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ORIGINAL ARTICLE

The Role of the Computed Tomography (CT) Thorax in the Diagnosis of COVID-19 for Patients Presenting with Acute Surgical Emergencies. A Single Institute Experience

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Abstract

The current Coronavirus disease 2019 (COVID-19) pandemic has had a huge impact on emergency surgical services in the UK. The Royal College of Surgeons (RCS) published guidelines about COVID-19 pandemic in March, 2020 to aid decision making for the surgeons. These guidelines recommended that all patients requiring urgent surgery should have reverse transcriptase polymerase chain reaction (RT-PCR) and/or computed tomography (CT) thorax pre-operatively. However, it is currently unclear whether the use of CT thorax is a sensitive and specific diagnostic test. The objective of this study was to find out whether CT thorax is a reliable and accurate test in the diagnosis of COVID-19 compared to RT-PCR. This is particularly important in surgical patients where there is no time to wait for RT-PCR results. A prospective cohort study of patients presented with acute surgical emergencies at a University Teaching Hospital was conducted. Data was collected from March 23, to May 15, 2020, during the peak of the crisis in the UK. All adult patients presented with operable general surgical emergencies were considered eligible. Another group of patients, admitted with acute medical emergencies but with suspected COVID-19 infection, was used for comparison. Data was manually collected, and sensitivity, specificity and predictive value were calculated using the MedCalc statistical software version 19.2.6. Standard reporting for COVID-19 infection for CT chest based on guidelines from British Society of Thoracic Imaging (BSTI) and Radiological Society of North America (RSNA) was used. Patients who had their CT thorax reported as typical or classic of COVID 19 (high probability) were treated as infected cases with extra precautions in the wards and surgical theatres as suggested by health and safety executive (HSE). These patients had serial RT-PCR during their admissions or in the post-operative phase, if the first swab was negative. For the study, 259 patients were considered eligible for inclusion from both groups. Patients admitted for acute surgical emergencies were treated according to RCS guidelines and subjected to RT-PCR test and/or CT scan of the thorax. There were 207 patients with high clinical suspicion of COVID-19. Of those 207 patients, 77 patients had CT thorax with radiographic features consistent with COVID-19 pneumonia. However, only 40 patients had a positive RT-PCR result. CT thorax was normal in 130 patients, out of which 29 patients were found to have COVID-19 diagnosis after swab test. Sensitivity of CT scan to diagnose COVID-19 infection was found to be 58% (95% CI; 45.48% to 69.76%) whilst specificity was 73% (95% CI; 64.99% to 80.37%) with a negative predictive value of 77.69% (95% CI; 72.17% to 82.39%). CT scan was found to be a reliable tool in the diagnosis of COVID-19. With a negative predictive value of up to 82.4%, CT thorax can play an important role to help surgeons in their decision making for asymptomatic suspected cases of COVID-19. However, over-reliance on CT scan which also has a high false positive rate for diagnosis of COVID-19 infections can lead to overtreatment, overuse of resources and delays in decision-making process. Hence, results should be interpreted with caution and correlated with clinical presentation and swab test results.

Keywords COVID-19 · Pandemic · SARS-CoV-2 · CT chest · Viral pneumonia · Surgery · RT-PCR

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Introduction

The global COVID-19 pandemic had a profound effect on health care services worldwide. Both elective and emergency surgical departments were affected. Our institution had seen significant disruption to elective cancer surgery and the problem ensued. Elective non-cancer surgery was postponed indefinitely since country wide lock down (Fig. 1).

In the department of emergency surgery, all operable cases went through a robust screening process for COVID-19 before decision for surgery was made, potentially leading to delays in treatment.

Viral nucleic acid testing played a significant role in helping in diagnosis and subsequent management of COVID-19 epidemic. However, RT-PCR swab tests were not widely available in the early stages of the pandemic and could take up to 72 h to return a result. In Emergency Surgery where many decisions are time dependent, surgeons sought for a fast and reliable diagnostic tool and that made CT thorax an ideal choice.

