



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Radiologist Reporting and Operational Management for Patients With Suspected COVID-19

Mark M. Hammer, MD^a, Anna H. Zhao, BA^{a,b}, Andetta R. Hunsaker, MD^a, Alejandra Duran Mendicuti, MD^a, Aaron D. Sodickson, MD, PhD^a, Giles W. Boland, MD^{b,c}, Ramin Khorasani, MD, MPH^{b,d}

Abstract

Purpose: The aim of this study was to evaluate the adoption and outcomes of locally designed reporting guidelines for patients with possible coronavirus disease 2019 (COVID-19).

Methods: A departmental guideline was developed for radiologists that specified reporting terminology and required communication for patients with imaging findings suggestive of COVID-19, on the basis of patient test status and imaging indication. In this retrospective study, radiology reports completed from March 1, 2020, to May 3, 2020, that mentioned COVID-19 were reviewed. Reports were divided into patients with known COVID-19, patients with “suspected” COVID-19 (having an order indication of respiratory or infectious signs or symptoms), and “unsuspected patients” (other order indications, eg, trauma or non-chest pain). The primary outcome was the percentage of COVID-19 reports using recommended terminology; the secondary outcome was percentages of suspected and unsuspected patients diagnosed with COVID-19. Relationships between categorical variables were assessed using the Fisher exact test.

Results: Among 77,400 total reports, 1,083 suggested COVID-19 on the basis of imaging findings; 774 of COVID-19 reports (71%) used recommended terminology. Of 574 patients without known COVID-19 at the time of interpretation, 345 (60%) were eventually diagnosed with COVID-19, including 61% (315 of 516) of suspected and 52% (30 of 58) of unsuspected patients. Nearly all unsuspected patients (46 of 58) were identified on CT.

Conclusions: Radiologists rapidly adopted recommended reporting terminology for patients with suspected COVID-19. The majority of patients for whom radiologists raised concern for COVID-19 were subsequently diagnosed with the disease, including the majority of clinically unsuspected patients. Using unambiguous terminology and timely notification about previously unsuspected patients will become increasingly critical to facilitate COVID-19 testing and contact tracing as states begin to lift restrictions.

Key Words: COVID-19, reporting guidelines, report terminology, diagnostic certainty

J Am Coll Radiol 2020;17:1056-1060. Copyright © 2020 American College of Radiology

^aDepartment of Radiology, Brigham and Women’s Hospital, Harvard Medical School, Boston, Massachusetts.

^bCenter for Evidence-Based Imaging, Brigham and Women’s Hospital, Harvard Medical School, Boston, Massachusetts.

^cChair, Department of Radiology, Brigham and Women’s Hospital, Harvard Medical School, Boston, Massachusetts.

^dVice Chair for Quality and Safety, Department of Radiology, Brigham and Women’s Hospital, Harvard Medical School, Boston, Massachusetts.

Corresponding author and reprints: Mark M. Hammer, MD, Department of Radiology, Brigham and Women’s Hospital, Harvard Medical School, 75 Francis Street, Boston, MA 02115; e-mail: mmhammer@bwh.harvard.edu.

The authors state that they have no conflict of interest related to the material discussed in this article. Drs Hammer, Zhao, Hunsaker, Duran Mendicuti, Sodickson, Boland, and Khorasani are nonpartner, nonpartnership track employees.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has created new challenges for health care with regard to patient triage, isolation, and diagnosis. To manage and control the pandemic, patients with suspected COVID-19 must be isolated and expediently tested [1]; positive patients must be cared for with personal protective equipment and, if discharged, instructed to self-quarantine.

Radiology plays an important role in this process in two main respects: first, patients with known or suspected COVID-19 require personnel to use personal protective equipment and undertake appropriate cleaning of imaging rooms and scanners, and second, patients with no clinical

suspicion for COVID-19 (hereafter unsuspected patients) may be identified by imaging itself. To address these two scenarios effectively, radiologists need to establish unambiguous reporting terminology and communication algorithms with resulting downstream workflows to handle each scenario [1-3]. Importantly, these workflows must include protocols for reporting unsuspected patients and tracing personnel and scanners that came into contact with infected patients.

