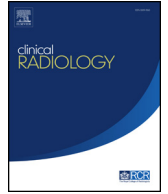




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# Mechanical thrombectomy for acute ischaemic stroke during the COVID-19 pandemic: changes to UK practice and lessons learned

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## ARTICLE INFORMATION

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**AIM:** To describe evolving practices in the provision of mechanical thrombectomy (MT) services across the UK during the COVID-19 pandemic, the responses of and impact on MT teams, and the effects on training.

**MATERIALS AND METHODS:** The UK Neurointerventional Group (UKNG) and the British Society of Neuroradiologists (BSNR) sent out a national survey on 1 May 2020 to all 28 UK neuroscience centres that have the potential capability to perform MT.

**RESULTS:** Responses were received from 27/28 MT-capable centres (96%). Three of the 27 centres do not currently provide MT services. There was a 27.7% reduction in MTs performed during April 2020 compared with the first 3 months of the year. All MT patients in 20/24 centres that responded were considered as COVID-19 suspicious/positive unless or until proven otherwise. Twenty-two of the 24 centres reported delays to the patient pathway. Seventeen of the 24 centres reported that the COVID-19 pandemic had reduced training opportunities for specialist registrars (SpR). Fourteen of the 24 centres reported that the pandemic had hampered their development plans for their local or regional MT service.

**CONCLUSION:** The present survey has highlighted a trend of decreasing cases and delays in the patient pathway during the early stages of the COVID-19 pandemic across UK centres.

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## Introduction

COVID-19 caused by SARS-CoV-2 produced an international outbreak at the end of 2019, and on 11 March 2020 the World Health Organization declared it a global pandemic. The pandemic spread to the UK by late January

2020, and on 23 March, the UK government instituted a lockdown on the whole population.

In other respiratory tract infections, it is well documented that the risk of stroke is increased by a factor of 2.3–7.82 within the first 3 days of infection.<sup>1</sup> Although early evidence suggests COVID-19 also confers an increased risk

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of acute ischaemic stroke (AIS), the underlying pathological mechanism remains uncertain, although multiple reports suggest infected patients can develop a hypercoagulable condition<sup>2–4</sup>; D-dimer levels are reported to be up to 12-fold higher than normal.<sup>2</sup>

In a study of 221 consecutive patients admitted to one hospital in Wuhan, China, with confirmed COVID-19, AIS occurred in 11 (5%) of patients with a range of stroke subtypes.<sup>2</sup> COVID-19 causes the most severe illness in the elderly, the immunocompromised, and those with other significant comorbidities<sup>5,6</sup>; most patients with COVID-19-related AIS fall into one or more of these categories.

Mechanical thrombectomy (MT) alongside intravenous thrombolysis (if not contraindicated) is the first-line treatment for patients with AIS and occlusion of a large cerebral artery demonstrated by computed tomography (CT) angiography (CTA) or magnetic resonance angiography (MRA).<sup>7</sup>

The COVID-19 pandemic has presented new and varied challenges to the still-evolving UK MT services. Practices within interventional neuroradiology (INR) theatres have had to be significantly modified to protect both staff and patients. National and international interventional and neuro-interventional societies have issued guidelines regarding recommended changes in practice, some of which have contributed to forming a framework for current clinical practice.<sup>8,9</sup> As the UK emerges from the worst of the initial peak of the pandemic, the authors, on behalf of the British Society of Neuroradiologists (BSNR) and the UK Neurointerventional Group (UKNG), sought to review the initial challenges to the UK's MT service and its response in order to evaluate and disseminate the lessons learned.

## Materials and methods

An online survey (Google Forms) was sent out on 1 May 2020 to all 28 UK neuroscience centres that have the potential capability to perform MT (Electronic Supplementary Material S1: Survey).

Standard data and statistical analysis (*t*-test and Fisher's exact test) was carried out using GraphPad Prism (GraphPad Software). Statistical significance was set at  $p < 0.05$ .

### *Number of MTs performed*

To gain insight into MT service provision across the UK, the survey asked for the number of patients undergoing MT during each month from January to April 2020, in order to document the rate of MT procedures carried out immediately before and during the first 3 months of the COVID-19 pandemic in the UK.

### *MT patient pathway*

To establish changes made to the MT triage protocols for patients with AIS during the COVID-19 pandemic, in the absence of a positive COVID-19 test result, the survey requested information regarding what screening measures for COVID-19 had been introduced for MT patient referrals

and whether all MT-eligible patients were managed as if they had suspected COVID-19. Data were requested regarding whether there had been any tendency in the UK to narrow the acceptance criteria for AIS patients referred for MT in an effort to (a) mitigate the spread of COVID-19 to neuroscience centre patients, healthcare workers, and their families, (b) to target therapies to those patients in most need, and (c) to optimise allocation of healthcare resources including personal protection equipment (PPE).

