Frequency and spectrum of incidental findings when using chest CT as a primary triage tool for COVID-19

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HIGHLIGHTS

- Of the 232 participants triaged with chest CT for COVID-19, 126 (54 %) showed one or more incidental findings (IF).
- 53 Participants (23 %) showed a potentially significant IF.
- A potentially significant IF requires further diagnostic or clinical work up.
- The most common potentially significant IFs were coronary artery calcifications, suspicious breast- and pulmonary nodules.

ARTICLE INFO

ABSTRACT

Purpose: To determine the prevalence and spectrum of incidental findings (IFs) identified in patients undergoing chest CT as a primary triage tool for COVID-19.

Methods: In this study 232 patients were triaged in our COVID-19 Screening Unit by means of a chest CT (March 25–April 23, 2020). Original radiology reports were evaluated retrospectively for the description of IFs, which were defined as any finding in the report not related to the purpose of the scan. Documented IFs were categorized according to clinical relevance into minor and potentially significant IFs and according to anatomical location into pulmonary, mediastinal, cardiovascular, breast, upper abdominal and skeletal categories. IFs were reported as frequencies and percentages; descriptive statistics were used.

Results: In total 197 IFs were detected in 126 patients (54 % of the participants). Patients with IFs were on average older (54.0 years old, SD 16.6) than patients without IFs (44.8 years old, SD 14.6, P < 0.05). In total 60 potentially significant IFs were detected in 53 patients (23 % of the participants). Most often reported were coronary artery calcifications (n = 23, 38 % of total potentially significant IFs/ 10 % of the total study population), suspicious breast nodules (n = 7, 12 % of total potentially significant IFs/ 3% of the total study population) and pulmonary nodules (n = 7, 12 % of total potentially significant IFs/ 3% of the total study population).

Conclusion: A considerable number of IFs were detected by using chest CT as a primary triage tool for COVID-19, of which a substantial percentage (23 %) is potentially clinically relevant.

1. Introduction

Since the start of the pandemic, chest computer tomography (CT) has been used for diagnosis and follow up in symptomatic patients suspected of Coronavirus Disease 2019 (COVID-19). In the early stages, our hospital was forced to adopt the advice as mentioned in the multinational statement paper from the Fleischner Society: "to use chest CT as a rapid primary triage tool, especially in epidemic regions that suffer from scarcity of RT-PCR testing material", which unfortunately was the case in our hospital during the first weeks of the pandemic [1–3].

The sensitivity of chest CT to COVID-19 related pneumonia is good; sensitivity is comparable to the use of reverse transcriptase-polymerase chain reaction (RT-PCR) assay [4]. The typical imaging appearance of a COVID-19 related pneumonia includes peripherally located ground glass

and - in a later stadium - more consolidative abnormalities, with a predominance in basal and posterior lung fields [5–9]. Apart from these COVID-19 related abnormalities, the use of CT as a triage tool will unavoidably lead to incidental findings (IFs), since lung parenchyma but also surrounding extrapulmonary structures of mediastinum, cardiovascular system and upper abdomen are imaged. Moreover, since a scan protocol without intravenous contrast medium is used, IFs may be inadequately characterized.

Although the use of chest CT as a triage tool for COVID-19 is relatively new, studies in the setting of coronary artery disease and lung cancer screening have shown that IFs are not uncommon [10]. The bulk of these IFs are without clinical implication. A small amount could be considered as potentially significant, with wide ranges varying between 3 and 42 % depending on the scoring method and definition of IF [10–18]. The identification of IFs is on the one hand desirable: the detection of clinically silent, potentially serious lesions at an early stage contributes to decreased morbidity and mortality. On the other hand, further diagnostic work up of IFs leads to additional costs, anxiety, time and risk of iatrogenic complications [19].

