RESEARCH ARTICLE

Re-visiting the impact of the first wave of COVID-19 on neurosurgical practice and training in a large UK neurosurgery unit: a retrospective review [version 1; peer review: 1 approved with reservations]

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Abstract

Introduction

The response throughout the National Health Service (NHS) to the first wave of coronavirus disease 2019 (COVID-19) was substantial. With repeat winter waves of COVID-19 or other viral pathogens in the future being likely, we sought to review the impact of the response to the first wave on the delivery and training of neurosurgery in a large tertiary neurosurgical centre.

Methods

We performed a retrospective review over the three-month period of 8th March to 7th June 2020 as indicative of the peak of the pandemic in the UK. For referrals, our online referral portal was reviewed (ORION). For admissions and operations, electronic patient records were reviewed (EPIC systems). Trust wide update emails and policies were also reviewed.

Results

In response to the pandemic, neurosurgical service provision was severely restricted in the early days of the pandemic in the form of reduced beds, medical and nursing staff and theatres. This was rapidly realised to be unsustainable, and resources were slowly reopened although not to pre-COVID-19 levels. Although referrals did not substantially reduce, the number of elective and emergency admissions, length of stay, theatre efficiency and operative numbers (by pathology and grade of operating surgeon) did significantly

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reduce except for emergencies performed by consultants. If similar trainee operating numbers would have persisted, this would lead to a significant delay to completion of training.

Conclusions

All aspects of neurosurgical provision were detrimentally affected due to the rapid response to the first wave of COVID-19 in our institution. Such repeated reductions in acute services such as neurosurgery would be unsustainable. It is pertinent to re-visit these effects in preparation for future infection waves to better protect acute neurosurgical services.

Keywords

COVID-19 pandemic; Neurosurgery; Health Services; Neurosurgical training; Delivery of Health Care

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Plain english summary

In response to the first wave of the covid pandemic, many services in the National Health Service (NHS) were severely restricted. With winter waves of the coronavirus disease 2019 (COVID-19) or other viruses likely being repeated occurrences in the future, we sought to re-visit the impact of the first wave response on neurosurgical service provision in our trust. We found that all aspects of neurosurgical care were substantially reduced. Referrals did not reduce in number, although both emergency and elective admissions did reduce. Despite this, the number of emergency operations did not reduce. This demonstrates that truly urgent operations were still performed. However, there is a possibility that some less urgent emergencies were kept at local hospitals and managed remotely. Within the limited theatre capacity that was left, theatre time efficiency also reduced. These changes invariably had a significant impact on the delivery of neurosurgical care and on waiting times. The impact on operative exposure of neurosurgical trainees is also evaluated and found to be a substantial reduction in experience. Future provision to allow the NHS to provide care during future waves of COVID-19, or other viruses, is crucial. Our data demonstrate that in the panic of the first wave, the response did not spare acute specialities such as neurosurgery. Such changes to services such as neurosurgery are unsustainable, and a protection of acute services is required in the future. Our data aims to provide support for that argument.

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has had a global impact on all aspects of healthcare provision, education, and training. Health care systems were largely unprepared for the pandemic and were caught by surprise. The amount of human and material resources that would be required to tackle such a pandemic were unknown. This lack of preparation caused resources to be rapidly mobilised to assist the medical effort. This change had a substantial impact on the way surgical specialities were practiced and taught. Initial uncertainty regarding the behaviour of the virus led to various changes in surgical practice including¹: the use of protective and preventative measures in and out of operative theatres; an expectation that most or all provision would be consultant led; the redeployment of surgical trainees to assist with the medical effort; and a large reduction in elective work. These changes did not spare even the most acute specialities. Despite the acuity and urgency of many neurosurgical services, the pandemic has nonetheless had a large impact globally on neurosurgery²⁻⁴ varying from prolonged waiting lists⁵ to negatively affecting the mental health of neurosurgery trainees (Alhaj *et al.* 2020).