Initial studies showed promising role of CT scan in rapid diagnosis of COVID-19 citing false negative results by RT-PCR TEST [1]. Later expert reports and guidelines showed that evidence is contrary to that (https://www.rcsed.ac.uk/media/681195/guidelines-for-pre-operative-covid-19-testing-for-elective-cancer-surgery-1305202.pdf). Inui and colleagues reviewed CT scans of 112 cases of RT-PCR-confirmed COVID-19 from the *Diamond Princess* cruise ship. Less than two-thirds (61%) of cases had lung opacities on CT [2].

Our aim was to determine the diagnostic accuracy in terms of sensitivity and specificity of CT chest in diagnosing and confirming COVID-19 infection in patients presenting with acute surgical and medical pathologies.

Methodology

Prospective data of patients admitted with operable pathologies from the first day of country wide lockdown for COVID-19 pandemic (March 23, 2020 to May 15) was used. Patients were treated according to national and local guidelines dictated on guidance from the World Health Organisation (WHO), Health and Safety Executive (HSE) and the National Health Service (NHS). The intercollegiate Royal College of Surgeons guidelines were published on 23rd of March 23 that recommended to 'test all and treat all' as COVID positive.

Another group of patients ($n = 74$) with acute medical emergencies admitted under medical specialties for suspected COVID-19 infection during the same time period was also included in the study. It was done to further analyse sensitivity and specificity of CT scan in diagnosing COVID-19 infection. This group of patients was admitted with suspected COVID-19 infection and had CT scan of their chest as a part of investigation of their presenting symptoms and was treated for respiratory symptoms caused by COVID-19 or other respiratory pathologies. These patients had CT scans on admission which were proceeded by serial swab test just as happened in surgical patients.

All patients requiring surgery were subjected to radiographic imaging of the thorax and swab test (RT-PCR). All suspected patients had swab test and chest imaging followed by isolation, whilst all unsuspected patients admitted for surgical pathologies had chest imaging and then subjected to swab test and isolation, based on results of imaging.

In case of inadequate swab testing or constant clinical suspicion in suspected cases, swab tests were repeated as suggested by local MDT involving the infection control team, respiratory physicians and microbiologists. Normally swabs were repeated on day 2 and then again on day 5.

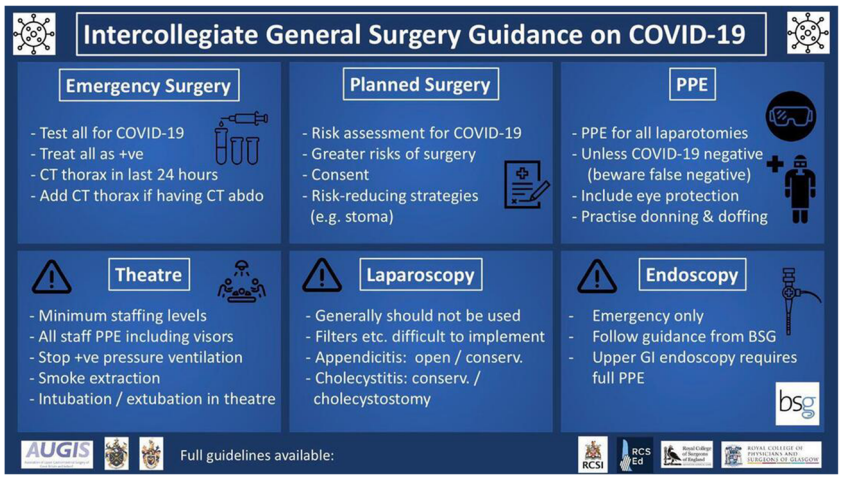

Fig. 1 Intercollegiate general surgery guidance on COVID-19

Radiologists in our hospital used a standardised reporting format including a severity score recommended by the British society of thoracic imaging (BSTI) and Radiological Society of North America (RSNA) to report for any COVID-19 related changes. BSTI template classifies COVID-19 related changes into four broader categories based on the probability [3]. Whilst RSNA has classified the CT appearance of COVID-19 into four categories for standardised reporting language [4].