The use of chest CT as a primary triage tool for COVID-19 is a form of "targeted screening". It is not asymptomatic individuals that are screened, but patients with a clinical suspicion of a COVID-19 pneumonia. The aforementioned coronary artery disease and lung cancer screening trials could also be considered a form of targeted screening, including participants of a certain age with a former or current history of smoking. Although IFs in these screening trials have been reported on in multiple publications, no data on IFs in the COVID-19 screening population has been reported before. We believe that the population of our COVID-19 screening database has a different composition including a lower age group with fewer risk factors, which could have consequences for the number and type of IFs. This lead to the purpose of the present study: to retrospectively determine the prevalence and spectrum of IFs seen in patients undergoing chest CT used as a primary triage tool for COVID-19.

2. Methods

2.1. Participants

Data were collected from our screening program for COVID-19. From March 25 till April 23 2020, 232 patients suspected of having COVID-19 were triaged in our COVID-19 Screening Unit (CSU), a tent including a mobile CT scanner that was set up next to the emergency department of our hospital. Outpatients were referred to the CSU via their general practitioner, the national corona check app [20], or were brought in by ambulance. The intention of a separate CSU was to screen patients suspected for COVID-19 pneumonia and to identify patients in need of hospitalization, and to keep our emergency department uncontaminated and accessible for regular emergency patients. Patients were considered suspicious for COVID-19 if they had fever, cough or shortness of breath; no asymptomatic patients were screened. Exclusion criteria comprised age younger than 18 years old, pregnancy, reduced consciousness and critical clinical condition (i.e. SpO2 < 88 %, respiratory frequency > 30/min, systolic blood pressure < 100 or mean arterial pressure < 60, oxygen requirement > 5 L).

After being included in the screening program, all 232 CSU patients directly underwent a triage CT scan and were included in this study. Due to scarcity of RT-PCR tests in our region, we only confirmed diagnosis by RT-PCR testing in patients that were admitted in our hospital. Clinical data of all CSU patients, data on the need for hospitalization and following RT-PCR testing will be reported elsewhere [21]. The institutional ethical review board approved of this retrospective study.

2.2. Imaging protocol

Scans were performed with a 16-slice multidetector CT scanner (Philips Brilliance, Philips, Best the Netherlands). The scan protocol did not include the use of intravenous contrast medium. Patients were scanned in caudocranial direction, from lung bases including posterior recess to lung apex, with the help of a scout view. A single breath hold protocol of 100 mAs and 120 Kv was used, with pitch 0.938 and rotation time 0.5 s. Mean general effective radiation dose was 2,9 mSv (SD 1.0). Axial images were reconstructed with 1.0 mm slice thickness and 0.5 mm increments (16 s breath hold scan). For dyspneic patients the protocol comprised 2.0 mm slices with 1.0 mm increments (8 s breath hold scan). Images were reconstructed with a hard reconstruction algorithm for lung parenchyma as well as a soft reconstruction algorithm for soft tissues.

Scans were read in consensus by teams of two radiologists on service at the CSU (between 6 and 21 years of experience) for the presence of COVID-19-related pneumonia and any other pulmonary or extrapulmonary abnormalities. Both lung and soft tissue windows were read. Because the purpose of the CT triage was the detection of COVID19-related pneumonia or other infectious alternative diagnosis, the description of IFs was left to the discretion of the reading radiologists and there were no established criteria for the identification and reporting of these findings.

2.3. Incidental findings

All original CT reports were evaluated retrospectively by IK for the description of IFs, which were defined as any finding in the report not related to the purpose of the scan. If the radiologists report was not clear, corresponding images were reviewed by IK and JP (chest radiologists with respectively 6 years and 17 years of experience). Documented IFs were extracted as free text and were subsequently categorized in two manners. Firstly, into minor and potentially significant IFs according to clinical relevance (Table 1). Findings were considered potentially significant if they required further diagnostic or clinical work up (e.g. additional imaging or treatment or medication changes), which was or will be performed in our hospital at a later stage. The team of two radiologists decided on cases of doubt in consensus, with help of multiple recent whitepapers from the American College of Radiologists (ACR)

Table 1
Differentiation of incidental findings as detected on triage chest CT for COVID-19, into minor versus potentially significant [22–27].

