Review of orthopaedic trauma surgery during the peak of COVID-19 pandemic – An observational cohort study in the UK

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A B S T R A C T

Aim: This study aims to estimate the risk of acquiring medical complication or death from COVID-19 infection in patients who were admitted for orthopaedic trauma surgery during the peak and plateau of pandemic. Unlike other recently published studies, where patient-cohort included a more morbid group and cancer surgeries, we report on a group of patients who had limb surgery and were more akin to elective orthopaedic surgery.

Methods: The study included 214 patients who underwent orthopaedic trauma surgeries in the hospital between 12th March and 12th May-2020 when the pandemic was on the rise in the United Kingdom. Data was collected on demographic profile including comorbidities, ASA grade, COVID-19 testing, type of procedures and any readmissions, complications or mortality due to COVID-19.

Results: There were 7.9% readmissions and 52.9% of it was for respiratory complications. Only one patient had positive COVID-19 test during readmission. 30-day mortality for trauma surgeries was 0% if hip fractures were excluded and 2.8% in all patients. All the mortalities were for proximal femur fracture surgeries and between ASA Grade 3 and 4 or in patients above the age of 70 years.

Conclusion: This study suggests that presence of COVID-19 virus in the community and hospital did not adversely affect the outcome of orthopaedic trauma surgeries or lead to excess mortality or readmissions in patients undergoing limb trauma surgery. The findings also support resumption of elective orthopaedic surgeries with appropriate risk stratification, patient optimization and with adequate infrastructural support amidst the recovery phase of the pandemic.

1. Introduction

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was declared a pandemic on March 11, 2020 by the World Health Organization and very soon it spread to most parts of the world. In the UK, there have been over 1,706,000 confirmed cases of SARS-CoV-2, with almost 61,000 related deaths till date. The pandemic has tested the resilience of health-care systems, including hospitals, which were largely unprepared for the scale of the pandemic. Patients having surgery are a vulnerable group at risk of SARS-CoV-2(COVID-19) exposure in hospital and might be particularly susceptible to subsequent post-operative complications, due to the pro-inflammatory cytokine and immunosuppressive responses to surgery. Some early publications have shown a remarkably high post-operative mortality due to COVID-19 infection. This has led to an overly cautious approach for orthopaedic surgeries and reinstution of elective orthopaedic services have been very protracted. However, those publications report outcome of surgery in a more moribund group of patients leading to an inherent bias and more evidence is needed to assess whether this reported high peri-operative mortality risk can be applied to orthopaedic patients.

Guidelines have been published for the management of surgical patients during the COVID-19 pandemic. However, they are based on limited evidence. Therefore, the impact of COVID-19 on peri-operative complications and mortality needs to be established in order to enable surgical teams and patients to make evidence-based decisions during this unprecedented pandemic. This study reported from a geographical region with significant cases of COVID-19 infection which was reported to be only next to London and was considered to be one of the areas with high national density of positive cases.

The primary aim of this study is to estimate the risk of acquiring...
a severe complication or death from COVID-19 infection in patients who were admitted for orthopaedic trauma surgery. Unlike the other published studies, where the patient-cohort includes a more morbid group and cancer surgeries, we have studied and reported on a group more akin to elective orthopaedic surgery.

2. Patients and methods

2.1. Data collection

This prospective observational study included 214 patients who underwent orthopaedic trauma surgeries at our hospital between 12th March and 12th May-2020 during COVID-19 pandemic which was at its peak in our region during this period. We collected data from our local dataset and from our electronic health records (Cerner) following approval from the institutional review board.

We collected data on the demographic parameters including age, sex, American Society of Anaesthesiologists’ (ASA) Grade, BMI, ethnicity, diagnosis, operative interventions, type of anaesthesia used and length of hospital stay. Patients were further assigned to sub-speciality groups (upper limb and lower limb surgery), day-case and in-patient procedures.