Several reporting guidelines have been proposed to address reporting radiologic findings in patients with suspected COVID-19, including RSNA guidelines and COVID-19 Reporting and Data System (CO-RADS) from the Dutch Radiologic Society [4,5]. However, these guidelines do not specifically address radiology departmental workflow, such as communications and contact tracing. Here, we describe the implementation of our departmental policies for reporting and operational management of patients with known, suspected, and unsuspected COVID-19. The aim of this study was to evaluate the initial adoption and outcomes of a locally designed radiologist reporting guideline for patients with possible COVID-19 detected at imaging.

METHODS

Study Setting and Human Subjects

This retrospective study was approved by the institutional review board and carried out according to HIPAA guidelines. The study institution is a large academic medical center with a 793-bed quaternary care hospital. A multi-specialty radiology department is responsible for radiologic studies conducted within the academic medical center, community hospital, outpatient cancer center, and outpatient imaging centers.

Departmental Guideline (Intervention)

Departmental guidelines for reporting and operational workflow for patients with known, clinically suspected, and imaging suspected COVID-19 were developed by a team including radiology leadership, thoracic radiologists, infection control, and hospital leadership (Fig. 1). In brief, we asked radiologists to use a previously developed reporting diagnostic Certainty Scale (Table 1) to convey their subjective degrees of confidence regarding the diagnosis of COVID-19 [6]. This diagnostic Certainty Scale was designed to reduce variation in the terminology used by radiologists to convey certainty in radiology reports. The scale, which was already in use in our department, provides an ordinal scale of terminology ranging from “very unlikely” to “most likely” to enable radiologists to convey their degree of certainty about a diagnosis in a

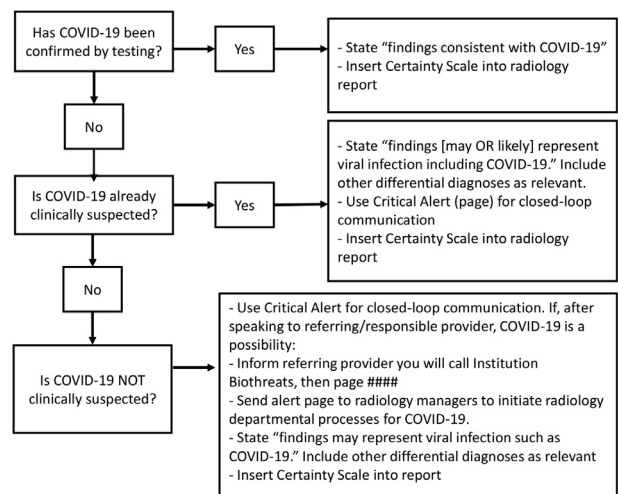


Fig 1. Departmental workflow and reporting guidelines for coronavirus disease 2019 (COVID-19) suspected by imaging findings. Radiologists were asked to use this guideline for patients with imaging findings suggestive of COVID-19, on the basis of patient test status at the time of interpretation and imaging indication.

clear and unambiguous manner to referring physicians and patients.

Specifically with regard to COVID-19, radiologists are asked to use “consistent with” for a diagnosis of COVID-19 confirmed by reverse transcriptase polymerase chain reaction (RT-PCR), and “likely represent” or “may represent” for unknown (either unsuspected or not yet RT-PCR-confirmed) diagnoses at the time of interpretation. If a diagnosis of COVID-19 is not probable, radiologists are asked to not use “COVID-19” in their reports.

In addition to the report wording, the guidelines include specific actions for the radiologist and departmental operations team to take, depending upon clinical suspicion of COVID-19. In particular, for clinically unsuspected patients

Table 1. Departmental Certainty Scale for radiology reporting

Term	Likelihood of Diagnosis
Consistent with	Known diagnosis
Most likely	Very high probability (>90%)
Likely	High probability (>75% to <90%)
May represent	Intermediate probability (>25% to <75%)
Unlikely	Low probability (>5% to <25%)
Very unlikely	Very low probability (<5%)

in whom imaging findings raise the possibility of COVID-19, the guidelines instruct the radiologist to call hospital infection control and alert departmental operations to ensure adequate cleaning and initiate contact tracing.