Minor IF	Potentially significant IF
Pulmonary	
Nonspecific nodule (micro-nodule, granuloma), pleural fluid, bronchiectasis, known ILD (sarcoidosis, asthma), emphysema, bronchial wall thickening, pleural calcification	Suspicious nodule, pleural fluid without explanation, endobronchial lesion
Mediastinal	
Lymphadenopathy with explanation, nonspecific thyroid nodule	Pericardial fluid, lymphadenopathy without explanation, suspicious thyroid nodule
Cardiovascular	
	Coronary artery calcifications, aneurysm subclavian artery, aneurysm abdominal aorta, cardiomegaly, aneurysm ascending aorta, aortic valve calcifications
Breast	
Gynecomastia, cyst	Suspicious nodule, ruptured prosthesis
Upper abdominal	
Hypodensity spleen, cholecystolithiasis, renal cyst, liver cyst, benign adrenal lesion, diaphragmatic hernia, mesenteric panniculitis, liver steatosis, lymphadenopathy with explanation	Splenomegaly, non-cystic liver lesion, lymphadenopathy without explanation
Skeletal	
Nonspecific vertebral lucency, vertebral hemangioma	

that describe the management of different IFs on CT, including cardiovascular and mediastinal findings, incidental thyroid nodules, incidental adrenal, renal and liver masses [22–26]. Secondly, IFs were categorized according to anatomical location into pulmonary, mediastinal, cardiovascular, breast, upper abdominal and skeletal categories.

Lymphadenopathy as IF was placed either in the minor or the potentially significant categories, depending on whether there was an explanation for the enlarged lymph nodes (> 1 cm) on the scan. With associated pulmonary findings, mildly enlarged mediastinal or hilar lymph nodes likely do not require further diagnostic workup and were classified into the minor category. However, in cases of isolated, significantly enlarged mediastinal lymph nodes, imaging follow-up or diagnostic procedures have to be considered, and in this case the IF was categorized in the potentially significant category. Coronary artery calcifications were classified as potentially significant, according to the recently published guidelines described in a British consensus statement [27]. The detection of an alternative pulmonary infectious disease in our population was not classified as "incidental" but rather as an alternative diagnosis, given the clinical context. Therefore we decided to exclude these diagnoses from IF analysis in 27 patients. It concerned the following alternative infectious diagnoses: lobar pneumonia other than COVID-19 (n = 11), bronchopneumonia / bronchiolitis (n = 15) and 1 case with an intrapulmonary abscess.

2.4. Statistical analysis

IFs were reported as frequencies and percentages; descriptive statistics were used. Data were analyzed with the Statistical Package for the Social Sciences for Windows, version 22, 2020 (SPSS, Inc., Chicago, Il). Differences in characteristics between groups were tested for statistical significance with a one-way ANOVA test. Differences were considered statistically significant if $P < 0.05$.

3. Results

3.1. Participants

In total 232 patients were seen in the CSU and triaged with a chest CT. Median age was 50.0, SD 16.2 years; 122 (53 %) were women. For the diagnosis of possible COVID-19 related pneumonia the CO-RADS classification according to Prokop et al. was used [5]. Ninetyone patients had a high suspicion for COVID-19 related pneumonia: CO-RADS 4 in 12 patients and CO-RADS 5 in 79 patients.

A total of 197 IFs were detected in 126 patients (54 %); 106 patients showed no IFs. Of these 126 patients with IFs, 79 patients had 1 IF, 31 patients had 2 IFs, 9 patients had 3 IFs, 6 patents had 4 IFs and 1 patient had 5 IFs. Patients with IFs were older (54.0 years old, SD 16.6) than patients without IF (44.8 years old, SD 14.6, P < 0.05). IFs were equally divided between sexes; 64 patients with IFs were women (51 %, not statistically significant).

