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A dual-site trauma system during COVID-19 pandemic – Our experience in a high-risk area with 60-day mortality report

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ABSTRACT

Aim: We set up a COVID–free trauma site due to the high rates of COVID-19 infections within our hospital. We aimed to determine the incidence of post-operative COVID-19 infection within the first two weeks post-treatment at the COVID-free site and the postoperative mortality rate. We analysed data for non-hip fracture and fragility hip fracture patients separately.

Method: Data was collected for 138 patients presented during the study period, having 147 operations in total. 103 were non-hip fracture patients and 35 were hip fracture patients.

Results: All patients were followed up and none of the non-hip fracture cohort developed symptoms of COVID-19 infection. Postoperative 60-day mortality rate for this cohort was 0.97%. Of the 35 hip fracture patients, none were tested positive for COVID-19. However, two patients were treated as suspected COVID cases due to their symptoms.

Conclusion: Establishing a separate site with screening for COVID-19 infection can allow safe emergency surgery.

1. Introduction

In early 2020 the rapidly expanding COVID-19 pandemic had an unprecedented impact on the National Health Service (NHS) and its ability to provide safe and effective care. Our Trust saw one of the highest rates of COVID-19 infection in the United Kingdom, forcing decisions on how best to distribute limited resources to provide the best possible care for those presenting with COVID-19 and non-COVID-19 related conditions.[1] Twenty wards were repurposed to care for COVID-19 patients and critical care capacity was increased five-fold.

Previous publications from the early stages of the pandemic suggested very high rates of patient to patient in hospital transmission and high rates of morbidity and mortality with perioperative COVID infection.[2,3] To protect patients requiring trauma surgery and to allow increased bed capacity for medical teams at our base hospital, our trauma and orthopaedic department services were relocated to a local private elective hospital to provide a safe COVID-free site for emergency trauma surgery and perioperative care. The service relocation occurred with the aims of maintaining the same level of non-elective trauma and orthopaedic care as in non-COVID times, but with a dual-site system where COVID and non-COVID trauma patients were separated at admission to prevent in-hospital COVID-19 transmission. With the arrival of the second wave, it is pertinent to review our cohort for the risk of COVID associated mortality and morbidity in order to establish a safe practice for this winter.

Admitting and operating on COVID-19 free patients increases their risk of contracting COVID-19 infection while in hospital.[2] Therefore, the management of these trauma patients requires careful planning to allow high quality multi-disciplinary inpatient care, whilst aiming to prevent COVID-free patients from contracting the infection when being in hospital for surgery.

Trauma patients admitted to our COVID-free site were first screened for symptoms of coronavirus infection as defined by Public Health England.[4] They would only be treated at the COVID-free site if they were asymptomatic. Any symptomatic patients were treated at the COVID base hospital site.

The objective of this study was to determine the incidence of post-operative COVID-19 infection following operative treatment of trauma

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patients at the COVID-free site. The main aim of our study was to assess the postoperative COVID-19 infection rate and the mortality rate in trauma patients, to predict whether same principles can be used in safely delivering elective service during the second wave. As fragility hip fracture patients as a group tend to inherently have a higher mortality and morbidity rate, we considered this cohort of patients separately and their data will be presented in this study in a subgroup analysis.

Therefore, by reviewing the outcomes, the effectiveness and safety of maintaining separate COVID-free sites can be assessed as we look to form safe management protocols to recommence or continue providing elective trauma and orthopaedic surgery during the winter.

2. Methods

Inclusion criteria for this study were all patients requiring operative intervention at the COVID-free site. These included a combination of day case and non-day case procedures for patients either admitted directly from emergency departments (ED) or as planned TCI (To Come In) admissions after being reviewed in ED or fracture clinic by the orthopaedic team. Exclusion criteria were any patients deemed to have already had COVID-19 infection pre-operatively. Fragility hip fracture patients were assessed as a separate cohort.[5]

Initially, presenting patients were reviewed by the ED team and screened for COVID-19 symptoms. Suspected cases were patients presenting with COVID-19 symptoms as outlined by Public Health England[4] and World Health Organisation guidance.[6] These symptoms include fever, dry cough, tiredness, myalgia, arthralgia, headache or anosmia. After referral to our orthopaedic team, via ED or fracture clinic, patients were again screened for clinical features of COVID-19 infection based on Trust guidelines, including routine physiological observations, haematological and biochemistry tests as well as chest radiographs. Suspected cases remained at the base COVID site and were isolated on a COVID ward, awaiting their surgery and swab results.

If patients did not show signs or symptoms suspicious for COVID-19 infection, and had no contact with anyone showing signs of COVID-19, they were either transferred directly from ED to the COVID-free site or asked to self-isolate until they could be admitted as a TCI case at the earliest available date. At the COVID-free site, patients were admitted to open bays or side rooms. If a patient developed COVID-19 symptoms they were immediately moved into a side room on the ward, as per our Trust's infection control protocols. Patients had surgery at the COVID-free site in 'clean' theatres with staff wearing full Personal Protective Equipment (PPE), as per NHS England guidelines.[7] The patients received post-operative care on the COVID-free orthopaedic ward.

Data was collected on general trauma patients treated at the COVID-free site between the 30th of March and May 27, 2020 (60 days), and on fragility hip fracture patients treated between 30th March and April 29, 2020 (30 days). Study approval was obtained from the department audit lead and the NHS Research Ethics Committee decision tool excluded the need for formal ethical approval. Electronic online patient databases (eHandover, Medway, Bluespier, and CyberLab) were used to maintain and collect accurate data.