Although the diagnostic Certainty Scale had been in effect in the department for approximately 1 year, the COVID-19 guidelines were discussed at the beginning of March and formally distributed via e-mail to all attending radiologists and trainees in the department on March 13, 2020.

Cohort Selection and Data Collection

All radiology examination reports signed between March 1, 2020, and May 3, 2020, were identified. All modalities and patient settings (inpatient, outpatient, and emergency department) were included. A locally developed natural language processing algorithm (CEBI-Miner [7]) was used to search reports for the following keywords in the impression section of the report: “COVID,” “COVID19,” “COVID-19,” “coronavirus,” “SARS-CoV-2,” and “2019-nCoV.” These reports were then manually reviewed to verify the presence of these keywords. Only examinations for which the report described imaging findings potentially related to COVID-19 were included (eg, reports stating “follow-up may be deferred in the setting of COVID-19 pandemic” or reports that described “no imaging findings to suggest COVID-19” were excluded).

Manual chart review by a medical student identified the results of any RT-PCR testing for COVID-19 (though patients without RT-PCR were not excluded). Radiology order indication was extracted from the report or, if not present in the report, the examination order in the electronic medical record. Study indications were broadly classified as “suspected COVID-19” if the patient had any respiratory or infectious signs or symptoms, including chest pain, or as “unsuspected patients” (undergoing imaging for other reasons, such as trauma, cancer staging, or non-chest pain). The report terminology used to describe COVID-19 was extracted by manual review.

Outcome Measures

The primary study outcome was the percentage of COVID-19 reports using the recommended reporting terminology. Secondary outcomes were the percentage of patients diagnosed with COVID-19 by suspected versus unsuspected indication and modality and the percentage of patients diagnosed with COVID-19 by report terminology.

Statistical Analysis

Data were analyzed using Microsoft Excel (Microsoft, Redmond, Washington) and JMP Pro version 15 (SAS

Institute, Cary, North Carolina). Relationships between categorical variables were tested using the Fisher exact test, one sided. The statistical significance threshold was set at $P < .05$.

RESULTS

Study Population and Report Terminology

A total of 77,400 radiology reports were completed during the study period. Among these, 1,083 reports (1.4%) contained imaging findings suggestive of COVID-19 in the impression section; 509 were known COVID-19 positive at the time of interpretation, 516 were suspected, and 58 were reports for unsuspected patients. COVID-19-suggestive findings were predominantly in chest radiographs, chest CT examinations, and CT angiography reports (Table 2). Four reports describing “no findings to suggest COVID-19” were excluded.

Reports using terminology from the Certainty Scale accounted for 71% of all reports ($n = 774$). The most commonly used terms are shown in Table 3. Of 509 reports with known COVID-19 diagnoses, 296 (58%) used “consistent with,” and 91 (18%) used either “may represent” or “likely represent.” Of 574 reports without known COVID-19 diagnoses, 271 (47%) used “may represent,” and 90 (16%) used “likely represent.”

Diagnosis of COVID-19

Of 574 reports without known diagnoses of COVID-19 at the time of interpretation, 345 (60%) were eventually diagnosed with COVID-19. Among suspected patients, 315 of 516 (61%) were COVID-19 positive. The percentage of COVID-19 positive was greater for radiography than CT (279 of 423 [66%] versus 36 of 93 [39%], $P < .0001$). Of

Table 2. Distribution of radiologic examinations with imaging findings suggestive of coronavirus disease 2019 in the report impression by modality

Examination	Frequency (%)
Chest radiography	796 (74)
Chest CT or CT angiography	225 (21)
Abdominal CT	47 (4)
Neck or cervical spinal CT	10 (0.9)
Abdominal radiography	3 (0.3)
Abdominal MRI	1 (0.1)
PET/CT	1 (0.1)
Total	1,083 (100)

Table 3. Most commonly used reporting terminology for imaging findings suggestive of coronavirus disease 2019

Term	Frequency (%)
May represent	301 (28)
Consistent with	300 (28)
Likely represent	151 (14)
Concerning for	53 (5)
All others	278 (26)

Note: All terms used in at least 5% of reports are listed individually.

the 516 reports for suspected patients, 336 (65%) used recommended report terminology.