3.2. Minor IFs

In total 137 minor IFs were detected in 85 patients (37 % of the total study population); with a mean of 0.6 minor IF per triaged individual. Emphysema and bronchial wall thickening were most often reported, respectively n = 23 (17 % of total minor IFs/ 10 % of the total study population) and n = 19 (14 % of total minor IFs / 8 % of the total study population), with nonspecific pulmonary nodules n = 12 (9 % of total minor IFs / 5 % of the total study population), bronchiectasis and liver cysts both n = 11 (8 % of total minor IFs / 5 % of the total study population) being less prevalent.

3.3. Possibly significant IFs

In total 60 potentially significant IFs were detected in 53 patients (23

% of the total study population); with a mean of 0.26 potentially significant IF per triaged individual (Table 2). Of these 53 patients with a possible significant IF, 12 had a minor significant IF as well. Coronary artery calcifications were most often reported (n = 23, 38 % of total possibly significant IFs / 10 % of the total study population), followed by suspicious breast nodules (n = 7, 12 % of total possibly significant IFs / 3% of the total study population) and pulmonary nodules in need of follow up (n = 7, 12 % of total possibly significant IFs / 3% of the total study population). Examples of possibly significant IFs are depicted in Figs. 1–3.

3.4. Anatomy of IFs

In general, most of the IFs were of pulmonary origin (n = 90, 46 % of total number of IFs), followed by upper abdominal (n = 48, 24 %), cardiovascular (n = 33, 17 %), breast (n = 14, 7 %), mediastinal (n = 10, 5%) and skeletal (n = 2, 1 %) origin (Table 3). When focusing on the potentially significant IFs this changes to a predominance of abnormalities in the cardiovascular organ system (n = 30, 50 %), followed by pulmonary (n = 12, 20 %) and less frequently breast (n = 8, 13 %), upper abdominal (n = 6, 10 %) and mediastinal (n = 4, 7 %) locations. No potentially significant lesions were detected in the skeletal system.

4. Discussion

This retrospective study shows that using chest CT as a primary triage tool for COVID-19 leads to a considerable number of IFs. The majority of patients (77 %) had no IFs or findings with minor significance that required no further diagnostic evaluation. Nevertheless, a substantial number of potentially significant IFs were identified in 23 % of triaged individuals.

To our knowledge this is the first COVID-19 triage CT study reporting on the presence and spectrum of IFs; while we are highly interested in reports from other institutes, we considered it noteworthy to compare our results with data from different studies that also used chest CT as a screening tool. For instance, several coronary artery disease screening studies report a range of clinically significant IFs varying between 3 and 42 % [10,15–18]. The major lung cancer screening studies report a range of clinically significant, actionable IFs varying between 7% and 27 % [10–14]. The present study shows a comparable prevalence of 23 % of patients with potentially significant IFs. Our cohort comprised a younger population with a median age of 48 years versus 42–66 years in the aforementioned coronary artery disease screening and 55–65 years in the lung cancer screening studies, with less risk factors: in the coronary

Table 2

Frequency and spectrum of potentially significant incidental findings in 53 out of 232 patients triaged with chest CT for COVID-19.