While changes in health care priorities are expected during times of national crisis as with a pandemic, disruption to acute specialities poses significant risks to patients and places a strain on future resources after a crisis has passed. With repeated winter waves and other pandemics/epidemics in the future likely or possible⁶, the aim of this study was therefore to re-visit the impact of the response to the first wave of the COVID-19

pandemic in a large tertiary centre on the provision and training of an acute speciality such as neurosurgery including the handling of referrals, triage of patients, case prioritisation and, the impact on operative caseload and neurosurgical training. Such a retrospective review sought to assess to what extent were neurosurgical services spared or hindered.

Methods

No ethics approval was required for this study. This study involved an anonymous review of retrospective group level data and no individualised patient data was used. As such, the project was registered as an audit within our institution.

This is a retrospective observational study conducted in a single large neurosurgical tertiary referral centre. To understand the changes in operative practice and management of referrals, we reviewed our hospital practice via two electronic databases (described below). These databases were both accessed in July 2020 with the data retrieved covering the time-period of 8th March to 7th of June.

The following details were extracted from electronic patient records, anaesthetic, and operative notes to evaluate all neurosurgical admissions and operations performed (platform: EPIC systems, Verona Wisconsin). No exclusion criteria were applied.

- Date of admission
- Age of patient
- Length of stay
- Grade of performing surgeon (consultant and numbered or non-numbered trainee)
- Emergency (admission from Accident and Emergency or from referring hospital) or elective case (planned admission from the patient's home)
- Subspecialty of the overseeing consultant
- Operation timings (total time in theatre, time of knife-to-skin, theatre downtime)

For operations performed, the subspecialty of the overseeing consultant was used as a correlate for the pathology being treated. This could be used as separate subspecialty consultant on-call rotas were in use.

Regional referrals are uploaded on an online platform (Orion Outcome Registry Intervention and Operation Network (ORION), Obex Technologies Ltd, Cambridge). From ORION, we collected the number of referrals and referral outcome.

The three-month period of 8th March to 7th June was used as indicative of the peak of the pandemic as experienced in the United Kingdom (UK). This time period covers the emergence

of the first case of COVID-19 and the main government-enforced lockdown. Data for the same three-month period (8th of March to 7th of June) was collected for each year from 2016 to 2020 for comparison. No missing data was encountered.

All data collected was compiled in Microsoft Excel 2016 spreadsheets. All statistical analyses were performed on GraphPad (v9.3.1). The respective statistical analyses are described in the appropriate results section. Where available, p-values are reported and deemed statistically significant if <0.05 . Figures were produced using GraphPad and Microsoft Excel.

Changes in hospital policy and resource allocation were monitored from the daily COVID-19 trust-wide emails and the intranet database of hospital guidelines.

Results

Changes to facilities and resources

At the start of the pandemic, the department of neurosurgery at CUH counts 20 consultants and provides neurosurgical care for the East of England region (population: 6.235 million). Pre-COVID-19, 4 fully dedicated neurosurgery operating theatres ran each day on weekdays and an additional operating theatre on two working days a week. One of the operating theatres is a 24/7 emergency list. There is only emergency care provision on weekends. There is anaesthetic cover for three general anaesthetic neuro-endovascular lists a week.

Following the UK Government advice and the NHS England COVID-19 mitigation guidance our trust suspended all elective operating with effect from 23rd March 2020. This meant that the neurosurgical operating was only available in one 24/7 emergency operating theatre. There was no additional anaesthetic provision for the neuro-endovascular service. Rather, emergency interventional neuroradiology was provided using the same staff for the single emergency theatre.

Significant changes were made to the neurosurgical bed pool, reducing the number of beds to allow for emergency neurosurgery care only and repurposing other neurosurgical wards as medical. Further, all wards were labelled green, amber or red wards in a hospital-wide triage system based on the likelihood of COVID-19 infection. The 16-bed female neurosurgical ward was changed into an amber COVID-19 area and the 21-bed trauma rehab unit into a red COVID-19 area.

