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[Diagnostic Test Accuracy Review]

Thoracic imaging tests for the diagnosis of COVID-19

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ABSTRACT

Background

The diagnosis of infection by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) presents major challenges. Reverse transcriptase polymerase chain reaction (RT-PCR) testing is used to diagnose a current infection, but its utility as a reference standard is constrained by sampling errors, limited sensitivity (71% to 98%), and dependence on the timing of specimen collection. Chest imaging tests are being used in the diagnosis of COVID-19 disease, or when RT-PCR testing is unavailable.

Objectives

To determine the diagnostic accuracy of chest imaging (computed tomography (CT), X-ray and ultrasound) in people with suspected or confirmed COVID-19.

Search methods

We searched the COVID-19 Living Evidence Database from the University of Bern, the Cochrane COVID-19 Study Register, and The Stephen B. Thacker CDC Library. In addition, we checked repositories of COVID-19 publications. We did not apply any language restrictions. We conducted searches for this review iteration up to 5 May 2020.

Selection criteria

We included studies of all designs that produce estimates of test accuracy or provide data from which estimates can be computed. We included two types of cross-sectional designs: a) where all patients suspected of the target condition enter the study through the same route and b) where it is not clear up front who has and who does not have the target condition, or where the patients with the target condition are recruited in a different way or from a different population from the patients without the target condition. When studies used a variety of reference standards, we included all of them.

Data collection and analysis

We screened studies and extracted data independently, in duplicate. We also assessed the risk of bias and applicability concerns independently, in duplicate, using the QUADAS-2 checklist and presented the results of estimated sensitivity and specificity, using paired forest plots, and summarised in tables. We used a hierarchical meta-analysis model where appropriate. We presented uncertainty of the accuracy estimates using 95% confidence intervals (CIs).

Main results

We included 84 studies, falling into two categories: studies with participants with confirmed diagnoses of COVID-19 at the time of recruitment (71 studies with 6331 participants) and studies with participants suspected of COVID-19 (13 studies with 1948 participants, including three case-control studies with 549 cases and controls). Chest CT was evaluated in 78 studies (8105 participants), chest X-ray in nine studies (682 COVID-19 cases), and chest ultrasound in two studies (32 COVID-19 cases). All evaluations of chest X-ray and ultrasound were conducted in studies with confirmed diagnoses only. Twenty-five per cent (21/84) of all studies were available only as preprints, 15/71 studies in the confirmed cases group and 6/13 of the studies in the suspected group.

Among 71 studies that included confirmed cases, 41 studies had included symptomatic cases only, 25 studies had included cases regardless of their symptoms, five studies had included asymptomatic cases only, three of which included a combination of confirmed and suspected cases. Seventy studies were conducted in Asia, 2 in Europe, 2 in North America and one in South America. Fifty-one studies included inpatients while the remaining 24 studies were conducted in mixed or unclear settings. Risk of bias was high in most studies, mainly due to concerns about selection of participants and applicability.

Among the 13 studies that included suspected cases, nine studies were conducted in Asia, and one in Europe. Seven studies included inpatients while the remaining three studies were conducted in mixed or unclear settings.

In studies that included confirmed cases the pooled sensitivity of chest CT was 93.1% (95%CI: 90.2 - 95.0 (65 studies, 5759 cases); and for X-ray 82.1% (95%CI: 62.5 to 92.7 (9 studies, 682 cases). Heterogeneity judged by visual assessment of the ROC plots was considerable. Two studies evaluated the diagnostic accuracy of point-of-care ultrasound and both reported zero false negatives (with 10 and 22 participants having undergone ultrasound, respectively). These studies only reported True Positive and False Negative data, therefore it was not possible to pool and derive estimates of specificity.

In studies that included suspected cases, the pooled sensitivity of CT was 86.2% (95%CI: 71.9 to 93.8 (13 studies, 2346 participants) and specificity was 18.1% (95%CI: 3.71 to 55.8). Heterogeneity judged by visual assessment of the forest plots was high.

Chest CT may give approximately the same proportion of positive results for patients with and without a SARS-CoV-2 infection: the chances of getting a positive CT result are 86% (95% CI: 72 to 94) in patient with a SARS-CoV-2 infection and 82% (95% CI: 44 to 96) in patients without.

Authors' conclusions

The uncertainty resulting from the poor study quality and the heterogeneity of included studies limit our ability to confidently draw conclusions based on our results. Our findings indicate that chest CT is sensitive but not specific for the diagnosis of COVID-19 in suspected patients, meaning that CT may not be capable of differentiating SARS-CoV-2 infection from other causes of respiratory illness. This low specificity could also be the result of the poor sensitivity of the reference standard (RT-PCR), as CT could potentially be more sensitive than RT-PCR in some cases. Because of limited data, accuracy estimates of chest X-ray and ultrasound of the lungs for the diagnosis of COVID-19 should be carefully interpreted.

