Admission COVID-19 clinical risk assessment for guiding patient placement and diagnostic testing strategy

Authors: Nick K Jones,[A*] Isobel Ramsay,[B*] Elinor Moore,[C] Jonathan Fuld,[D] Chris Adcock,[E] Edward Banham-Hall,[E] Judith Babar,[F] Effrossyni Gkrania-Klotsas[C] and Hoi Ping Mok[G]

ABSTRACT

Introduction

Without universal access to point-of-care SARS-CoV-2 testing, many hospitals rely on clinical judgement alone for identifying cases of COVID-19 early.

Methods

Cambridge University Hospitals NHS Foundation Trust introduced a 'traffic light' clinical judgement aid to the COVID-19 admissions unit in mid-March 2020. Ability to accurately predict COVID-19 was audited retrospectively across different stages of the epidemic.

Results

One SARS-CoV-2 PCR positive patient (1/41, 2%) was misallocated to a 'green' (non-COVID-19) area during the first period of observation, and no patients (0/32, 0%) were mislabelled 'green' during the second period. 33 of 62 (53%) labelled 'red' (high risk) tested SARS-CoV-2 PCR positive during the first period, while 5 of 22 (23%) 'red' patients were PCR positive in the second.

Conclusion

COVID-19 clinical risk stratification on initial assessment effectively identifies non-COVID-19 patients. However, diagnosing COVID-19 is challenging and risk of overcalling COVID-19 should be recognised, especially when background prevalence is low.

KEYWORDS: SARS-CoV-2, COVID-19, coronavirus, triage, diagnostics, infection control

DOI: 10.7861/clinmed.2020-0519

Authors: [A]specialist registrar in infectious diseases and medical virology, Addenbrooke's Hospital, Cambridge, UK; [B]specialist registrar in infectious diseases and medical microbiology, Addenbrooke's Hospital, Cambridge, UK; [C]consultant in infectious diseases, Addenbrooke's Hospital, Cambridge, UK; [D]consultant in acute and respiratory medicine, Addenbrooke's Hospital, Cambridge, UK; [E]consultant in acute medicine, Addenbrooke's Hospital, Cambridge, UK; [F]consultant radiologist, Addenbrooke's Hospital, Cambridge, UK; [G]consultant in infectious diseases and acute medicine, Addenbrooke's Hospital, Cambridge, UK; *equal first authors

Introduction

The COVID-19 pandemic is creating enormous logistical challenges for health services across the UK, with many hospitals having been forced to restructure systems that have been in place for decades. Major priorities in the re-design of pathways for patient admission are to ensure potentially infectious patients are kept separate from those that remain susceptible, and to utilise testing capacity rationally and effectively. Until point-of-care (POC) SARS-CoV-2 testing becomes universally available,[1] clinical judgement will continue to form the basis of patient placement decisions. Here, we report our experience of using a clinical risk stratification system developed in our hospital.

Methods

Similar to other hospitals,[2] we have been using a COVID-19 risk stratification system to categorise patients according to how readily their presenting symptoms, clinical signs, POC blood test results and chest X-ray images can be explained by COVID-19 or alternative diagnoses (Table 1). Traffic light colours are assigned to individual cases based on clinical judgement during initial assessment at the time of admission. Such clinical risk assessment requires prior knowledge of the typical presenting features of COVID-19, but does not involve the use of strict diagnostic criteria and is not a validated diagnostic or prognostic tool. It invites the physician to consider the extent to which the presenting clinical features can be explained by COVID-19 or an alternative diagnosis. We introduced the system in combination with a succinct summary table of the most commonly reported clinical, POC laboratory and radiological findings in COVID-19 cases (Table 2) to aid non-specialist clinicians in the assessment of this novel disease. Illustrative examples of cases assigned to various cohorts are described in Box 1. The intended benefits of the system were to guide patient placement and identify patients for whom a single negative PCR test might be insufficient grounds to exclude COVID-19. The latter is particularly important due to the limited sensitivity of rt-PCR on material obtained from the upper respiratory tract ,[3,8–10] and the high risk to healthcare workers associated with routine deep respiratory sampling through bronchoalveolar lavage.