Avoiding delays between stroke onset and recanalisation of large vessel occlusion (LVO) is of paramount importance in achieving optimal outcomes for AIS patients; however, additional safety measures as a result of the COVID-19 pandemic inevitably hindered normal workflow patterns before, during, and after MT. The survey also assessed whether additional precautions at several stages of MT patient flows caused delays in treatment, and what were considered the primary contributing factors. Furthermore, hospital visitors are largely prohibited during the pandemic, which presents challenges to obtaining an accurate history and conducting informed consent. The survey sought responses to ascertain whether the pandemic had affected the patient consent process prior to MT and how the absence of relatives accompanying the patient had changed established working practices.

Intra-procedural additional safety precautions are essential to minimise exposure of healthcare staff to respiratory secretions from patients with confirmed or suspected COVID-19 and those patients in whom the COVID-19 status is uncertain. The survey was used to establish the rates of local (LA) and general anaesthetic (GA) used for patients undergoing MT anaesthetic prior to the COVID-19 outbreak, whether or not it was routine practice to intubate patients in theatre prior to bringing the patient into the angiography room for MT, and determine if practice had changed as a result of the pandemic. It is important to ensure safe levels of PPE are used by all members of staff within the angiography suite. It is also essential to minimise the number of personnel in the room who are potentially exposed to patient respiratory aerosol. The survey also assessed the level of PPE used during MT procedures in the UK under the conditions of either local or general anaesthesia.

There have been anecdotal reports of procedural differences experienced whilst treating COVID-19 patients with AIS including rate of successful recanalisations, clot location, consistency, and burden of thrombus. Centres were asked to provide the number of successful recanalisations, defined as thrombolysis in cerebral infarction (TICI) scores of 2B or above, during the months from January to April 2020. Additionally, the survey sought to evaluate whether UK INRs had noticed procedural differences in treating COVID-19 patients in comparison with non-COVID-19 patients and whether clinical outcomes and mortality rates had changed.

Post-procedurally, for suspected or confirmed COVID-19 patients, data were required regarding whether MT centres had changed their practice around recovery or routine post-MT brain imaging, and if there had been any issues

with regards to repatriation of MT patients to the referring primary stroke centre.

### Effects on training and working

UK MT centres were asked whether or not the COVID-19 pandemic had affected training opportunities for INR specialist registrars (SpR), and if yes, what the reasons were. To determine the impact of the pandemic, the survey questioned whether UK MT centres had split INRs into separate teams and to provide details on how they had arranged their rota accordingly. Additional responses were gathered in relation to any other changes to INR working patterns and if any centres had noticed an adverse impact on the mental health of INRs and the wider MT team.

### Impact on MT service development

Respondents were asked to indicate whether the COVID-19 pandemic had hampered their centre's MT service development.

## Results

Responses were received from 27/28 MT-capable centres (96%) via an online web link (see Acknowledgements). Of the 27 responders to the UKNG/BSNR survey, three UK neuroscience centres do not currently provide MT services. Following lockdown on 23 March 2020, there was a 27.7% reduction in MTs performed during April 2020 compared with the first 3 months of the year (Fig 1).

Twenty of the 24 MT-active centres that responded considered all MT patients as COVID-19 suspicious/positive unless or until proven otherwise. Sixteen of the 24 centres used symptomatic screening questionnaires at the point of referral. Four of the 24 centres introduced a CT chest as an additional screening test to the patient referral pathway.

Seven of the 24 centres used no additional COVID-19 pre-MT screening procedures (Fig 2).

Eleven of 24 MT-active UK centres had changed their case selection towards stricter adherence to national MT patient acceptance criteria and some had introduced an age threshold. Reasons given included additional delays in patient transfer potentially resulting in futile procedures. Twenty-two out of 24 centres reported delays to the patient pathway. More than one response per centre was permitted to facilitate documentation of multiple possible contributory reasons. The most common reasons for delay were delayed presentation from stroke onset (16/24), delayed investigation of MT patients (11/24), delayed referral to MT centre (9/24), and delayed inter-facility transfer (9/24). Limited resources were reported as a contributing factor in 16/24 centres including availability of an appropriate bed, lack of anaesthetic availability, angiography room occupancy for patient recovery, and/or delays from additional COVID-19-related angiography room cleaning.