Changes to the neurosurgical workforce included the re-deployment of 1 registrar and 1 junior clinical fellow to the COVID-19 medical workforce. Due to the high numbers of aerosol generating procedures within neurosurgery nursing staff who were deemed to be at risk (based on health risk assessments) were allocated to other areas. The trust policies for self-isolation and sickness for COVID-19 meant at times there were large numbers of nursing staff unavailable to work. A further reduction to the availability of nursing staff was caused by government guidance on pregnancy which caused several nursing staff to have to work from home.

It was rapidly recognised that this skeleton neurosurgical service was inadequate and, in the weeks and months to come, the Trust and the Department regularly revised the strategy taking into account the national guidelines, the need for (neuro) surgical services, and the COVID-19 patient load. As a result, on the 30th March, a second neurosurgical theatre was opened for emergency and urgent cases, and on the 8th April, the third neurosurgical operating theatre was opened for urgent cases. Additionally, the Trust started running three NHS operating lists every week in the independent sector (two at Nuffield Hospital Cambridge and one at the Spire Centre Cambridge) (for timeline, see Figure 1⁷). There was still no separate provision for emergency and urgent neuro-endovascular cases. These procedures continued to be carried out using the staff allocated to the 3 neurosurgical operating theatres, consequently interrupting the neurosurgical lists.

Figure 1. Timeline of Cambridge University Hospital (CUH) theatre changes against daily positive COVID tests in the UK.

With increased operative capacity, the neurosurgical bed and ward staff pool gradually increased over this period of time, however not yet reaching pre-COVID-19 levels.

Referrals

The number of regional referrals made in the three-month period of the lockdown did not substantially reduce when compared with the number of referrals in the same time-period from previous years (Figure 2). Comparing the referrals in 2020 with this trend, the number of referrals may have reduced during the peak of the pandemic.

Admissions

The reduced operative capacity, bed pool and ward staffing levels as outlined above, produced a substantial reduced capacity for admissions, affecting both elective and emergency admissions (Figure 3). The number of elective and emergency admissions had begun to recover by May 2020 yet remained below pre-COVID-19 levels.

The average age of patients admitted did not change compared to previous years (Figure 4) (Kruskal-Wallis test: emergency

$p=0.1531$, elective $p=0.5447$). However, the average length of stay did significantly reduce for emergency cases but did not change for elective cases (Kruskal-Wallis test: emergency $p=0.0029$, elective $p=0.1473$).

Theatre efficiency

The average duration of operations (time from the patient entering the operating theatre to entering recovery) and the average time of knife-to-skin (time from the patient entering the theatre to the start of operating) did not change substantially during the three-month pandemic period. However, the average downtime in which no operating was occurring increased substantially compared to previous years (Figure 5).

The total number of theatre sessions during the March to June period (where a full day of operating is defined as 2 sessions) was lower in 2020 by 28.5% compared to the average of the four years prior (Table 1). Concomitant with the increase in theatre downtime, the rate of cases per session was reduced by 18.2%, further indicating a reduction in theatre efficiency. Using the average of cases performed and session count over the four years prior to 2020, the cases per session ratio

Figure 2. Number of referrals per month over Feb to May, 2018-2020.

Figure 3. Number of emergency and elective admissions per month from 2016-2020.

Figure 4. Average age and length of stay for emergency and elective admissions from 2016-2020.

Figure 5. Average theatre timings in the Mar-June periods from 2016 to 2020.

decreased significantly in 2020 (two tailed z-statistic = 52.5, $p < 0.0001$).

Theatre activity by pathology

Across all subspecialties, a reduction in total number of operations performed during the three-month pandemic period was seen (Figure 6). Shown in figure is the percent change for each subspecialty in total, elective, and emergency change in the three-month period compared to the average of the same

time period over the four years prior. Elective work is substantially reduced while the reduction in emergency work is more modest. The emergency work for paediatrics did not reduce substantially, while for oncology the emergency work increased.