- Typical appearance

– peripheral, bilateral, GGO ± consolidation or visible intralobular lines ("crazy paving" pattern)
– multifocal GGO of rounded morphology ± consolidation or visible intralobular lines ("crazy paving" pattern)
– reverse halo sign or other findings of organising pneumonia

- Indeterminate appearance

– absence of typical CT findings and the presence of

multifocal, diffuse, perihilar or unilateral GGO ± consolidation lacking a specific distribution and are non-rounded or non-peripheral
few very small GGO with a non-rounded and non-peripheral distribution

- Atypical appearance

– absence of typical or indeterminate features and the presence of

isolated lobar or segmental consolidation without GGO
discrete small nodules (e.g. centrilobular, tree-in-bud)
lung cavitation
smoother interlobular septal thickening with pleural effusion

- Negative for pneumonia: no CT features to suggest pneumonia, absent Ground glass opacity (GGO) and consolidation.

In our study, only typical features were taken as an evidence of presence of viral pneumonia changes secondary to COVID-19 infection. Typical features were reported as classical features and high probability was given to only typical features of COVID-19 pneumonia.

Results

Number of patients presented with acute surgical pathology was 185. Out of which 41 patients were suspected based on symptoms or CT findings. In the second group, 74 patients were found to be eligible for the study purpose. All patients were suspected for COVID-19 infection and were subjected to CT chest and RT-PCR swab test.

In total, 259 patients were considered eligible for inclusion from both groups. Patients admitted for acute surgical emergencies were treated according to RCS guidelines and subjected to RT-PCR test and/or CT scan of the thorax. There were 207 patients with high clinical suspicion of COVID-19. Of those 207 patients, 77 patients had CT thorax which reported typical or severe radiographic features consistent with COVID-19 infection. However, only 40 patients (40/77) had a positive RT-PCR result. CT was normal in 130 patients and out of which 29 patients were found to have a definitive diagnosis after swab test.

Sensitivity and specificity of CT to diagnose COVID-19 were determined using the MedCalc statistical software version 19.2.6 on the assumption that RT-PCR is the gold standard investigation. Serial swab tests were done in suspected cases to increase the pickup rate of swab test and compensate for its low sensitivity.

The sensitivity of CT imaging used to diagnose COVID-19 infection was low at 58% (95% CI; 45.48% to 69.76%). Specificity was 73% (95% CI; 64.99% to 80.37%) with a negative predictive value of 77.69% (95% CI; 72.17% to 82.39%). CT imaging was found to have a high false positive rate making it an unreliable tool for a definitive diagnosis in the presence of concomitant respiratory pathologies, but with a strong negative predictive value at 82.4% makes it a useful tool for the exclusion of COVID-19 infection and can be helpful in surgical decision making for asymptomatic patients (Table 1).In our study, more than 70% of all acute surgical presentations which are normally treated surgically were treated conservatively with good outcome. Five patients (12.5%) developed COVID-19 in the postoperative phase who recovered eventually but showed that postoperative recovery can make patients vulnerable to get infection and all efforts should be made to avoid unnecessary surgeries during current pandemic (Table 2).

Discussion

Current RCS guidelines for the diagnosis of COVID-19 are based on the principle of mass casualty incident response (MCI). During MCIs, preserving financial and human resources is crucial. The society of American gastrointestinal and endoscopic surgeons (SAGES) and the European Association for Endoscopic Surgery (EAES) recommendation came in early April. Intercollegiate surgical guidelines were published on 6th of April 2020 (https://www.rcsed.ac.uk/media/681195/guidelines-for-pre-operative-covid-19-testing-for-elective-cancer-surgery-1305202.pdf). In summary, these guidelines suggested that priority should be given to acute patients. It was also suggested

