Cardiovascular findings on computed tomography in patients with unclear finding situation and trauma of unknown origin

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Abstract
Incidental cardiovascular findings are common and can be found in up to 70% of patients. Previously, several reports about incidental findings (IFs) on whole body computed tomography (CT) were published. However, no previous study investigated cardiovascular IFs in patients with unclear finding situation and trauma of unknown origin on whole body CT.

The radiological database of 2 university hospitals was screened for patients with trauma of unknown origin and unclear finding situation investigated by whole body CT. The images were retrospectively analyzed by 2 radiologists in consensus. The findings were classified according to their clinical relevance. Clinically nonrelevant findings like valvular sclerosis, aortic sclerosis, or anatomic variants were excluded from this study. Moreover, the radiology reports were analyzed to assess initial reporting by the radiologist.

Overall, we identified 60 patients with a mean age of 63 years. A total of 98 clinically relevant cardiovascular IFs (CRCIF) were identified in 60 (75%) patients (1.6 CRCIF per patient). The most prevalent finding was cardiomegaly in 23 patients, followed by coronary sclerosis in 21 patients and aortic ectasia in 11 patients; other findings were rarer. Sixty-one findings were reported (62.2%) and 37 were nonreported (37.8%). Thirty patients (50%) showed no traumatic event on whole body CT.

CRCIFs are common in patients with unclear finding situation and trauma of unknown origin. Despite initial indication for trauma detection, the whole body CT should carefully be evaluated for CRCIF because of the high prevalence of clinically relevant findings. Notably, 37.76% of the findings were not reported by the radiologist.

Abbreviations: CT = computed tomography, CRCIF = clinically relevant cardiovascular incidental finding, IF = incidental finding.

Keywords: cardiovascular finding, incidental finding, whole body CT

1. Introduction
Incidental findings (IF) are defined as findings that are not related to the scope of the ordered investigation\textsuperscript{[1,2]}

According to the literature, IFs are common and can be detected in up to 70% of all imaging investigations\textsuperscript{[2,3]}. As reported previously, most IFs are of low clinical relevance\textsuperscript{[2,3]}. For example, the most findings are simple renal or liver cysts, gall bladder stones, or colonic diverticula\textsuperscript{[3]} However, some IFs, such as pulmonary embolism or malignant tumors, can be more relevant to the clinical course of the patient than the initial reason of the imaging investigation\textsuperscript{[4,5]}. Different cardiovascular findings represent a frequent group of clinically relevant cardiovascular IF (CRCIF)\textsuperscript{[6,7]}. They comprise disorders like aneurysms, calcifications of the heart valves and arteries, and thromboembolisms, which can sometimes be clinically asymptomatic and require no further work up or need therapeutic interventions like a large aortic aneurysms\textsuperscript{[6,7]}

Whole body computed tomography (CT) is a widely used imaging modality for whole body imaging in trauma patients to detect possible hazardous injuries\textsuperscript{[8]}. Notably, the rising usage leads to an increasing detection rate of IFs in trauma patients\textsuperscript{[9]}. Previously, the rate of IFs was up to 75% on whole body CT in trauma patients\textsuperscript{[10–17]}. Moreover, some IFs are not reported by the radiologist. An explanation might be that they were not seen by the radiologist or they were valued as not important enough to be reported\textsuperscript{[18]}. For this reason, the rate of IFs on whole body CT might be higher than described in the literature because some studies investigated only radiological reports and therefore might not detect every IF\textsuperscript{[10,14,16,17]}

It is a common incidence in emergency medicine to find an unconscious patient without any further information regarding the actual accident or anamnestic features of known disorders of the patient. These patients are frequently investigated by whole body CT to rule out a possible trauma and to gain crucial information about other hazardous disorders. In our daily clinical experience, we identified that these patients tend to show more cardiovascular than traumatic findings despite the primary indication for trauma evaluation. Therefore, the reason for this...
study was to evaluate clinically relevant cardiovascular IFs (CRCIFs) on whole body CT in this selective patient collective.