Twelve of 24 centres reported having to change their consent process and or their practices for communicating with relatives.

There had been no significant change to the proportion of MTs performed under GA during the COVID-19 pandemic (range from 72.7% to 64.3%; Fig 3). Prior to the pandemic 2/24 centres routinely performed endotracheal intubation in general theatres prior to transferring patients to the angiography suite; during the pandemic 5/24 centres did.

For MT performed under LA, 16/24 centres used enhanced PPE, 7/24 used safe PPE (fluid-resistant surgical mask, face shield/goggles, and gloves) and 1/24 did not employ additional measures to standard theatre operating kit. For MT performed under general anaesthesia, 16/24 centres used enhanced PPE and 8/24 used safe PPE.

There was no significant change to the proportion of MT procedures that resulted in successful recanalisation (defined as TIC12B–3 inclusive; range from 84.2% to 79.1%;

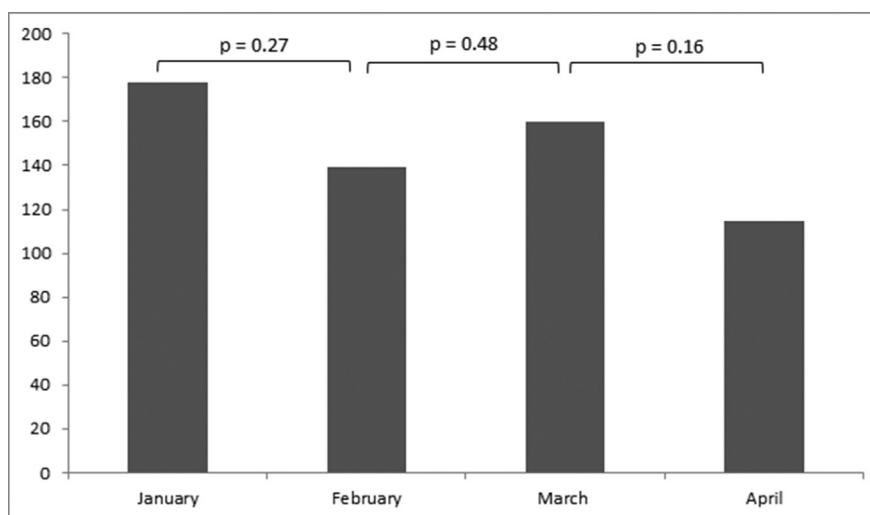
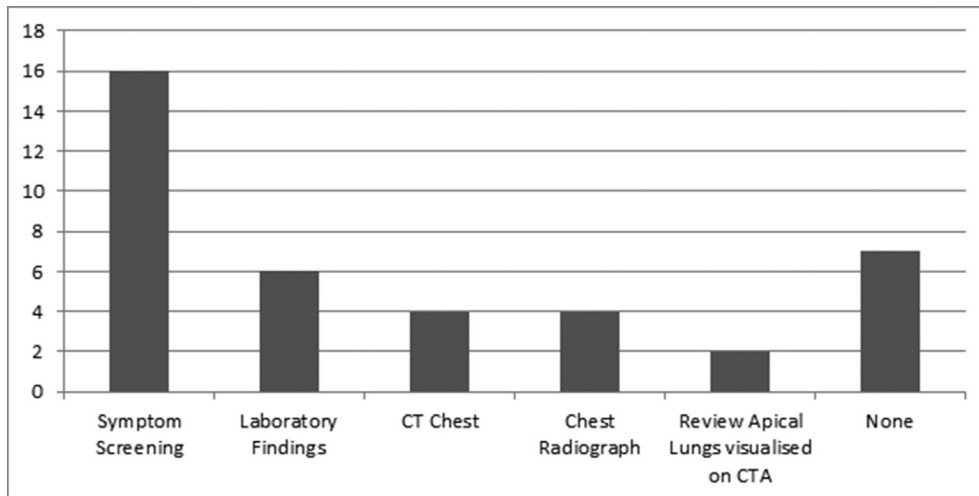
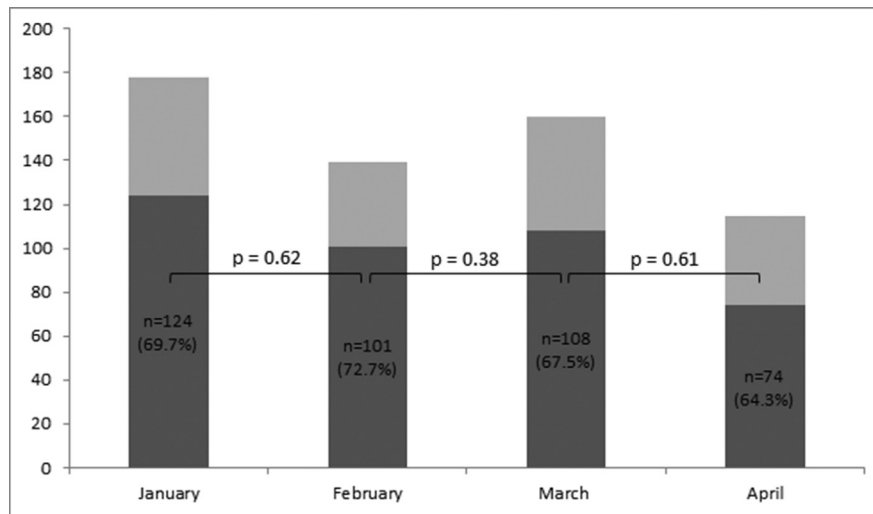