All pre-existing co-morbidities and any history of malignancy were recorded. Patients were categorised according to the number of significant co-morbid conditions that they had and were assigned into the following groups: none, 1,2,3 and more than 3 co-morbidities. We specifically enquired about the known risk factors associated with poor outcomes from COVID-19 infection such as diabetes, hypertension, respiratory, cerebrovascular (CVA/TIA), renal, cardiological, gastrointestinal and neurological conditions.(new reference) We also kept a special note on other co-morbidities such as dementia, hormone disorders like hypothyroidism, metabolic disorders, mental health disorders and other conditions which can significantly affect the quality of life and overall outcome. Two separate analyses were performed with and without the ‘fragility fractures of lower limb in the elderly’ to minimise the confounding effects on mortality which is well known to be associated with this group.

2.2. Testing, diagnosis and treatment pathway

Laboratory testing for COVID-19 infection was based on viral RNA detection by quantitative RT-PCR from swab sampling. Samples included nasal swabs and oropharyngeal swabs and analyses were performed according to the standardized protocols. Patients with a clinical suspicion of COVID-19 infection11 or with positive swab results were admitted on a ‘Red Ward’ and were operated on in a designated ‘COVID Theatre’ with standard personal protective equipment (PPE). Clinical diagnosis consistent with COVID-19 infection11 was made by a panel of senior physicians and based on clinical presentation of symptoms highly indicative of COVID-19 infection, including cough, fever, and myalgia.11 Radiological diagnosis was based on thorax CT, in keeping with locally implemented protocols. Initially due to limited testing capacity, asymptomatic patients without clinical suspicion were not tested. Asymptomatic or patients with negative results were managed in ‘Blue’ wards and were operated on in ‘Clean’ theatres where we followed the standard protocols as per pre-pandemic period.

2.3. Outcome

We monitored all the patients for 30 days from the surgery. Our primary measured outcome was post-operative 30-day mortality. Mortality data was cross checked with the Office for National Statistics (ONS). Secondary outcomes included was any significant adverse event due to COVID-19 infection leading to readmission or morbidity.

2.4. Statistical analysis

Continuous variables are expressed as mean ± standard deviation (SD) and compared using Student’s t-test. Categorical variables are expressed as percentages and compared using the Chi-squared test. All statistical tests of significance were two-tailed, and P values < 0.05 were considered statistically significant. Statistical analyses were performed using SPSS 16.0 statistics software (SPSS Inc. Chicago, IL, USA).

3. Results

Of the 214 orthopaedic trauma surgeries carried out during the first surge of the pandemic, there were 6 deaths (2.8%). Table 1 shows the distribution of the patients with respect to different demographic parameters and corresponding mortality. There were no significant differences based on gender or associated comorbidities. This table shows a statistically significant difference in mortality based on the ‘Red’ or ‘Blue’ ward and ‘COVID’ and ‘Clean’ (Non-COVID) theatres but in our view, this is more of an association than causal. Patients on the ‘Red ward’ were usually the ones who presented with chest symptoms and they were often frail elderly and presented with hip fractures.

Table 2 shows that all the mortalities were in those aged 70 years and above and they were in the ASA Grade 3–5 cohort. There were 46 neck of femur fracture surgeries in this cohort. Six patients who died within 30 days of surgery were all operated on neck of femur fractures and they all had spinal anaesthesia during their surgery. Consequently, it is reflected as higher overall mortality (7.5%) for patients who had spinal anaesthesia during surgery. It is once again difficult to prove the association of spinal anaesthesia with mortality because of the strong bias and confounding factors. It is likely that patients who received spinal anaesthetic in