In preparation for an increase in COVID-19 admissions, Cambridge University Hospitals NHS Foundation Trust (CUH) set up

Table 1. Summary of traffic light risk stratification system

Clinical assessment	Descriptor
Green: COVID-19 is not in the differential diagnosis	An alternative diagnosis is the most likely explanation for the entire clinical picture, including the features that would otherwise point towards COVID-19
Amber: COVID-19 is in the differential diagnoses but not the leading diagnosis (another diagnosis is at least as likely as COVID-19)	The clinical features could be consistent with COVID-19, but an alternative diagnosis could reasonably explain the clinical picture
Red: COVID-19 is the leading diagnosis (COVID-19 is top of the list of differential diagnoses)	Several clinical features point towards a diagnosis of COVID-19
	An alternative diagnosis might explain the clinical features, but the overall clinical picture is more in keeping with that of COVID-19 (or its complications)
	The overall clinical suspicion is so strong that a single negative swab is insufficient to dissuade the clinician from a diagnosis of COVID-19

an admissions unit run by acute physicians for those with suspected COVID-19, which was separated from the main emergency department (ED) and opened on 17 March 2020. All patients with symptoms compatible with possible COVID-19 at initial community or hospital triage were directed to the COVID-19 admissions unit. However, patients requiring higher-dependency care in an ED resuscitation area (NEWS score ≥7) were deemed unsuitable.

Results

CUH began using the COVID-19 traffic lights system trust-wide in mid-March 2020. An audit of its performance in predicting cases of laboratory confirmed COVID-19 in the COVID-19 admissions unit was undertaken retrospectively via manual review of patient notes. The UK was put into lockdown with strict social distancing measures from 23 March 2020. Locally, the peak number of COVID-19 admissions occurred in the week beginning 8 April 2020. By the end of the audited period (20 May), the published cumulative incidence rate of COVID-19 in the East of England was 214/100,000, making it the seventh highest of the nine regions of England. For comparison, the highest regional cumulative incidence rate in England at that time was 364/100,000 in the North East, and the lowest was 132/100,000 in the Southwest.[11] From 21 March 2020 to 14 April 2020, of 165 audited patients to

Table 2. Clinical decision support table[3–7]

	Clinical	Contacts	Laboratory	Radiology
Key features	Fever >37.8 Persistent cough Dyspnoea Fatigue Myalgia Hypoxia Anosmia	Contact with a known or suspected case within the last 14 days	Lymphopenia Thrombocytopenia (usually mild) Raised CRP Raised D-dimer	CXR: patchy ground glass opacities, typically predominantly peripheral and basal
Additional notes	GI disturbance and other atypical presentations have been reported. It is important that all patients are directly questioned about new respiratory symptoms and fever, even if this is not their presenting complaint The possibility of COVID-19 should be considered in elderly patients with non-specific signs/symptoms	Direct questioning about household or occupational exposure to individuals with febrile/respiratory illness is recommended Consider local prevalence of COVID-19. As the epidemic unfolds, the index of suspicion of COVID-19 should be altered accordingly	Neutrophilia with a very high CRP should raise suspicion of bacterial infection rather COVID even though it does not necessarily exclude COVID-19	X-ray changes may be bilateral or unilateral Over time, patchy ground glass opacities may coalesce into denser consolidation Pleural effusions, lymphadenopathy, cavitation or masses may point towards alternative diagnoses Consider other diagnoses that may lead to ground glass changes.

CRP = C-reactive protein; CXR = chest radiograph.

Box 1. Illustrative examples of cases assigned to different traffic light categories

Case 1

A man in his 50s with potential contact with COVID-19 2 weeks prior to presentation was admitted with 7 days of swinging fever, nausea, poor oral intake and shortness of breath. His temperature was 38.9°C on admission and he required 1L of oxygen to maintain an oxygen saturation of 96%. Examination revealed sparse crackles only. Chest radiograph (CXR) demonstrated patchy consolidation in both bases. Admission bloods showed lymphopenia with lymphocytes at 0.56×10^9/L.

Assessment: With possible exposure, congruent clinical picture, classic CXR and lymphopenia, he was classed as 'red' and later tested positive for SARS-CoV-2 by rt-PCR on an upper respiratory tract (URT) swab.

Case 2

A man in his late 80s with multiple comorbidities, including known prostate malignancy, who had moved into a care home shortly prior to presentation with increasing confusion, was admitted. He was apyrexial with normal oxygen saturation on admission. Examination revealed a tense, palpable bladder, and urinary retention was confirmed by bladder scan. He was found to have a cough, although CXR and bloods were unremarkable. Collateral history revealed that he has been having a cough for 'years'.

Assessment: He was classed as 'green' and later tested negative for SARS-CoV-2 by rt-PCR on an URT swab.

Case 3

A female in her 70s with a background history of COPD presented with 4 days of cough productive of creamy sputum, shortness of breath and reduced exercise tolerance. She was apyrexic on admission and had an oxygen saturation of 94% on room air. Examination revealed a wheezy chest. Admission bloods showed a neutrophil count of 6.46×10^9/L, lymphocytes of 1.09×10^9/L and CRP <4 mg/L. Bi-basal atelectasis was seen on CXR. Whilst SARS-CoV-2 is a plausible cause for this episode of COPD exacerbation, the trigger could also be a variety of infective or non-infective insults.

