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

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ABSTRACT

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.[1] 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.[2] 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.[3,4] Some early publications[5] 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. 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[6,7,8] 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.[9,10]

The primary aim of this study is to estimate the risk of acquiring

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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-morbid conditions 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 infection[11] 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 infection[11] 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

Table 1
Distribution of the patients with respect to peri-operative variables and mortality.

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%)	<0.00001*
Blue	199	197 (98.9%)	2 (1.1%)	
Theatre				
COVID	15	12 (80%)	3 (20%)	0.000029*
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 $p < 0.05$.

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)
		No	Yes	
Age				
Up to 16	29	29 (100%)	0	0
17–29	28	28 (100%)	0	0
30–49	44	44 (100%)	0	0
50–69	47	47 (100%)	0	0
70 & Above	66	60 (90.9%)	6 (9.1%)	0
ASA				
ASA 1-2	142	142 (100%)	0	0
ASA 3-5	72	66 (91.6%)	6 (8.4%)	0
Subspecialty				
Upper Limb	88	88 (100%)	0	0
Lower Limb	126	120 (95.2%)	6 (4.8%)	0
Anaesthesia				
GA	106	106 (100%)	0	0
Spinal	67	62 (92.5%)	5 (7.5%)	0
GA + LA	3	3 (100%)	0	0
GA + Block	13	12 (92.3%)	1 (7.7%)	0
LA	14	14 (100%)	0	0
Epidural	1	1 (100%)	0	0
GA + Epidural	1	1 (100%)	0	0
Block	1	1 (100%)	0	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	Hemiarthroplasty	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	4	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

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.[3,4] Some early publications have shown a remarkably high post-operative mortality due to COVID-19 infection.[5,12] 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[12] 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.[12] 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

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.[13] 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 ($p = 0.00.27$) 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 patients[15] 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. Importantly, 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 Ireland[14] 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 transmission. 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 Group[21] reported similar association of mortality and COVID-19 infection in their study cohort considering proximal femur fractures.

In our study group, all the mortalities were in the age group of 70 years and above. COVIDSurg collaborative[12] 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 difficult 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 test[24] (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 variability of the demographic profile of trauma patients.

We experienced an 18.2% readmission rate for COVID-19 positive patients following surgery and there was a statistically significant 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 the 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 during readmission and there was no statistically significant association 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 hospitalization, that allows for a safe restart of planned routine care, within an ongoing endemic COVID-19 situation has also been acknowledged 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.[28] 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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Data used in this study could be made available if requested through proper channel.

This study was approved by the Institutional Review Board and performed in accordance with the ethical guidelines.

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