Operating numbers and effect on training

Comparing the three-month period 8th March to 7th June in 2020 with previous years we found a significant reduction in the total number of operations performed per month (Figure 7a).

Table 1. Number of theatre sessions and operations performed in the Mar-June period from 2016 to 2020.

Time period	Sum of session count (all day = 2 sessions)	Operations performed	Cases per session
Mar to Jun 2016	377	417	1.1
Mar to Jun 2017	495	529	1.1
Mar to Jun 2018	506	549	1.1
Mar to Jun 2019	518	571	1.1
Mar to Jun 2020	339	293	0.9

Figure 6. Operations performed in the Mar-June period from 2016 to 2020 broken down by emergency/elective and by subspecialty interest of the overseeing consultant.

Figure 7. 7a (left) Operations per month and 7b (right) total emergency and elective operations from 2016 to 2020.

This reduction was primarily driven by a reduction in elective work (Figure 7b) (Ordinary one-way ANOVA: $p < 0.0001$).

The number of total operations carried out by consultants and juniors (includes trainees and non-trainees) was globally reduced (Figure 8). This was primarily driven by a reduction in elective operations for all grades. However, a modest reduction in emergency cases was also seen for juniors.

The number of operations performed by trainees followed a similar pattern to that of all juniors (Figure 9). Currently, to obtain a Neurosurgical Certificate of Completion of training (CCT), trainees are required to obtain a minimum of 1200 operations and the formal duration of training is eight years. To assess the magnitude of this reduction, we estimated that if such an operative rate was sustained achieving CCT would be delayed by a further 1.5 to 4 years (Figure 9).

Discussion

Principal findings

The COVID-19 first wave and lockdown in the UK spanned the time period of 8th March to 7th June. The response to the first wave has highlighted a substantial lack of preparedness within the NHS. Further waves have occurred since this time

and despite a substantial national vaccination campaign, a further winter wave in 2021 has occurred⁶. Our review of the impact of the first wave on our trust and the reaction to it demonstrates a significant hit to admissions, operative throughput, and training. Recalling these consequences is crucial at this juncture with future pandemics or epidemics likely. There is therefore a need to reiterate the importance of protecting acute services such as Neurosurgery.

During the first wave, we found a very minimal reduction in referrals from local hospitals (Figure 2), despite nation-wide reduction in all accident and emergency (A+E) activity^{8,9}. Any minimal reduction may have been contributed to by a change in referrer practice, a change in the pathologies occurring e.g. reduced trauma from reduced traffic during lockdown¹⁰, or public fear and avoidance of hospitals. Such a reduction in referrals may not occur in the face of future waves if the public become desensitised to life under repeated waves.

The response to the first wave caused a substantial reduction in admissions, including emergency cases (Figure 3). Concomitantly, there was a reduction in the average length of stay (Figure 4). While we cannot be certain what caused this pattern, potential causative factors include: stricter triage of

Figure 8. Number of operations performed in the Mar-June period from 2016-2020 broken down by emergency/elective and grade of operating surgeon

Figure 9. Total number of operations performed by trainees with projected time to completion of CCT.

referred patients and/or increased use of on-call advice provision to assist with remote care of patients at their local referring hospitals. This is an area for future investigation to assess whether this apparent increased efficiency was detrimental to patient care or a useful side effect of the stresses of the pandemic.

While the total number of operations did significantly decrease, the number of emergency operations did not (Figure 7). In the context of a modest reduction in referrals and a significant reduction in admissions, a stable rate of emergency operations likely reflects that urgent cases were still able to obtain necessary treatment.

Our data demonstrate a reduction in theatre efficiency as theatre downtime increased and operations per theatre session decreased (Figure 5 and Table 1). Since patient time in theatre and time of knife-to-skin did not change, the reduced efficiency is likely caused by perioperative processes. Namely, the increased precautions and use of personal protective equipment, anaesthetic time, occasional need for patient post-op recovery to occur in theatre and more rigorous cleaning of facilities between cases. An awareness of this effect is needed to

permit future resources to allow more efficient use of theatre resources, such as dedicated post-operative recovery areas to not delay further operative throughput.