Assessment: She was classed as 'amber' and was subsequently tested negative for SARS-CoV-2 by rt-PCR on an URT swab.

Case 4

A female in her mid-80s who lives alone with early dementia was found to be more confused by her carers. On admission she was febrile at 38.6°C. Oxygen saturation was 96% on room air. A thorough examination did not reveal any positive findings. Her bloods showed total WCC of 3.9×10^9/L, neutrophils 2.37×10^9/L, lymphocytes 0.98×10^9/L, CRP 34 mg/L, and normal liver function tests. CXR was also normal.

Assessment: With an undifferentiated fever and no other clinical findings to point towards a diagnosis, she was initially classed as 'amber'. On day 2 of admission she had increasing dyspnoea, and desaturated to require 2L of oxygen for maintenance of 94% oxygen saturations. Repeat bloods showed more marked lymphopenia at 0.74×10^9/L, without a concurrent rise in neutrophils. She was reclassed as 'red' and was later tested positive for SARS-CoV-2 by rt-PCR on an URT swab.

have been assigned traffic light colours by consultant physicians in acute medicine, 33 of 62 (53%) labelled 'red' (high risk) were found to be SARS-CoV-2 PCR positive, while 12 of 62 (19%) labelled 'amber' (moderate risk) and only one of 41 (2%) labelled 'green' (low risk) were SARS-CoV-2 PCR positive. In the context of falling community SARS-CoV-2 transmission as a result of the UK lockdown,[12] five out of 22 (23%) audited patients labelled 'red' between 28 April 2020 and 20 May 2020 were found to be SARS-CoV-2 PCR positive, while 1 of 65 (2%) labelled 'amber' and none of 32 'green' tested positive. Although the limited clinical sensitivity of rt-PCR on upper respiratory tract samples makes under-representation of the true rate of COVID-19 in each traffic light group likely, the proportion of 'red' patients that tested negative is notably high. This has important implications for patient placement and onward testing strategy. We followed up 44 of the 46 'red' patients with initial negative rt-PCR test and found that 14 (32%) had had at least one repeat swab for rt-PCR within one week of admission, three of whom tested positive. Hospital-acquired infection was thought to be a possible explanation for one of these cases. Eleven (25%) of 44 rt-PCR negative 'red' patients received a clear alternative diagnosis by the point of discharge.

Discussion

In hospitals with limited access to single-patient isolation facilities, cohort nursing of patients awaiting test results is inevitable. The traffic lights clinical risk stratification aid has proven useful in identifying non-COVID-19 patients and can enable NHS Trusts to optimise their use of available side rooms. The data above show that diagnosing COVID-19 through clinical means alone is challenging. In response to declining population incidence after the first wave, we moved to a policy of only cohort nursing patients confirmed as positive for SARS-CoV-2 by rt-PCR. Patients badged as 'green' also continue to be routinely nursed in standard shared facilities away from the designated COVID-19 areas. All patients in which COVID-19 remains possible but unconfirmed (eg 'amber' patients awaiting rt-PCR results and 'red' patients that have tested negative on single rt-PCR) are prioritised for side rooms or maximally spaced shared bays (two patients per six-bedded bay). This strategy aims to minimise the risk of in-hospital exposures between infectious and susceptible patients.

The data generated here have also allowed us to predict the performance of additional testing strategies for excluding COVID-19, by applying published data on the sensitivity and specificity of both rt-PCR on upper respiratory tract samples and CT imaging of the thorax (Table 3) to patient groups in each of the traffic lights risk categories. We estimated that routine use of CT scans would likely result in overcalling COVID-19 because of low specificity, even in cases of high risk 'red' patients. In view of this, we recommend repeat rt-PCR on serial upper, or preferably lower, respiratory tract samples as the most reliable way of investigating cases of ongoing diagnostic uncertainty when initial rt-PCR results are negative. At the time of the study, laboratory capacity for SARS-CoV-2 rt-PCR was limited, and evidence for the optimal frequency and timing of serial sampling for diagnosing COVID-19 was lacking. Pragmatic recommendations for the investigation of individuals with high clinical suspicion of COVID-19 were therefore implemented, in which an initial negative result was to be immediately followed by repeat sampling, typically a few days after

Table 3. Summary of performance of diagnostic tests for COVID-19 from the literature