Figure 1 Number of MTs performed across the UK in 2020 (t-test).



**Figure 2** COVID-19 pre-MT acceptance screening procedures.



**Figure 3** Number of MTs performed under GA (Fisher's exact test).

Fig 4); however, six of 24 centres reported (subjectively) more friable and or adverse clot consistency in COVID-19 patients. Three centres reported a decrease in National Institutes of Health Stroke Scale (NIHSS) at 24 h post-MT in COVID-19 patients and one centre reported an increase in mortality post-MT in COVID-19 patients.

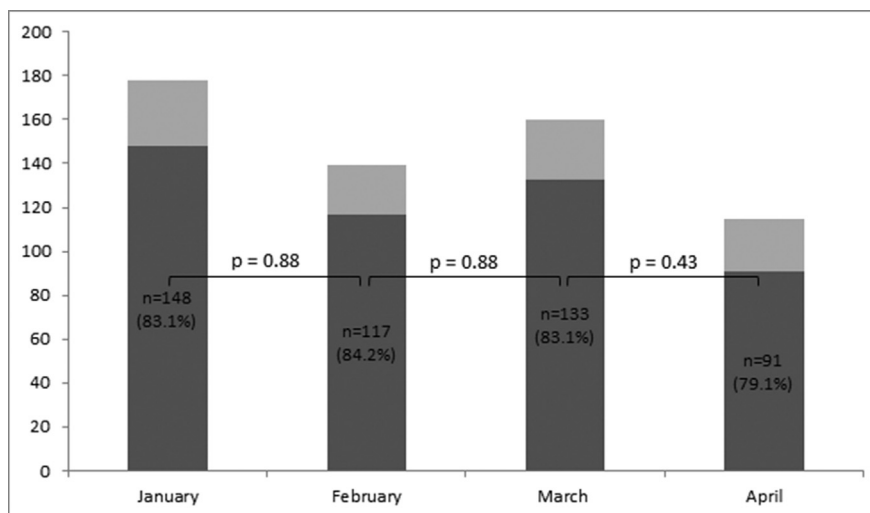
Ten of the 24 MT-active centres changed to recovering suspected or confirmed COVID-19 patients within the angiography suite following their MT procedure. No centre reported a change to their standard post-MT imaging protocol.

Six of the MT-active 24 centres reported additional delays to patient repatriation to the primary stroke centre post-MT, the most commonly cited reason being a lack of availability of appropriate isolation beds (n=4).

Seventeen of the 24 centres reported that the COVID-19 pandemic had reduced training opportunities for INR

SpRs. Reduced caseload (15/24), infection-control measures mandating minimum staff being present for procedure (8/24), and trainee service re-deployment (6/24) were the main reasons given. As a result, 3/24 centres said they planned to extend training programmes for affected SpRs.

Nine of the 24 centres had split their INR consultant staff into teams during the pandemic, mostly into 1-in-2 or 1-in-3 rotas. Other changes to the normal working patterns included virtual multidisciplinary team meetings (MDT), (partial) re-deployment to cover diagnostic radiology rotas, reduced out-of-hours services due to reduced nursing support, and working from home (remote reporting of neurological imaging). In the present survey, 10/24 centres reported an adverse effect on the mental health of the wider angiography team, and 8/24 centres reported an adverse effect on the mental health of INRs.



**Figure 4** Successful recanalisation defined as TICI 2B/2C/3 (Fisher's exact test).

Fourteen of the 24 centres reported that the pandemic had hampered their development plans for their local or regional MT service.