| Variables               | No of Operations (n = 214) | 30-day Mortality | P-value |
|-------------------------|----------------------------|------------------|---------|
|                          | No                        | Yes              |         |
| Gender                  |                           |                  |         |
| Male                    | 117                       | 114 (97.4%)      | 3 (2.6%)| 0.815588 |
| Female                  | 97                        | 94 (96.9%)       | 3 (3.1%)|         |
| Co-morbidities          |                           |                  |         |
| None                    | 92                        | 92 (100%)        | 0       |         |
| 1                       | 46                        | 46 (100%)        | 0       |         |
| 2                       | 34                        | 31 (91.1%)       | 3 (8.9%)| 0.950599|
| 3                       | 26                        | 24 (92.3%)       | 2 (7.7%)|         |
| >3                      | 16                        | 15 (93.7%)       | 1 (6.3%)|         |
| Ward                    |                           |                  |         |
| Red                     | 15                        | 11 (73.4%)       | 4 (26.6%)| <0.0001*|
| Blue                    | 199                       | 197 (98.9%)      | 2 (1.1%)|         |
| Theatre                 |                           |                  |         |
| COVID                   | 15                        | 12 (80%)         | 3 (20%) | 0.00029*|
| Clean                   | 199                       | 196 (98.5%)      | 3 (1.5%)|         |
| COVID Result            |                           |                  |         |
| Positive                | 11                        | 8 (72.7%)        | 3 (27.3%)| 0.027292*|
| Negative                | 52                        | 49 (94.2%)       | 3 (5.8%)|         |
| Not Tested              | 151                       | 151 (100%)       | 0       |         |
| Length of Hospital Stay |                           |                  |         |
| 1 week                  | 94                        | 92 (97.8%)       | 2 (2.2%)| 0.066283|
| 2 weeks                 | 44                        | 43 (97.7%)       | 1 (2.3%)|         |
| 3 weeks                 | 12                        | 10 (83.3%)       | 2 (16.7%)|         |
| >3 weeks                | 13                        | 12 (92.3%)       | 1 (7.7%)|         |
| Day case                | 51                        | 51 (100%)        | 0       |         |

NB: (*) mark indicates statistically significant p-values at p < 0.05.
preference to GA were more high risk. There was no mortality for upper limb trauma surgery and day trauma surgeries. When we perform the same analysis without taking account of the lower limb fragility fractures, there were no mortalities.

There were 17 readmissions in total (7.9%). Five of these were for surgical reasons such as wound infection, bleeding or second surgery. The remaining 12 were readmitted for medical/respiratory reasons. Two of these patients tested positive for COVID-19 during readmission. Eight of these were negative and the remaining two were not tested. However, there was only one mortality among these 17 readmissions. This patient was readmitted following a surgical complication and was diagnosed COVID-positive previously during his index hip surgery.

All the deaths that occurred were in the hip fracture patients with their characteristics summarised in the table below (Table 3).

4. Discussion

With the advent of the pandemic, almost all elective surgeries were forced to stop due to the demand on manpower and hospital beds and other resources during the crisis. In addition to this, patients having surgery are considered a vulnerable group at risk of SARS-CoV-2(COVID-19) exposure in hospital. Some early publications have shown a remarkably high post-operative mortality due to COVID-19 infection. This has led to an overly cautious approach for orthopaedic surgeries and reinstitution of elective orthopaedic services have been very protracted. One of the first published papers in The Lancet from multicentre COVIDSurg Collaborative study group shows that, during post-operative period, 30-day mortality was 23.8% and incidence of pulmonary complication was 51.2%. Furthermore, 38% of the patients with pulmonary complication have died within 30 post-operative days. This study showed that pulmonary complication is the most crucial factor for post-operative outcome. However, the COVIDSurg study consisted of emergency surgical procedures involving different specialities and out of the 1128 patients in that study, only 224 were orthopaedic trauma patients with a wide variety of injuries. Therefore, it is not truly reflective of the impact of COVID infection on orthopaedic trauma victims. Their 1128 patients involved oncological surgery, thoracic, abdominal and hepatobiliary surgery which may likely to cause more systemic response and mortality. These patients are also likely to be sicker and hence a higher mortality may result. In contrast, patients undergoing elective orthopaedic surgery tend to be fitter, more