COVID-19-suggestive findings in unsuspected patients were nearly all seen on CT (46 of 58 [79%]), and 30 of 58 unsuspected patients (52%) subsequently tested positive for COVID-19 ($P = .11$ for the difference between suspected and unsuspected). Among unsuspected patients, 24 of 46 (52%) of those undergoing CT were diagnosed with COVID-19 compared with 6 of 11 (55%) of those who underwent chest radiography. One unsuspected patient was identified on PET/CT but was not diagnosed with COVID-19. Of the 58 reports for unsuspected patients, 36 (62%) used recommended report terminology.

The distributions of indication and COVID-19 diagnosis rates in unsuspected patients are given in Table 4. Of the unsuspected patients, two did not undergo COVID-19 testing documented in our electronic health record; one

Table 4. Imaging indication and percentage of patients with eventual COVID-19 diagnoses among clinically unsuspected patients

Indication	COVID-19 Diagnosis
Abdominal complaints (n = 26)	14 (54%)
Trauma (n = 12)	7 (58%)
Altered mental status (n = 8)	2 (63%)
Line placement (n = 6)	4 (67%)
Malignancy (n = 2)	0 (0%)
Coronary artery disease (n = 1)	1 (100%)
Neck pain (n = 1)	0 (0%)
Pulmonary nodule (n = 1)	0 (0%)
Routine (n = 1)	0 (0%)

COVID-19 = coronavirus disease 2019.

patient's findings were thought unlikely to represent COVID-19 by imaging, and the other was thought to be likely. In the latter instance, the ordering physician and the infection control group were contacted.

Among reports using the term "likely represent," 69 of 90 patients (77%) were eventually diagnosed as COVID-19 positive, and among reports using "may represent," 174 of 271 patients (64%) were eventually diagnosed with COVID-19 ($P = .02$).

DISCUSSION

We demonstrate the successful implementation and adoption by radiologists of departmental guidelines for use when patients are found with suspected COVID-19 on the basis of imaging findings. These reporting guidelines apply to patients with clinically known, clinically suspected, and clinically unsuspected COVID-19 and provide a framework for both reporting terminology and communication requirements. These enable timely clinical management decisions (testing, contact tracing) and operational recovery (including room and scanner cleaning and contact tracing in the Department of Radiology). Radiologists broadly adopted the recommended language, with approximately three-quarters of reports using terms from our Certainty Scale. Notably, the majority of both clinically suspected and clinically unsuspected patients for whom radiologists raised concern for COVID-19 did indeed turn out to be positive (61% and 52%, respectively).

Although existing reporting guidelines from the RSNA and the CO-RADS are helpful in defining the imaging patterns that are typical, indeterminate, and atypical for COVID-19, they are not specifically tailored to the clinical scenario. Critically, they do not provide a framework for patient management and may be puzzling for referring physicians who are left with uncertainty about the radiologist's diagnostic confidence.

By using a previously developed, department-wide diagnostic Certainty Scale [6], our departmental guidance places imaging findings in a confidence spectrum that is transparent to the referring provider. Although this confidence scale is not necessarily tied to a likelihood of disease being present, it provides a framework for clinicians and easily allows radiologists to include multiple differential diagnoses with varying degrees of confidence. Indeed, in our study, 77% of reports stating that findings "likely represent" COVID-19 were eventually positive, compared with 64% of reports stating that findings "may represent" COVID-19. Of note, these results are in keeping with how we explain the Certainty Scale to our referring providers and patients (<https://rad.bwh.harvard.edu/diagnostic-certainty-scale>): we describe "likely represents"

as having probability of >75% and <90% and “may represent” with probability boundaries of >25% and <75%. Future studies will be needed to validate and assess the reproducibility of the Certainty Scale for communicating uncertainty in radiology reports.