## Discussion

Early evidence from Chinese studies demonstrated that COVID-19 can cause neurological deficits in infected patients and AIS in approximately 5%.<sup>2,4</sup> Despite the Chinese data indicating high stroke incidence in COVID-19 patients, reports from most countries affected by the pandemic suggest that referrals to hospital for stroke treatment including MT actually fell, at least initially, following government-imposed lockdown measures. In a prospective study of 1,513 patients at 32 centres in all the administrative regions of France, there was a 21% decrease in MT case volumes during the initial stages of the COVID-19 epidemic.<sup>10</sup> Although some cities, notably New York, noticed a surge in MT numbers, including for AIS in younger patients,<sup>11</sup> a national survey of 856 hospitals across the USA found a 39% decline in the number of patients receiving stroke imaging.<sup>12</sup> The present survey indicates a similar trend with a 27.7% reduction in MTs performed in April 2020 across the UK.

The efficacy of MT is inversely proportional to the delay between stroke onset and LVO recanalisation. There are anecdotal accounts of patients being reluctant to present to hospital during the pandemic. Once admitted, additional safety measures were, of necessity, imposed onto the patient journey including added precautions on the stroke ward, in the CT machines, during ambulance transfer, during airway preparation, within the angiography suite, and during warding and repatriation. In France, significantly increased delays were found between imaging and groin puncture, overall and in transferred patients in particular.<sup>10</sup> The majority of the UK centres encountered delays to multiple steps in the patient pathway. Given the

uncertainty over the duration of the pandemic, these issues need to be urgently addressed to ensure the best possible functional outcomes for patients.<sup>13</sup>

One of the challenges in identifying COVID-19 in AIS is an inability to obtain an accurate history of clinical symptoms due to underlying speech problems and/or confusion. Furthermore, at present COVID-19 status cannot be confirmed or excluded using antigen or antibody testing within the timeframe required for initial evaluation and decision-making regarding time-critical therapies for patients with AIS. A significant rate of false-negative antigen tests is known to occur. The Society of NeuroInterventional Surgery (SNIS) recommendation was that, for MT patients without a documented "negative" COVID-19 status, healthcare staff in the angiography room should wear enhanced PPE at all times, including N-95 or FFP2/FFP3 air-filtration mask.<sup>9</sup> Discordant pre-MT screening practices and variable use of PPE across the country was likely a reflection of initially confusing and rapidly changing guidelines at local, regional, and national level.

Given that the majority of patients presenting for MT will have unknown COVID-19 status, the Society for Neuroscience in Anesthesiology & Critical Care (SNACC), SNIS and European Society of Minimally Invasive Neurological Therapy (ESMINT) strongly recommended a lower threshold for intubation, especially if the anaesthetist or INR have any concerns for possible conversion from LA to GA.<sup>8,9,14</sup> It is further recommended that intubation should not take place within the angiography suite, but rather in a negative-pressure environment, regardless of its location, prior to transfer to the angiography suite. Fiorella *et al.* cited The Anaesthesia Patient Safety Foundation recommendation that suspected or confirmed COVID-19 patients should not be brought back to post-acute care units, and those requiring extubation should not have this performed in the angiography suite.<sup>15</sup> In preparation for potential future pandemics, and in the interest of infection control in

general, it is preferable to have negative-pressure angiography rooms and/or a separate area for anaesthetic induction and post-MT recovery within the interventional radiology theatres.

Working during the pandemic has brought many challenges; however, UK centres have adapted local processes at pace to ensure ongoing provision of this vital health service with no significant changes to the reported rate of successful recanalisation. Going forward, the adverse impact on service development, training for SpRs, and the effect on the mental health of INR and wider teams should be acknowledged.

Some limitations of this survey need to be acknowledged. The qualitative assessment of patient delays provides an overall insight to the issues faced at UK MT centres; however, further analysis on patient outcome could not be ascertained. The subjective binary self-reporting of mental health of UK MT teams during the pandemic limits deeper understanding of its impact. The changes to training were assessed by clinical INR leads at each centre rather than relying on responses from SpRs themselves.

In conclusion, the present survey has highlighted a trend of decreasing cases and delays in the patient pathway during the early stages of the COVID-19 pandemic across UK centres. Patient anxiety and initial confusion amongst stroke/INR teams may have initially contributed to reduced numbers of MT procedures. Further and larger studies would help advance knowledge of how changes in practice for this essential time-critical service can improve the management of MT-eligible patients during this or any future pandemic.

## Conflict of interest

The authors declare no conflict of interest.

## Acknowledgements

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.crad.2020.07.001>.

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