| Table 2 Distribution of the patients' characteristics and mortality among the study population. |
| Variables | No of Operations (n = 214) | 30-day Mortality including all patients (n = 214) | 30-day mortality without fragility fractures (n = 168) |
| Age | | |
| Up to 16 | 29 | 29 (100%) | 0 |
| 17–29 | 28 | 28 (100%) | 0 |
| 30–49 | 44 | 44 (100%) | 0 |
| 50–69 | 47 | 47 (100%) | 0 |
| 70 & Above | 66 | 60 (90.9%) | 6 (9.1%) |
| ASA | | |
| ASA 1-2 | 142 | 142 (100%) | 0 |
| ASA 3-5 | 72 | 66 (91.6%) | 6 (8.4%) |
| Subspecialty | | |
| Upper Limb | 88 | 88 (100%) | 0 |
| Lower Limb | 126 | 120 (95.2%) | 6 (4.8%) |
| Anaesthesia | | |
| GA | 106 | 106 (100%) | 0 |
| Spinal | 67 | 62 (92.5%) | 5 (7.5%) |
| GA + LA | 3 | 3 (100%) | 0 |
| GA + Block | 13 | 12 (92.3%) | 1 (7.7%) |
| LA | 14 | 14 (100%) | 0 |
| Epidual | 1 | 1 (100%) | 0 |
| GA + Epidural | 1 | 1 (100%) | 0 |
| Block | 1 | 1 (100%) | 0 |

| Table 3 Characteristics of the patients who died within 30 days of index surgery. |
| Patients | Case-1 | Case-2 | Case-3 | Case-4 | Case-5 | Case-6 |
| Age | 94 | 78 | 90 | 92 | 90 | 82 |
| Sex | Female | Female | Male | Male | Male | Female |
| Diagnosis | Extracapsular neck of femur fracture | Intracapsular neck of femur fracture | Extracapsular neck of femur fracture | Intracapsular neck of femur fracture | Intracapsular neck of femur fracture | Extracapsular neck of femur fracture |
| Procedure | Intramedullary Nailing | Intramedullary Nailing | Intramedullary Nailing | Hemiarthroplasty | Hemiarthroplasty | Dynamic Hip Screw Fixation |
| Designated Theatre | Clean | COVID | clean | COVID | COVID | Clean |
| Ward | Cold | Hot | Hot | Hot | Hot | Cold |
| ASA Grade | 4 | 3 | 3 | 3 | 3 | 3 |
| Comorbidities | >3 | 2 | 3 | 3 | 2 | 2 |
| Readmission | Yes | No | No | No | No | No |
| LOS | 15 | 4 | 7 | 13 | 24 | 21 |
| Primary Cause of Death | 1a-COVID pneumonia | 1a-HAP | 1a-HAP, 1b-bronchiectasis | 1a-COVID pneumonia | 1a-COVID pneumonia | 1a-COVID pneumonia |
mobile post-operatively and by the nature of surgery being on
limbs, it is less likely to cause systemic upset. We therefore feel that
the findings of the COVIDSurg collaborative cannot be applied to
the orthopaedic surgery in general or likewise to other surgical
specialties wanting to resume elective surgery. At the time of
writing, there was no other data to establish safety of elective
surgery during this pandemic and it is going to be impossible to
produce one particularly when all the elective work has remained
shut down. On the other hand, orthopaedic trauma operations have
continued as normal during this crisis. These operations are done in
a heterogenous group of patients and a wide variety of surgeries
have been performed. This group of trauma patients, barring
proximal femur fractures, will probably provide the closest match
to elective surgical cohort, in terms of patient characteristics, type
of operations and in-patient stay.