Table 1 Diagnostic accuracy of CT scan in diagnosing COVID-19

Statistic	Value	95% CI
Sensitivity	50.00%	23.04 to 76.96%
Specificity	81.30%	73.28 to 87.76%
Positive predictive value	23.33%	13.82 to 36.61%
Negative predictive value	93.46%	89.37 to 96.05%
Accuracy	78.10%	70.24 to 84.71%

that a diagnosis of COVID-19 should be considered in any patient referred acutely and requiring emergency surgery. Guidelines also suggested that any patient undergoing an abdominal CT scan for acute abdominal pain as an emergency presentation should have a CT chest at the same time, unless CT chest was previously performed within last 24 h (https://www.rcsed.ac.uk/media/681195/guidelines-for-pre-operative-covid-19-testing-for-elective-cancer-surgery-1305202.pdf). The rationale behind these guidelines was to streamline the journey of surgical patients in the hospital and to minimise spread of COVID-19 infection to patients, health professionals and sterile theatre environment.

RT-PCR COVID-19 swab test gives the definitive diagnosis, but the sensitivity is between 60 and 70% [1]. The false negative rate is high. The laboratory test experienced several challenges including availability, reagent shortages, variability of results among different manufactures and delay in reporting. There were other concerns like improper sampling and timing of sampling, as low viral load can affect the results (https://www.rcseng.ac.uk/standards-and-research/standards-and-guidance/good-practice-guides/coronavirus). Initial data for post-operative mortality was high among patients with COVID-19 infection [5]. With initial unavailability of tests, kits in some parts of the world and limited data for their validity diverted the attention of surgeons towards other reliable and rapid means to diagnose COVID-19 infection. CT scan was their preferred choice as it is used widely for diagnosis of most of the surgical pathologies.

Some radiology literature suggested a pivotal role of CT in diagnosis of COVID-19 infection. Ai and colleagues reported on 1014 patients who received both RT-PCR and CT in Wuhan, China, during the epidemic. They found that 97% of cases with RT-PCR-confirmed diagnoses had CT findings of pneumonia, and concluded, "CT imaging has high sensitivity for diagnosis of COVID-19" [6].

A very significant study found that chest CT had a low rate of missed diagnosis of COVID-19 (3.9%) and may be useful as a standard method for the rapid diagnosis of COVID-19 to optimise the management of patients [7]. This study showed the potential of CT scan for diagnosis of COVID-19 infection and demonstrated the decent diagnostic accuracy of CT chest. Based on initial promising role of CT in diagnosing viral pneumonia caused by COVID-19 infection, it was used widely specially in the surgical departments.

Other investigators were less optimistic. Inui and colleagues reviewed CT scans of 112 cases of RT-PCR confirmed COVID-19 from the *Diamond Princess* cruise ship. Less than two-thirds (61%) of cases had lung opacities on CT; 20% of symptomatic patients had negative CT scan [2].

In an expert opinion, Michael Hope and colleagues felt that considering CT pivotal for COVID-19 diagnosis could lead to distraction during the pandemic and can compromise patient safety because of the delays it can cause. They have also raised concerns that patient movement within the hospital may increase exposure of patient and staff to the virus [8]. One of the repercussions of using CT in the diagnosis of COVID-19 is that safely

Table 2 Brief summary of surgical presentations, treatment and outcome

Presentation	Treated conservatively	Treated surgically	Outcome
Acute cholecystitis $n = 40$	39	1	No mortality no readmission
Acute appendicitis $n = 35$	17	18	1 mortality 2 readmission
Small bowel obstruction $n = 21$	12	9	No mortality no readmission
Bowel perforation $n = 7$	6	1	Mortality 3
Malignancy $n = 11$	5	6	No mortality no readmission
IBD $n = 9$		9	No mortality no readmission
Abdominal wall hernia $n = 6$	3	3	Mortality 1
Sigmoid volvulus $n = 3$	2	1	Mortality 3
Abscess $n = 10$	2	8	No mortality no readmission
Diverticulitis $n = 12$	10	1	No mortality no readmission
Ischaemic colitis $n = 2$	2	0	All discharged
Pseudo-obstruction $n = 2$	2	0	No mortality no readmission
Non-specific adnominal pain $n = 3$	3	0	1 mortality
Post-operative wound infection $n = 3$	3	0	No mortality no readmission
Miscellaneous $n = 24$	24	0	Mortality 2