Future diagnostic accuracy studies should avoid cases-only studies and pre-define positive imaging findings. Planned updates of this review will aim to: increase precision around the accuracy estimates for CT (ideally with low risk of bias studies); obtain further data to inform accuracy of chest X rays and ultrasound; and continue to search for studies that fulfil secondary objectives to inform the utility of imaging along different diagnostic pathways.

PLAIN LANGUAGE SUMMARY

How accurate is chest imaging for diagnosing COVID-19?

Why is this question important?

People with suspected COVID-19 need to know quickly whether they are infected, so that they can self-isolate, receive treatment, and inform close contacts. Currently, formal diagnosis of COVID-19 infection requires laboratory analysis of blood or nose and throat samples. The laboratory test, called RT-PCR, requires specialist equipment and takes at least 24 hours to produce a result. Further, RT-PCR is not completely accurate and a second RT-PCR or a different test may be required to confirm the diagnosis.

COVID-19 is a respiratory infection: people with COVID-19 may have a cough, may have difficulty breathing and in severe cases may have COVID-19 pneumonia. Clinicians use chest imaging tests to diagnose COVID-19 disease, when awaiting RT-PCR test results, for example, or when RT-PCR results are negative, and the person has COVID-19 symptoms.

We wanted to find out how accurate chest imaging is in diagnosing COVID-19 disease in people with known or suspected infection.

What are chest imaging tests?

X-rays or scans produce an image of the organs and structures (heart, lungs and airways) in the chest. They can detect blockages, inflammation and excess fluid.

- X-rays (radiography) use a small amount of radiation to produce a 2-D image. They are usually carried out in hospitals using fixed equipment by a radiographer but may also be carried out using a portable machine.

- Computed tomography (CT) scans use a computer to merge multiple X-ray images taken from different angles to produce a 2-D image that can be converted to a 3-D image. They require highly specialised equipment and are carried out in hospital by a specialist radiographer.

- Ultrasound scans use high-frequency sound waves to produce an image. They can be carried out in hospital or other healthcare settings such as a doctor's surgery or clinic.

What did we do?

We searched for studies that assessed the accuracy of chest imaging to diagnose COVID-19 disease. Studies could include people with either suspected or confirmed COVID-19, based on the results of an RT-PCR or other test. Studies could be of any design and take place anywhere.

What did we find?

We found 84 studies with 8279 people. Studies included either only people with confirmed COVID-19 diagnosis (71 studies, involving 6331 people) or both suspected and confirmed COVID-19 (13 studies, involving 1948 people). Infection was mainly confirmed using RT-PCR.

The majority of studies evaluated chest CT. We found studies from all over the world; 78 studies took place in Asia.

Accuracy of chest imaging for diagnosing COVID-19 in people with confirmed infection

On average, chest CT correctly identified infection in 93% of people with confirmed COVID-19 (65 studies, 5759 people). Chest X-ray correctly identified infection in 82% of people with confirmed COVID-19 (nine studies, 682 people). Lung ultrasound correctly identified infection in 100% of people with confirmed COVID-19 (2 studies, 32 people).

Accuracy of chest imaging for diagnosing COVID-19 in people with suspected or confirmed infection

On average, chest CT correctly identified infection in 86% of people who were infected with COVID-19 (13 studies, 2346 people). However, it incorrectly identified infection in 82% of people who were not infected with COVID-19. We did not find any studies that reported data on lung ultrasound.

How reliable are the results?

Studies reported limited information about how they confirmed COVID-19 diagnosis, how they recruited participants, and they did not always use robust methods. Most studies only included people with a confirmed COVID-19 diagnosis, so we have little information about the ability of chest imaging to rule out COVID-19 in people who are not infected. Also, studies did not report any pre-existing respiratory conditions that might have affected their results. Finally, 25% of studies were published as preprints, which do not undergo the same rigorous checks as published studies. We cannot confidently draw conclusions based on the results from studies included in this review.

What does this mean?

The evidence suggests that chest CT and chest X-ray may be good tests for confirming COVID-19 diagnosis in people who have been diagnosed with COVID-19 infection using another test. However, CT scans may be less accurate in confirming or ruling out infection in people with only suspected COVID-19.

We plan to update this review regularly as more research becomes available.

How up-to-date is this review?

The evidence in this Cochrane Review is current to May 2020.