Even before the COVID-19 pandemic, studies have found that
mortality following orthopaedic trauma surgery could be 2.8% which matches with our study. Tan et al.11 reported that neck of
femur fracture surgeries accounted for the highest mortality in a
study cohort of orthopaedic trauma surgeries with respiratory
complications being the most predominant cause in patients above
the age of 65 years. In our study cohort, all the mortalities occurred
following proximal femur fracture surgeries and with no surprise,
the mortalities were in those with pulmonary complications.
Therefore, it is evident that the proximal femoral fracture group
remains the most vulnerable and the mortality pattern has not
changed despite the pandemic. However, we couldn’t find any
significant mortality impact on other types of trauma surgeries
during COVID-19 pandemic.

Karayiannis et al.14 reported an all-cause mortality of 1.9% at 30
days for all patients undergoing orthopaedic trauma surgery within
Northern Ireland during the peak of the COVID-19 pandemic and
reported mortality rate of 14.8% at 30 days for patients contracting
COVID-19 infection. However, we found a 27.3% mortality for
COVID-19 positive patients and COVID-19 infection had statistically
significant association (p = 0.0027) with mortality. Importantly,
mortalities were limited to neck of femur surgeries.

In our study, all the mortalities were amongst ASA Grade 3–5
group and 8.4% of the patients in that group died within a month of
surgery. This is not surprising and even before the pandemic, some
studies have demonstrated that 85% of the 30-day post-operative
deaths were amongst ASA grade 3 and 4 patients15 following
trauma surgeries. A study of Spanish outcomes during the pandemic by Vives et al.,16 with similar population demographics like ours, showed that all (100%) the mortalities were amongst ASA
3–5 with of ASA 3, 4, 5 of 63.6%, 18.2%, 18.2% respectively. Impor-
tantly, in all these studies, the mortalities involved proximal
femoral fracture surgeries only and it is similar for our study as well.
As demonstrated in our study only patients with an ASA of 3 or
greater died. We had no 30-day mortality in patients’ ASA grades 1
or 2. A recently published study from Northern Ireland15 also had
similar findings. These findings would support the recent proposal
that commencing operating on low-risk patients requiring low risk
surgeries may be the safest and most effective way of reinstating
elective services.17

Although the patient who died within 30 days following surgery
had two or more comorbidities, none of these were statistically
significant (p = 0.95). It is quite possible that this is due to a Type 2
error. A multicentre cohort study by Kayani et al.18 categorised the
COVID-positive patients according to the numerical count of
comorbidities and found that patients with COVID-19 infection
who have greater than three comorbidities, have a statistically
significant higher mortality rate.

In our study, 30-day mortality was statistically significant if the
patients were operated on in a COVID-designated theatre and were
admitted to a ‘Red’ ward which has high risk of infection trans-
mision. Importantly, in this study, six patients who died within 30
days of their surgery were operated for proximal femur fractures.
We observed 13% (6 out of 46) mortality for surgically managed
proximal femur fractures which is higher than the national average
from pre-pandemic period as evidenced by National Hip Fracture
Database report.19 However, LeBrun et al.20 and the New York
COVID Hip Fracture Research Group21 reported similar association
of mortality and COVID-19 infection in their study cohort consid-
ering proximal femur fractures.

In our study group, all the mortalities were in the age group of
70 years and above. COVIDSurg collaborative12 also reported highest mortality in the same age group. In our study, there were no mortalities following upper limb surgery. As we observed all the
deaths following proximal femur fracture fixation, this likely have
accounted for the higher mortality rate in the lower limb surgery
group and indirectly with the spinal anaesthesia cohort.