performing imaging is problematic. At the very least, droplet precautions with appropriate protective gear (with global shortage in supply) need to be followed, CT scan rooms must be thoroughly cleaned, and the air needs to be recirculated given that COVID-19 is an airborne disease. Even if all protocols are followed, there is a risk that COVID-19 infection may be passed to other patients or staff in imaging departments. Given that CT findings suggesting COVID-19 pneumonia changes are not very specific in determining the diagnosis, clinicians should adopt a cautious approach when requesting imaging in suspected patients.

Various stakeholders and expert panels had a varied view about role of CT scan in the use of diagnosis of COVID-19 infection. The Royal College of Radiology (RCR) had adopted an initial cautious approach and permitted the additional use of CT thorax in assessing likelihood of COVID-19 infection (https://www.rcr.ac.uk/college/coronavirus-covid-19-what-rcr-doing/clinical-information/role-ct-chest/role-ct-chest). At the time of publication of initial guidelines, there was a paucity of evidence, but many experts believed that CT thorax may have an important role in stratifying risk in surgical patients presenting acutely and requiring a CT abdomen. In the absence of other form of reliable rapid tests for COVID-19 testing, CT chest was believed to help in quick diagnosis of COVID-19. However, RCR recommended that negative scan should not exclude COVID-19 infection (https://www.rcr.ac.uk/college/coronavirus-covid-19-what-rcr-doing/clinical-information/role-ct-chest/role-ct-chest).

The RCR published updated guidelines recently and discouraged routine CT chest owing to the relatively low detection rate of COVID-19 in asymptomatic patients with positive swab test and a 20% false negative rate in symptomatic patients, which indicates that pre-operative CT chest is of limited use. The RCS guidelines have not yet been updated to reflect this change from the royal college of radiologists (https://www.rcr.ac.uk/college/coronavirus-covid-19-what-rcr-doing/clinical-information/role-ct-chest/role-ct-chest).

Outside the UK, multiple radiological organisations and learned societies have stated that CT should not be relied upon as a diagnostic/screening tool for COVID-19. On March 16, 2020, an American-Singaporean panel published their findings and drawn guidelines for the diagnosis of COVID-19. CT findings were not part of their diagnostic criteria for COVID-19 [9].

With globally reported sensitivity of RT-PCR swab test being 60–70%, it is still more sensitive for the definitive diagnosis of COVID-19 infection when we look at our study results [1]. Surgical institutions should do an internal audit and adopt a cautious approach until new guidelines based on stronger evidence are available.

The limitation of our study is that it is a single institute experience with small number of patients. A review of 259 patients may not be enough to conclude definitively about diagnostic accuracy of CT scan for COVID-19 infection and a large observational multi-institutional study is required to provide stronger evidence.

In many other countries and even in the UK, swab test is still undergoing various development stages and a test kit with a rapid result with good reliability is still not widely available. The rapid test available in the UK still needs external validation from various accredited bodies. In countries like India where a major surge of COVID-19 cases is going on, CT scan can still be used as a fast and reliable diagnostic modality. In some parts of India, kits are not readily available and various test kits available have not passed the validity tests because of restrictions from institutions like Indian council of medical research (ICMR). Conversely, in rural areas where CT scans are not available in house, moving patients between hospitals for scans can be a risk to patients and others.

Conclusions

CT chest can be used as an important tool to exclude viral pneumonia caused by COVID-19, as it is highly specific, but with a low sensitivity and high false positive rate, it should not be relied upon as a sole definitive diagnostic tool to diagnose COVID-19 infection and confirmation with swab test along with isolation protocols should be observed in suspected cases. With a reasonable specificity and potential to diagnose COVID-19 infection, CT scan can play an important role in surgical decision making in asymptomatic pre-operative surgical patients.

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Data Availability On request

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval Not needed.

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