2. Patients and methods

This retrospective study was approved by the institutional ethics board and informed consent was waived.

2.1. Patient collective

In the time period between 2007 and 2016 radiological databases of 2 university hospitals (Martin-Luther University Halle-Wittenberg and University Hospital Leipzig) were screened for patients with unclear finding situation and trauma of unknown origin investigated by whole body CT. Overall, 1366 patients were investigated with whole body CT. Then, we screened the electronic patient records with search terms “unclear finding situation,” “unclear trauma,” and “unknown trauma.” Finally, 60 patients (4.4% of all patients investigated with whole body CT) were identified and included in this study. There were 38 men (63.3%) and 22 women (36.7%) with a mean age of 63 years (range 18–93 years). There were no previous anamnestic information regarding known disorders of the patients.

2.2. Computed tomography technique

Computed tomography (Somatom Sensation 64; Siemens, Erlangen, Germany, and Brilliance, Philips Medical Systems, Cleveland, OH) was performed in all patients. In all cases, 60 to 140 mL of iodinated intravenous contrast medium was given at a rate of 1.5 to 3.5 mL/s by a power injector (Medtron GmbH, Germany), with a scan delay of 30 to 90 seconds after onset of injection. Typical imaging parameters were 120 kVp, 150 to 300 mAs, and 0.6 to 6 mm slice thickness with a pitch of 0.6 to 1.0.

2.3. Image analysis

The CT images of all patients were reinterpreted by 2 radiologists (HJM and DS with 1 and 6 years of experience in computed tomography, respectively) by consensus. All images were available in digital form.

IFs findings were classified according to Lumbreras et al[3] for the clinical relevance. This classification is widely used for IFs and uses 3 categories (major, moderate, and minor clinically relevance) to divide IFs. A major finding implicates changes of the patient’s clinical course, for example, a new-found malignancy, whereas a minor finding is a simple cyst with no further diagnostic or therapeutic relevance. A moderate finding is in between and might need a diagnostic follow-up. Only major clinically relevant and moderate relevant IFs were included into this study. Minor clinically relevant findings like valvular sclerosis, aortic sclerosis, or anatomic variants were excluded.

At last, the radiology report was analyzed, whether the diagnosis was made by the radiologist or not. Figure 1 displays several different CRCIFs found in this patient sample.

2.4. Statistical analysis

Statistical analysis was performed using GraphPad Prism (GraphPad Software, La Jolla, CA). Collected data were evaluated by means of descriptive statistics. Continuous variables were expressed as mean ± standard deviation and categorical variables as percentages. Fisher exact test was used to compare between the groups of reported and nonreported IFs. An alpha level of 0.05 was chosen for statistical significance.

3. Results

Overall, 98 CRCIFs were identified in the 60 patients (1.6 CRCIF per patient). In 15 patients (25%), no CRCIFs were identified. An overview about all findings and their frequencies is given in Table 1. The most frequent finding was cardiomegaly (23 patients, 23.5% of all findings), followed by coronary sclerosis (21 patients, 21.4% of all findings), and aortic ectasia (11 patients, 11.2% of all findings). Other CRCIFs were rarer.

Traumatic events were detected in 30 patients (50%) and 30 patients (50%) showed no traumatic event on whole body CT.

Figure 1. (A) Cardiomegaly and coronary sclerosis in a 76-year-old female patient. Both findings were reported by the radiologist. (B) Deep venous thrombosis of both femoral veins in a 77-year-old male patient (arrow). No thrombosis was reported by the radiologist. (C) Pulmonary artery embolism of the right lower pulmonary artery in a 73-year-old male patient (arrow). This finding was reported by the radiologist. (D) A large heart thrombus and cardiomegaly in a 65-year-old female patient. The arrow points at the thrombus. Both findings were not reported.
Sixty-one findings were reported (62.2%) and 37 (37.8%) were not reported by the radiologist (Table 2). Divided according to the clinical relevance, both major as well as moderate clinical relevant findings were more reported than not reported. Moderate clinical findings were more reported than the major findings. Table 3 summarizes the report state grouped according to the diagnosis. The stenosis group was more reported than not reported.