In our study cohort of 214 patients, only one patient tested positive for COVID-19 following discharge in the community and
one other patient was new positive during readmission. It is diffi-
cult to determine whether they contracted the virus during the
hospital stay or following discharge. Therefore, considering the
extreme possible situation, it is possible that fewer than 1% of the
patients (2 out of 214) contracted the virus during trauma surgery
or hospital stay as they tested positive after discharge. However,
this is a completely hypothetical situation and difficult to draw any
robust conclusion. Lazizi et al.22 reported that 4% of their study
population contacted COVID-19 infection during orthopaedic
trauma surgery. Similarly, Hope. N et al.23 reported from a major UK
trauma centre that they found 4% incidence of post-operative
COVID-19 infection for patients who tested negative pre-
operatively. On the other hand, Kader et al.24 reported that the
theoretical risk of a patient with an undetected infection being
admitted for surgery and subsequently dying from the COVID-19
infection is estimated at approximately 1 in 7000. Therefore, even
if we consider the bias of a false negative COVID-19 test24 (1
in 7000), the overall mortality rate following infection could be low
for the orthopaedic trauma surgery group. Although, several
studies reported that the mortality could be higher for proximal
femoral fractures,20,21 it may not be generalised for the whole
cohort of orthopaedic trauma surgeries because of the wide vari-
ability of the demographic profile of trauma patients.

We experienced an 18.2% readmission rate for COVID-19 posi-
tive patients following surgery and there was a statistically signifi-
cant association between readmission rate and positive test results
(p = 0.02). There has been no evidence at the time of analysing this
paper, which would estimate the post-operative readmission rate
for COVID-19 positive patients. Richardson et al.25 reported an
overall 2.2% readmission rate for COVID-19 positive patients in
New York and Jeon et al.26 reported it to be 4.5% in South Korea.
However, none of the studies have reported on post-operative
readmission rate of patients. We have only one patient dying dur-
ing readmission and there was no statistically significant associa-
tion between mortality and readmission rate (p = 0.422).

This is accepted that COVID-19 will pose an ongoing risk for some time. However, similar recognition of the need for an exit
strategy for the countries that have passed their peak of hospital-
ization, that allows for a safe restart of planned routine care, within
an ongoing endemic COVID-19 situation has also been acknowl-
edged internationally.27 Several factors need to be addressed when
considering the reinstatement of elective services. An appropriate
number of beds both in intensive care unit (ICU) and non-ICU, PPEs,
ventilators and trained staff (anaesthetists and interventionists),
peri-anaesthesia units, critical care, diagnostic imaging, laboratory
services with adequate testing capacity and a safe COVID-free
institutional infrastructure are crucial.\(^{13}\) Furthermore, individualizing patient risk and their previous exposure to COVID-19\(^ {17}\) also important. Age, co-morbidities, ASA grading, immunocompromised state and physiological reserve of the patients have been shown to increase the potential severity of the disease.\(^ {29–31}\) The findings from the study would support the recent proposal that commencing operating on low-risk patients requiring low risk surgeries may be the safest and most effective way of reinstating elective services.\(^ {17}\)

As a trauma unit, we did not deny access to any patients. In addition, at the time of our study, testing for COVID-19 infection was restricted due to limited testing capacity. Despite this, the symptomatic testing strategy was effective. The working guidelines are based on a pragmatic approach, aiming to minimise the risk of COVID-19 infection to patients and staffs. Within an elective setting one could build in more restriction with respect to patient selection. The current trauma operating protocol was built on the reported evidence and guidelines available and though it does not specifically deal with elective surgery, extrapolation is still possible.

We acknowledge the weakness of this single centre, retrospective review within a limited sample size. At the time of the study, PCR-RNA testing was limited, and thus asymptomatic infection may have been missed. With a lack of any form of benchmark in the literature, it is our hope that the results from this study have provided evidence for orthopaedic trauma surgeries and indirectly will help guide a safe return to elective surgery.

5. Conclusion

In conclusion, the overall mortality and complications following surgery for limb trauma was not adversely affected during the COVID-19 pandemic. However, patients with lower limb fragility fractures remain at high-risk. Based on the outcome of our results and other published studies, it appears that elective surgery can be safely reinstated with appropriate risk stratification, patient optimization and with adequate infrastructural support.

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Declaration of competing interest

The authors have no conflict of interest to declare.

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This study was approved by the Institutional Review Board and Data used in this study could be made available if requested through proper channel.

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