| Type of IF	n (%)
Coronary artery calcifications	23 (38,3)
Breast mass	7 (11,7)
Suspicious lung nodule	7 (11,7)
Splenomegaly	3 (5,0)
Liver lesion	3 (5,0)
Mediastinal mass	2 (3,3)
Lung mass	2 (3,3)
Pleural fluid non explained	2 (3,3)
Pericardial fluid	2 (3,3)
Endobronchial lesion	1 (1,7)
Lymphadenopathy thoracic	1 (1,7)
Cardiomegaly	1 (1,7)
Aneurysm subclavian artery	1 (1,7)
Aneurysm abdominal aorta	1 (1,7)
Dilated ascending aorta	1 (1,7)
Aortic valve calcifications	1 (1,7)
Ruptured breast prosthesis	1 (1,7)
Suspicious thyroid nodule	1 (1,7)
Total	60 **(100,0)**
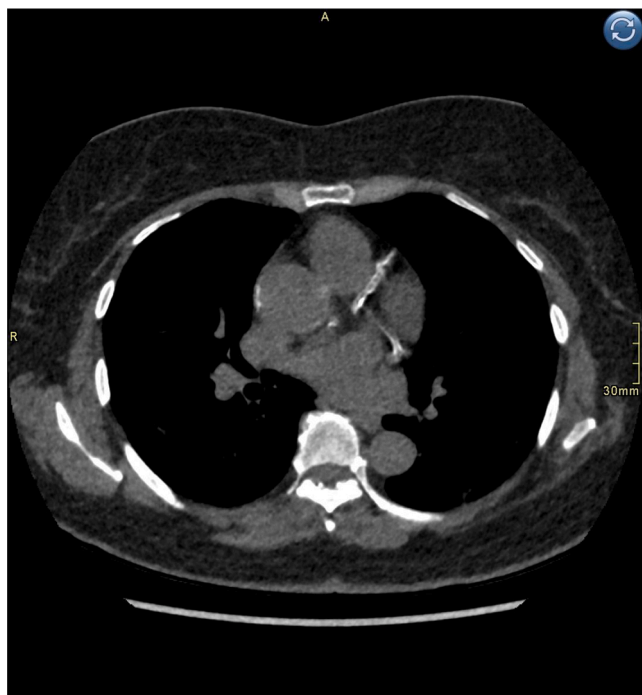
Fig. 1. Heavy coronary artery calcifications detected as potentially significant incidental finding in a patient triaged for COVID-19 by using chest CT.

Fig. 2. Pulmonary mass detected as potentially significant incidental finding in a patient triaged for COVID-19 by using chest CT.

Fig. 3. Possible thymoma detected as potentially significant incidental finding in a patient triaged for COVID-19 by using chest CT.

Table 3
Frequency of incidental findings by anatomical location in 232 patients triaged with chest CT for COVID-19.

Ranking	Total IFs, n (%) in 126 patients	Minor IF, n (%) in 85 patients[a]	Potentially significant IF, n (%) in 53 patients[a]
1	Pulmonary 90 (46 %)	Pulmonary 78 (57 %)	Cardiovascular 30 (50 %)
2	Upper abdominal 48 (24 %)	Upper abdominal 42 (31 %)	Pulmonary 12 (20 %)
3	Cardiovascular 33 (17 %)	Mediastinal 6 (4 %)	Breast 8 (13 %)
4	Breast 14 (7 %)	Breast 6 (4 %)	Upper abdominal 6 (10 %)
5	Mediastinal 10 (5 %)	Cardiovascular 3 (2 %)	Mediastinal 4 (7 %)
6	Skeletal 2 (1 %)	Skeletal 2 (1 %)	Skeletal 0 (0 %)
Total	**197 (100 %)**	**137 (100 %)**	**60 (100 %)**

[a] The numbers of 85 patients with minor IFs and 53 patients with potentially significant IFs do not add up to the total of 126 patients with an IF, since 12 patients had a combination of a minor IF as well as a potentially significant IF.

artery disease screening most of the participants and in lung cancer screening all participants were current or former smokers. Despite the younger age group and less risk factors, a considerable number of potentially significant IFs - somewhat higher than expected - might have been caused by several reasons.

The most important one is that the way of rating and definition of a (potentially significant) IF varies between studies. Even between radiologists there appears to be no consensus as to the definition, reporting or management of IFs detected at screening CT [28]. In some of the aforementioned coronary artery and lung cancer screening studies it was challenging to extract accurate information on which specific IFs where registered as actionable, but some examples can be stated. For instance, the 8% IF as described in the COSMOS trial comprise only malignancies [11], whereas in the present study also non-malignant actionable IFs were included. The NELSON trial was more strict in deciding on which IFs were potentially significant; e.g. at the time, an aneurysm of the abdominal aorta (AAA) of > 6.0 cm was described as a significant IF since this is an operation indication [29], whereas at present we handled a cut-off of > 3.5 cm since these patients need follow up imaging. In the present study, definition of what constituted a significant finding was left to the discretion of the radiologists, resembling daily practice. In the analysis, we were able to use recent publications of the ACR when differentiating minor from potentially significant IFs (see Table 1) [22–26,30]; these papers did not exist when IFs in the coronary artery disease and lung cancer screening setting were studied. As another example of the many differences in IF-definition, our study group decided to include the presence of coronary artery calcifications (CAC) as a potentially significant IF, contrasting most of the previous studies. CAC is a biomarker for atherosclerotic burden, and is associated with an increased risk of cardiovascular events, even in asymptomatic patients [27]. Knowing of the presence and extent of CAC may be valuable to patient and rereferring clinician, to increase patients awareness of