As noted earlier, our departmental guidelines also provide radiologists with an established workflow for handling patients with both clinically suspected and unsuspected COVID-19, including guidance about critical notification of the ordering provider as well as notification of infection control and operations staff regarding unsuspected patients. These protocols will likely become even more important in the future as mitigation measures decrease and the epidemic transitions to an endemic phase, with many sporadic unsuspected patients. Indeed, in our study, 58 of 1,083 reports (5.4%) containing “COVID-19” in the impression section were in patients not suspected to have COVID-19. The majority of these patients, 52%, were eventually diagnosed with the disease. We expect this scenario to become more common in the coming months.

An interesting phenomenon in our study was the relatively low rate of positive CT diagnoses in the suspected category. This was most likely caused by the fact that our hospital guidance is for physicians to use chest radiography as the initial imaging modality in patients with suspected COVID-19. In general, clinicians will order chest CT only if COVID-19 is not an initial consideration, an initial COVID-19 nasal swab test result is negative, or a patient with COVID-19 develops complications. Thus, the pretest probability in the CT group is much lower than in the chest radiography group in our study. Other hospitals and countries that have different imaging policies will likely see different results, potentially with a much higher positive predictive value of CT.

Our study had several limitations, principally that it was a single-center, retrospective analysis. However, we have shown the successful rapid implementation of our local operational guidelines for handling suspected COVID-19 imaging findings. Another limitation is that we do not have information about whether infection control was contacted for each unsuspected patient, as recommended in the guidelines. However, we did establish that testing was performed for nearly all of these patients. Finally, we did not evaluate reports in patients with known or suspected COVID-19 in which the term “COVID-19” was not used

in the report. Our reporting guidelines specifically instructed radiologists not to use the term “COVID-19” unless they actually suspected the diagnosis, and therefore reports that did not use the term “COVID-19” are not in the scope of this study.

TAKE-HOME POINTS

- We developed a departmental reporting and operations guideline for patients with imaging findings suggestive of COVID-19.
- Radiologists rapidly adopted the guideline, with 71% of reports (774 of 1,083) using recommended terminology.
- More than half of patients (52%) unsuspected of having COVID-19 at the time of imaging who had concerning imaging findings documented in the radiology report were diagnosed with COVID-19.

REFERENCES

1. Goh Y, Chua W, Lee JKT, et al. Operational strategies to prevent coronavirus disease 2019 (COVID-19) spread in radiology: experience from a Singapore radiology department after severe acute respiratory syndrome. *J Am Coll Radiol* 2020;17:717-23.
2. Mossa-Basha M, Meltzer CC, Kim DC, Tuite MJ, Kolli KP, Tan BS. Radiology department preparedness for COVID-19: radiology scientific expert panel. *Radiology* Available at: <https://pubs.rsna.org/doi/10.1148/radiol.2020200988>. Accessed June 17, 2020.
3. Prabhakar AM, Glover M, Schaefer PW, Brink JA. Academic radiology departmental operational strategy related to the coronavirus disease 2019 (COVID-19) pandemic. *J Am Coll Radiol* 2020;17:730-3.
4. Simpson S, Kay FU, Abbara S, et al. Radiological Society of North America expert consensus statement on reporting chest CT findings related to COVID-19. Endorsed by the Society of Thoracic Radiology, the American College of Radiology, and RSNA. *Radiol Cardiothorac Imaging* 2020;2:e200152.
5. Prokop M, van Everdingen W, van Rees Vellinga T, et al. CO-RADS—a categorical CT assessment scheme for patients with suspected COVID-19: definition and evaluation. *Radiology* Available at: <https://pubs.rsna.org/doi/full/10.1148/radiol.2020201473>. Accessed June 17, 2020.
6. Shinagare AB, Alper DP, Hashemi R, et al. Early adoption of a certainty scale to improve diagnostic certainty communication. *J Am Coll Radiol*. Available at: [https://www.jacr.org/article/S1546-1440\(20\)30370-7/abstract](https://www.jacr.org/article/S1546-1440(20)30370-7/abstract). Accessed May 11, 2020.
7. Alper DP, Shinagare AB, Hashemi SR, et al. Effect of a report template-enabled quality improvement initiative on use of preferred phrases for communicating normal findings in structured abdominal CT and MRI reports. *AJR Am J Roentgenol* 2020;214:835-42.