Test	Test performance
One URT swab	Sensitivity 66–71 % (one outlier 90 %)[8–10] Specificity unknown – low level positives may be indistinguishable from environmental contamination, affecting specificity
Two URT swabs	Sensitivity 94–98 %[8–10]
Three URT swabs	Sensitivity 98–100 %[8,10]
CT	Sensitivity 71–100 %[4,5,9,13–15] – can be as low as 44 % in early or asymptomatic disease[16,17] Specificity 53 %[14] Both sensitivity and specificity are operator-dependent[15]
One CXR	Sensitivity 64 % based on a single publication, overall limited evidence and skewed by practice in China where CT is the norm[10]

Abbreviations: URT = upper respiratory tract; CT = computed tomography; CXR = chest radiograph

the first swab was taken. There is ongoing work evaluating the role of serology in the diagnosis of COVID-19 in selected patients.[18]

Conclusion

As the pandemic unfolds, the background prevalence of COVID-19 will continue to change, and so will the proportion of patients in each traffic light risk category testing positive. We have found that the use of a risk stratification system for grading the clinical likelihood of COVID-19 at the point of initial assessment provides a helpful framework upon which to hang difficult patient placement decisions at the hospital front door, and to guide the hospital-wide response to the evolving pandemic. However, clinical diagnosis of COVID-19 has proven challenging and the risks of overcalling COVID-19 should be recognised. ■

References

1 Collier DA, Assennato SM, Warne B *et al*. Point of care nucleic acid testing for SARS-CoV-2 in hospitalized patients: a clinical validation trial and implementation study. *Cell Rep Med* 2020;1:100062.
2 Patterson B, Marks M, Martinez-Garcia G *et al*. A novel cohorting and isolation strategy for suspected COVID-19 cases during a pandemic. *J Hosp Infect* 2020;105:632–7.
3 Wang W, Xu Y, Gao R *et al*. Detection of SARS-CoV-2 in different types of clinical specimens. *JAMA* 2020;323:1843–4.
4 Guan WJ, Ni ZY, Hu Y *et al*. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med* 2020;382:1708–20.
5 Shi H, Han X, Jiang N *et al*. Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. *Lancet Infect Dis* 2020;20:425–34.
6 Liu K, Fang YY, Deng Y *et al*. Clinical characteristics of novel coronavirus cases in tertiary hospitals in Hubei Province. *Chin Med J (Engl)*. 2020;133:1025–31.
7 Yang X, Yu Y, Xu J *et al*. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med* 2020;8:475–81.
8 Fang Y, Zhang H, Xie J *et al*. Sensitivity of chest CT for COVID-19: Comparison to RT-PCR. *Radiology* 2020;296:E115–E7.
9 Ai T, Yang Z, Hou H *et al*. Correlation of chest CT and RT-PCR Testing for coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. *Radiology* 2020;296:E32–E40.
10 Wong HYF, Lam HYS, Fong AH *et al*. Frequency and distribution of chest radiographic findings in patients positive for COVID-19. *Radiology* 2020;296:E72–E8.
11 Public Health England. *National COVID-19 surveillance reports*. www.gov.uk/government/publications/national-covid-19-surveillance-reports#history.
12 Public Health England. *Coronavirus (COVID-19) in the UK*. Available at https://coronavirus.data.gov.uk/?_ga=2.203524627.2047977285.1592859198-753038366.1583154480
13 Su L, Ma X, Yu H *et al*. The different clinical characteristics of corona virus disease cases between children and their families in China - the character of children with COVID-19. *Emerg Microbes Infect* 2020;9:707–13.
14 Wen Z, Chi Y, Zhang L *et al*. Coronavirus Disease 2019: Initial detection on chest CT in a retrospective multicenter study of 103 Chinese subjects. *Radiol Cardiothorac Imaging* 2020;2:e200092.
15 Bai HX, Hsieh B, Xiong Z *et al*. Performance of radiologists in differentiating COVID-19 from non-COVID-19 viral pneumonia at Chest CT. *Radiology* 2020;296:E46–E54.
16 Bernheim A, Mei X, Huang M *et al*. Chest CT findings in coronavirus disease-19 (COVID-19): relationship to duration of infection. *Radiology* 2020;295:200463.
17 Ling Z, Xu X, Gan Q *et al*. Asymptomatic SARS-CoV-2 infected patients with persistent negative CT findings. *Eur J Radiol* 2020;126:108956.
18 Mlcochova P, Collier D, Ritchie A *et al*. Combined point-of-care nucleic acid and antibody testing for SARS-CoV-2 following emergence of D614G spike variant. *Cell Rep Med* 2000;1:100099.

Address for correspondence: Dr Nick Jones, Department of Infectious Diseases, Addenbrooke's Hospital, Hills Road, Cambridge CB2 0QQ, UK.
Email: nicholas.jones@addenbrookes.nhs.uk