latter, follow-up data were available for 30 patients. ECF were clinically significant more frequently if radiologist recommendations were present ($p < 0.001$).

The number of ECF in a case correlated with their clinical significance — the more ECF were found, the more likely at least one of them was clinically significant (p = 0.014).

4. Discussion

This study aimed to determine the prevalence and clinical significance of ECF in cardiovascular magnetic resonance. If ECF resulted in a new diagnosis, modified treatment plan, or was additionally investigated or imaged, it was deemed

Table 2 Relatively the most clinically significant extracardiac findings with follow-up.

ECF	Clinically significant, N	Total, N	% of clinically significant
Adrenal pathology	3	3	100
Renal mass	3	3	100
Pulmonary nodule	5	8	62.5
Hepatic mass	6	11	54.4
Hydronephrosis	2	4	50.0
Liver parenchyma changes	2	4	50.0
Breast lesion	1	2	50.0
Ascites	2	5	40.0

Note. ECF that were found only once are omitted due to low statistical reliability.

clinically significant. In this study, we found ECF in 5.3% of CMR. This result is similar to the 7.6% prevalence found in a smaller study by Chen et al.[9] Approximately a quarter of ECF were clinically significant in the follow-up — with an overall prevalence in CMR of 1.3%.

The majority of incidental findings outside the investigated system are clinically irrelevant or insignificant — anatomical variations or benign minor changes, such as simple cysts. However, they might also reveal clinically significant pathologies in early stages. Early treatment of such incidental pathologies (e.g., gall stones, early stage kidney or lung tumor) might prevent their progression, complications and eventually lead to better outcomes. On the other hand, further investigation of an incidental benign finding might be redundant and survival might not be improved.[15] Therefore, it is important to discriminate between clinically significant and insignificant ECF and to decide which should be treated and which could be left alone.

A few studies have investigated this topic using different designs and thus, making it difficult to compare their results. To determine the prevalence of ECF, it is possible to conduct CMR on a random group of volunteers or to analyze CMR cases already conducted for clinical indications. Furthermore, clinical CMR can be specifically reviewed for the second time in search of ECF or ECF can be tracked in the original reports. All study designs provide different insights into the topic, but they also render studies difficult to compare.

The prevalence of ECF is the largest if they are specifically sought for. McKenna et al found an 81% prevalence of ECF in CMR in a group of volunteers,[10] while Khosa et al found 43% ECF prevalence with a second revision of clinically indicated CMR.[11] Analyzing the original clinical CMR reports, Chan et al found a smaller prevalence of ECF — 7.6%.[9] This rate is similar to our result (5.3%), as the study designs were quite similar.

The definition of clinically significant or important ECF is another source of confusion. Some studies have employed an a priori definition and deliberately grouped ECF as minor and major,[13] potentially significant,[12] benign, indeterminate or worrisome.[11] The allocation was usually based on known clinical correlations or expected need for further investigation. However, a priori allocation might not be accurate, as the same finding might be benign in one case and significant in another.

Atalay et al[14] defined all ECF included in the impression section of the original cardiac MRI report as important and all ECF that resulted in a new diagnosis, intervention or treatment as significant. We used the same definition for the clinically significant ECF in this study. The prevalence of important ECF in the Atalay et al study was 27% compared to 5.3% in our study. The prevalence of significant ECF was 5% compared to 1.3%, respectively. However, the surveyed population was considerably bigger in our study (4165 subjects compared to 240).

Chan et al[9] called an ECF significant only if an intervention or a change in the patient's management ensued, excluding ECF that changed diagnosis only and ECF that were known previously. This narrow definition led to a small prevalence of significant ECF — 0.4%. In our study, we did not have information on whether ECF was previously known. However, even when a finding is already known, additional incidental imaging may be valuable as a follow-up opportunity. Changes or persistence of the incidentally found pathology may provide important information, helping to decide not to treat a patient unnecessarily.

Different prevalences reported in the studies could have a few explanations. Firstly, more ECF are found with the dedicated second revision of CMR (Chan et al[9]). Radiologists tend to register only some, but not all, minor changes or variations in the original clinical setting. This is especially the case for clinically insignificant ECF that are not expected to change the treatment plan of the patient. Secondly, the choice of the radiologist of which ECF to include in the report is sometimes subjective. In the follow-up of this study, it was noticed that nominally identical ECF (e.g., renal or liver cyst) were included in the diagnosis inconsistently. In other words, the same ECF could be considered significant in one case and insignificant in another. This might mean that the definition of a significant ECF should be further elaborated. A valuable insight would also be to learn whether ECF inclusion in the diagnosis depends on a subjective choice of the doctor, patient's previous medical history, present status, comorbidities or other factors.

In this study, ECF were also rated according to their relative clinical significance. This was performed to highlight some relatively rare ECF that were clinically significant always or very frequently. This could signal that they are associated with more grave or urgent conditions, and a special attention should be paid. For instance, such relatively more significant ECF were adrenal pathology, renal mass and pulmonary nodule. In contrast, ECF that constituted the major part of significant ECF but were relatively less important (e.g., pleural effusion, 24% of cases significant; diffuse lung changes, 29% of cases significant) were associated with milder diagnoses or were signs of complications, such as pneumonia.

Despite a large sample of patients and follow-up data, this study is subject to a few limitations. Due to the retrospective design, follow-up data were not available for all patients, and it was also not known whether ECF had already been found before. Additionally, we did not perform a separate dedicated reading of the actual CMR scans and focused only on the data from an original clinical

setting. Thus, the actual prevalence of ECF (as compared to the prevalence in original clinical setting) could be higher. More ECF, especially insignificant and minor findings, might be detected with a second reading.

In conclusion, although the incidental findings outside the investigated system in cardiovascular magnetic resonance are quite rare, a tangible part of them is clinically significant and might change a patient's diagnosis, lead to further investigations, intervention or treatment and therefore should not be dismissed.

Conflict of interests

None.

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