4. Discussion

To the best of our knowledge, this study is the first study that investigated CRCIFs in patients with unclear finding situation and trauma of unknown origin on whole body CT. Previously, several reports were published about IFs in polytrauma patients. The overall rate of IFs ranges from 34% to 75%. However, clinically relevant findings were rare and ranged from 2.9% to 15%. Furthermore, the frequency of relevant cardiovascular findings was low. For instance, Kroczeke et al found in their collective of 2440 patients clinically relevant cardiovascular findings in 345 cases (14.14%). Cardiomegaly was the most prevalent finding in 146 patients, followed by 64 patients with coronary sclerosis. In the study of Mukan et al, clinically significant cardiovascular findings were identified in 2.29%.

In the present study, CRCIF were found in 75% of the analyzed cases. In agreement with some previous reports, most frequently cardiomegaly, coronary artery sclerosis, and aortic ectasia occurred. However, potential urgent findings, such as pulmonary embolism, cardiac or arterial vessel thrombus, and several aneurysms were also diagnosed. Overall, major clinical findings accounted for 46.9% of all identified CRCIFs.

This rate is extremely high and may be explained by the older age of our patients. It is known that older patients have more IFs than younger patients. Presumably, several cardiovascular diseases may be the main cause of unclear finding situation in our patients. This is confirmed by the fact that traumatic events were identified in only 50% of the cases. Therefore, in this patient group, the cardiovascular system should be thoroughly assessed by the radiologist and cardiovascular findings should be categorized as major but not as incidental in the radiology report.

Notably, almost one-third of the cardiovascular findings in our study were not reported. This is in agreement with some previous studies regarding chest CT. For example, Sverzellati et al found an even higher rate of unreported findings of 63.2%. Other studies showed similar results. The authors reasoned that the radiologist concentrate on the lungs and not on the heart. Regarding nonreported CRCIFs in our study, there are several reasons to be recognized. The whole body CT is first interpreted by a resident radiologist with only few years of experience in CT imaging in a setting in which the diagnosis must be made fast. This might be the main reason, why the findings are not reported. Furthermore, we hypothesize that the radiologist concentrates on possible trauma manifestations and not on the cardiovascular system because an underlying trauma is suspicious by clinicians. Therefore, many findings might be overlooked in this way. Our results confirm this assumption. As seen, almost half of CRCIFs were not reported. Interestingly, arterial stenoses were more often reported in comparison to other significant cardiovascular findings. Furthermore, the moderate clinically relevant findings were reported in up to 67.3%, whereas major clinically relevant findings were reported in 58.7% of cases. This result is also unclear because major clinically relevant findings have a more important impact on the patient’s course than the moderate findings. Therefore, the radiologist should be sensitized for CRCIF on whole body CT.

Another reason might be that some findings like coronary sclerosis or cardiomegaly are noticed by the radiologist but not written down in the report because of its high frequency in daily routine, although these findings might be clinically relevant for the course of the patient. At last, Fakler et al reported that only about half of the IFs were properly reported in the discharge summary indicating that a lot of findings are not sufficiently reported to the forwarding physician. This loss of information might be crucial for the patient.

5. Limitations

There are several shortcomings of this study. First, it has a retrospective design and, therefore, we could not follow-up the
possible clinical impact of those IFs. Second, our study sample is relatively small resulting in possible selection bias. However, we recruited our study sample from 2 hospitals to improve the external validity. Third, the reporting style was specific for 2 German university hospitals and, therefore, other institutions might report IFs in another fashion.

In conclusion, CRCIFs are common in patients with trauma of unknown origin and unclear finding situation. Furthermore, 37.76% were not reported by the radiologist. Despite the indication of trauma evaluation, the whole body CT should carefully be evaluated for CRCIF because of the high prevalence of clinically relevant findings.