atherosclerosis and discuss risk modulation interventions such as life style changes and introduction of cholesterol lowering medication (e.g. statin) [31]. Based on our hospital policy, together with recent advice of the ACR and BSCI/BSCCT and BSTI we classified CAC as a potentially significant IF [22,27,32,33]. This difference in definition of a potentially significant IF is hence merely caused by change in insight overtime between the present study and the somewhat older publications of lung cancer screening studies (2001–2015).

A second explanation for our slightly higher than expected number of potentially significant IFs might be the group of pulmonary masses and suspicious nodules that need additional or follow up diagnostic imaging. In the lung cancer screening studies these were obviously not classified as "incidental" findings, whereas in our population they are; leading to an increased number of potentially significant IFs.

Thirdly, in contrast to other screening studies, the number of incidental breast lesions reported in our dataset is relatively high; 7 out of 232 participants (3%), versus 1% mentioned in literature [34]. This could have been caused by the fact that our cohort consisted of women with a younger age when compared to the other screening studies, with densely glandular breast tissue that might have been reported as suspicious breast masses. Furthermore, CT without intravenous contrast makes it more difficult to distinguish lesions from dense glandular tissue.

The debate on whether or not there is a place for chest CT as a primary triage tool for COVID-19 goes beyond the scope of this study. As opposed to the United States [35,36], in Europe the European Society of Radiology (ESR) and European Society of Thoracic Imaging (ESTI) state that there is a role for the radiologist in identifying and characterizing pulmonary involvement of COVID-19 [37]. The specific nature of the pandemic makes chest CT a good and accurate - and moreover a quick - tool to stratify patients selected from first-line triage. The paper also poses that the use of a mobile CT unit might be considered, as was conducted in our institution. Apart from screening, imaging can reveal underlying cardiopulmonary abnormalities that help in risk stratification and it can also reveal alternative diagnoses. During the present ongoing second wave of the pandemic, fortunately the availability of RT-PCR tests has increased and hospitals in our region have to rely less on chest CT as a triage tool. However, we still think it is important that radiologists are aware of the prevalence and spectrum of IFs when screening for COVID-19; although it concerns a younger population with less risk factors, the number of potentially significant IFs is substantial and should not be overlooked.

This study has several limitations. It concerns a retrospective analysis; we relied on the radiologists reports only. Since evaluation of IFs was not primary aim of the CT reports, it is possible that some findings were not reported or not incidental (known disease). Differences in interpretation and reporting of IFs between radiologists could have occurred; in total 10 radiologists worked at the CSU, however all cases were reviewed in teams of two radiologist in pairs. Furthermore, due to the descriptive and retrospective character of this study the table differentiating minor versus potentially significant IFs is not a complete review of possible IFs on a chest CT in general. For instance, interstitial lung diseases (not previously reported or unknown) or incidental renal masses are not mentioned, because there were none in our cohort. This might make it difficult for others to replicate this study, because they might not know how to categorize these. Lastly, we have no data on the work-up and follow up, so no information of definite outcome or assumption of costs can be made.

5. Conclusion

In conclusion, our results show that a considerable number of IFs were detected by using chest CT as a primary triage tool for COVID-19, of which a substantial percentage is potentially clinically relevant: in 23 % of the screened individuals an IF was identified that needed further diagnostic evaluation.

Ethical statement

The institutional ethical review board approved of this retrospective study.

Declaration of Competing Interest

The authors report no declarations of interest.

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