As expected, all pathology subtypes faced a reduction in elective work (Figure 6). However, urgent work did not decrease significantly across paediatric and oncology subspecialties. From observational assessment of our practice, we believe this may be due to a practice of admitting oncology or paediatric patients for treatment on the emergency list where their condition is urgent but not an emergency.

The number of emergency cases performed by consultants did not significantly reduce while those being performed by junior trainees did reduce. This reflects a trust-wide drive to increase consultant-led care and the redeployment of juniors for other clinical purposes. Furthermore, anecdotally, where juniors did operate this was primarily for emergency cases with very few complex or index cases performed by trainees. This low rate of operating would create a substantial deficit in the training and surgical acumen of trainees. To estimate the size of this effect, we calculated that if such an operative rate

were maintained, achieving completion of training would add an additional 1.5 to 4 years to the 8-year neurosurgical training period (Figure 9). To ameliorate these effects, in our institution cadaver microscopic dissections were formally introduced. Trainees were allocated time slots as they would for theatre slots and encouraged to use this facility in a structured way to maintain and progress their microscopic skills and anatomic knowledge. Other possible remedies include the increased exposure of trainees to operating that occurs in the independent sector.

In the context of relevant literature

The effect of the COVID-19 pandemic on neurosurgery has been palpable globally with major changes to practice¹. Neurosurgical institutions have adapted with various changes including stricter triaging of patients^{2,3}, suspending all or most non-urgent or elective cases¹¹, increased testing^{2,12} and even reductions in bone drilling speed to limit aerosol generation². Similar changes have been implemented specifically for spinal services^{12,13}.

Although we found a minimal reduction in the number of referrals, more substantial reductions in referrals have been reported elsewhere¹⁰. Furthermore, while our study demonstrates that emergency cases were not significantly affected, the impact on non-emergency urgent cases was detrimental (Figure 6). This is further corroborated by a reduction in the provision of necessary surgery for malignant brain tumours across the UK¹⁴.

It is critical to also note the severe impact of the pandemic on neurosurgical training. While the pandemic has led to some positive educational changes in the UK and globally including more online teaching, an increased use of open access resources¹⁵, reduced working hours with more time for activities such as research^{16–18} there is nonetheless evidence of an expected detrimental effect on trainee morale and wellbeing¹⁹. Furthermore, the effect on operative experience cannot be underestimated and future protections for training using ancillary resources such as simulation should be encouraged and supported²⁰. Other avenues include the increased use of the operative resources in the independent sector. Additionally, changes to training completion criteria could be considered. This may include, for example, an active change to a focus on index cases and the degree of independence of the trainee as opposed to operative numbers alone when assessing the trainee's progression.

Strengths and limitations

The principal strengths of our study include the contemporaneous capture of extensive data to understand the neurosurgical patient journey through the region. In addition, through the use of electronic databases, we were able to capture key parameters including the grade of operating surgeon and therefore

present a quantified estimate of the effects on neurosurgical training.

Limitations of our study include the method of assessing the pathology subtype for the operations performed by classifying according to the subspecialty of the named overseeing consultant. Also, while our study demonstrates important lessons for the future response to further infection waves, it is important to consider that the rates of COVID-19 infections in the East of England region were amongst the lowest in the UK.

Conclusion

In conclusion, the effect of the first wave of the COVID pandemic and the rapid response to this on the delivery and training of neurosurgery has been substantial and detrimental. The messages of our study are pertinent given the potential for future repeat waves of COVID-19 or other pathogens. A blanket approach to each medical and surgical specialty should be avoided. A nation's health resources must of course be directed at the most urgent needs and priorities will naturally adjust during a pandemic. However, with the knowledge that future pandemics or epidemics are likely, planning ahead for the protection of acute services, such as Neurosurgery, is essential. Additionally, postponement of elective or semi-elective procedures puts an extra strain on an already stretched health care system. Furthermore, training opportunities must be actively protected where possible, to allow career progression and crucially protect against a slump in trainee experience and confidence.