References
[1] Wolf SM, Lawrenz FP, Nelson CA, et al. Managing incidental findings in human subjects research: analysis and recommendations. J Law Med Ethics 2008;36:219–48.
[2] Orme NM, Fletcher JG, Siddiki HA, et al. Incidental findings in imaging research: evaluating incidence, benefit, and burden. Arch Intern Med 2010;170:1525–32.
[3] Lumbreras B, Donat L, Hernández-Aguado I. Incidental findings in imaging diagnostic tests: a systematic review. Br J Radiol 2010;83:2769–89.
[4] Furtado CD, Aguirre DA, Sirlin CB, et al. Whole-body CT screening: spectrum of findings and recommendations in 1192 patients. Radiology 2005;237:385–95.
[5] Surov A, Bach AG, Tcherkes A, et al. Non-osseous incidental findings in low-dose whole-body CT in patients with multiple myeloma. Br J Radiol 2014;87:20140185.
[6] Surov A, Bach AG, Schramm D. Clinically relevant cardiovascular findings detected on staging computed tomography in patients with several malignancies. Angiology 2016;67:630–7.
[7] Schramm D, Bach AG, Meyer HJ, et al. Thrombotic events as incidental finding on computed tomography in intensive care unit patients. Thromb Res 2016;141:171–4.
[8] Salim A, Sangthong B, Martín M, et al. Whole body imaging in blunt multisystem trauma patients without obvious signs of injury: results of a prospective study. Arch Surg 2006;141:468–73.
[9] Treskes K, Bos SA, Beenen LF, et al. High rates of clinically relevant incidental findings by total-body CT scanning in trauma patients; results of the REACT-2 trial. Eur Radiol 2017;27:2451–62.
[10] Fakler JK, Özkerül O, Josten C. Retrospective analysis of incidental non-trauma associated findings in severely injured patients identified by whole-body spiral CT scans. Patient Saf Surg 2014;8:36.
[11] Kroczeuk EK, Wieners G, Steffen I, et al. Non-traumatic incidental findings in patients undergoing whole-body computed tomography at initial emergency admission. Emerg Med J 2017;34:643–6.
[12] Paluska TR, Sise MJ, Sack DI, et al. Incidental CT findings in trauma patients: incidence and implications for care of the injured. J Trauma 2007;62:157–61.
[13] Barrett TW, Schierling M, Zhou C, et al. Prevalence of incidental findings in trauma patients detected by computed tomography imaging. Am J Emerg Med 2009;27:428–35.
[14] Munk MD, Feitman AB, Hostler DP, et al. Frequency and follow-up of incidental findings on trauma computed tomography scans: experience at a level one trauma center. J Emerg Med 2010;38:346–50.
[15] Hofstetter P, Herold T, Daneschnejad M, et al. Non-trauma-associated additional findings in whole-body CT examinations in patients with multiple trauma. Rodo 2008;180:120–6.
[16] Sierink JC, Salzther HP, Russchen MJ, et al. Incidental findings on total-body CT scans in trauma patients. Injury 2014;45:840–4.
[17] Seba MK, Murphy CG, McDonald S, et al. Incidental findings on whole-body trauma computed tomography: experience at a major trauma centre. Injury 2016;47:691–4.
[18] Sverzellati N, Arcadi T, Salvolini L, et al. Under reporting of cardiovascular findings on chest CT. Radiol Med 2016;121:190–9.
[19] Bach AG, Beckel C, Schurg N, et al. Imaging characteristics and embolus burden of unreported pulmonary embolism in oncologic patients. Clin Imaging 2015;39:237–42.
[20] Quentin M, Kropil P, Steiner S, et al. Prevalence and clinical significance of incidental cardiac findings in non-ECG-gated chest CT scans. Radiol Med 2011;51:59–64.
[21] Choy G, Kropil P, Scherer A, et al. Pertinent reportable incidental cardiac findings on chest CT without electrocardiography gating: review of 268 consecutive cases. Acta Radiol 2013;54:396–400.