Data availability

Underlying data

Harvard Dataverse: Re-visiting the impact of the first wave of COVID-19 on Neurosurgical Practice and Training in a Large UK Neurosurgery Unit. <https://doi.org/10.7910/DVN/EXRTD7>²¹

This project contains the following files:

- 1-AdmissionsTotals.tab
- 2-Admissionsbreakdown.tab
- 3-OperatingactivityCons.tab
- 4-OperatingactivityTrainee.tab
- 5-OperatingactivityAlljuniors.tab
- 6-Theatretimes.tab
- Datakey.pdf

Data are available under the terms of the [Creative Commons Zero “No rights reserved” data waiver](#) (CC0 1.0 Public domain dedication).

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The authors present a retrospective analysis of the impact of the COVID-19 pandemic on a large neurosurgical practice. The study is well written but to me, this manuscript lacks an overarching lesson or point that is driven by lacking statistical analysis.

Specific comments:

1. This is an observational study, and should therefore be reported according to the STROBE guidelines, which are available from the Equator Network. The guidelines should be identified in the methods section, and the structure of the paper revised so as to include each point in the guidelines in the requisite section.
2. Consequently, the statistical analysis in particular should be described comprehensively in the methods section and not "in the appropriate results section".
3. The analysis needs to be better described. In particular, how was the projected time to CCST completion calculated? It does not make sense to use a linear projection based upon the case rate in 2020, which I surmise this is, because this is an outlier year and a linear trend based on this would be highly misleading. How this projection was derived needs to be adequately described in the methods section, along with other tests used. In general, far more detail should be provided both in the methods section and in the figure captions. For example, many figures have error bars - what do these represent? 95% confidence intervals, standard errors, standard deviations?
4. Using ANOVA or Kruskal-Wallis tests treats the year as categorical, multinomial groupings, which it is not. Years can be considered continuous and therefore these analyses should utilise non-parametric correlations (Spearman's or Kendall's) or linear regression, which are far more statistically powerful in this context and may improve the statistical power of the study.
5. Tables describing the characteristics of patients before and during the pandemic would be

helpful. These can be aggregated, but even a comparison of pathologies would add to the paper. This is seemingly available given that the data is apparent in Figure 6 - I would suggest including this in table form instead.

6. Some of the headline results, eg. the 28.5% drop in the number of theatre sessions should be included in the abstract.
7. Figure 1 would be far more interesting if the number of cases operated could be included as an overlay to the number of COVID cases.
8. Regarding the above, relating the number of operated neurosurgical cases to the number of hospitalised patients with COVID, which I am sure is available from public sources, would be perhaps more robust given the latency period between diagnosis with COVID-19 and presentation to hospital. This would give an indication of how much of the decline in neurosurgical cases was related to the burden of COVID 19 on hospitals, which is of interest as the impact of COVID19 is multifactorial and also related to staff shortages due to isolation requirements, travel restrictions, logistics of pre-hospital testing, etc.
9. The authors mention using cadaver dissection labs to facilitate ongoing trainee experience despite the drop in case volumes. Can the authors comment on how successful this was? I think the manuscript would benefit immensely from some assessment, ideally objective but even survey-based with consideration of both consultants and trainees, of how good of a substitute the use of cadaveric simulation is for actual operative experience.
10. On page 9, the authors mention that the number of emergency operations remained constant while the number of elective surgeries was curtailed. This seems reasonable based upon Figure 7b, in which the number of emergency surgeries appears to even be higher than 2016. However, based upon Figure 8, there appears to be a marked drop off in total emergency volume in 2020 compared to 2016. Are these graphs based upon different datasets? Is there missing data that explains the discrepancy?

In general, this study would benefit greatly from a much more structured explanation of the methodology, correction of the statistical analysis, improved presentation of the results and more extensive commentary on the effectiveness of the measures implemented.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Neurosurgery, Traumatic Brain Injury

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.