The authors collected data to assess COVID-19 incidence in post-operative patients at first follow up appointment. Patients were asked whether they had developed COVID-19 symptoms from their operation date until their follow up appointment. Electronic patient records were reviewed to assess any radiological, biochemical or virological investigations performed since surgery. Previously published research has shown a median incubation time of 5 days for COVID-19, with 97.5% of those developing symptoms doing so within 11 days.[8] Therefore, patients were encouraged to isolate for the first 2 weeks after surgery where possible. At 30 and 60 days post-surgery, electronic hospital databases were checked for any reported mortality.

A positive COVID-19 status was determined by presence of clinical symptoms and a single positive result for detection of SARS-CoV-2 S gene (VIASURE SARS-CoV-2 gene Real-Time PCR Detection Kit, CerTest Biotect) from nose or throat swab specimens. A COVID-19 status was considered negative in the presence of two consecutive negative results or no clinical symptoms. The method of testing was in accordance with national PHE guidance for COVID-19 testing, at the time of the study.

Towards the end of the sample period, COVID-19 antibody testing became available for patients. Therefore, a sample group of our patients additionally had an Anti-SARS-CoV-2 IgG antibody blood test offered to them during their first follow up appointment. This was offered to a random selection of our follow up patients.

3. Results

During the study periods, 113 non-hip fracture operations were performed on 104 patients and 35 hip-fracture operations performed.

One patient was excluded from further analysis: an 82-year-old male patient who was asymptomatic at admission was transferred to the COVID-free site for fixation of a distal femoral periprosthetic fracture. Tests for the virus taken at admission in ED later came back positive, after the patient's operative procedure. The patient was nursed in a side room at the COVID-free site since admission as a precautionary measure because he was admitted from a care home. He was subsequently transferred back to the COVID site for medical management on a COVID-cohort ward. He made a full recovery. This patient was excluded from the study as he was deemed to have contracted the virus prior to admission.

Therefore, 138 patients met the inclusion criteria, undergoing 147 operations at the COVID-free site. Seventy-one (51%) patients were female and 67 (49%) were male.

Non-hip fracture cases (n = 113): The mean age of the cohort was 52.9 years (21–94 years, SD 22.4). Patient demographics are listed in Table 1. The American Society of Anaesthesiologists (ASA) grades for our cohort ranged between I to III: 26 (25.2%) were graded ASA I, 58 (56.3%) ASA II, and 19 (18.5%) ASA III. 101 (90.2%) operations were under general anaesthesia, 8 (7.1%) under regional anaesthesia and 3 (2.7%) under local anaesthesia. Sixty-seven (59.8%) were lower-limb operations and 45 (40.2%) were upper-limb operations. Of those, 16 cases (14.3%) were for lower-limb infection and 4 (3.6%) were for upper-limb infection. Operations performed include revision hip surgery for periprosthetic fracture, intramedullary nailing of long bone fractures, fixation of proximal humerus, elbow, wrist and ankle fracture and minor operations such as wound debridement. Operative time ranged from 30 to 220 min. The type of anaesthesia and operation type are summarised in Table 2.[9]

Of these 103 patients, 94 were either followed up as outpatients in a face to face fracture clinic or had repeat PCR swab tests as inpatients after two weeks of their operation.

Table 1
Non-hip fracture cohort - Overview of patient demographics and ASA grade.

	Patients	Percentage (%)
Total	**103**	**100**
Gender		
Female	59	57.3
Male	44	42.7
Age		
20-29	13	12.6
30-39	15	14.6
40-49	17	16.5
50-59	21	20.4
60-69	13	12.6
70-79	16	15.5
80-89	7	6.8
90-99	1	1.0
ASA		
I	26	25.2
II	58	56.3
III	17	16.6
IV	2	1.9

Table 2
Non-hip fracture cohort - Overview of form of anaesthesia and type of operation.

	Operations	Percentage (%)
Total	**112**	**100**
Anaesthesia		
General	101	90.2
Regional	8	7.1
Local	3	2.7
Operation type		
Lower limb trauma	51	45.5
Upper limb trauma	41	36.6
Lower limb infection	16	14.3
Upper limb infection	4	3.6

Ninety (90) patients attended their follow up appointments at the COVID-19 free site, and had screening questions and a temperature check before entering the building. All these patients were apyrexial and did not have any COVID-19 symptoms from their operation until their follow up appointment. Seventeen (17) patients required followed-up less than fourteen days post-surgery. All of these patients had subsequent telephone clinic follow up appointments and were routinely screened for COVID symptoms. The mean follow-up period, including telephone follow up, was 49 days post-surgery (range 39–110 days) and 37 days from the date of discharge (range 36–88 days).

One (1) patient was readmitted with a wound infection 4 weeks after the operation and had a repeat PCR swab test confirming they were negative for COVID-19.

One (1) patient was readmitted to hospital as an inpatient and was tested for COVID-19 infection at day 14 post-op which had a negative result. They were readmitted as a planned TCI for stabilisation following the initial injury of a knee dislocation.

Two (2) patients remained as inpatients for 14 and 16 days after their operation. These prolonged admissions were due to difficulties in providing a safe discharge. They both remained asymptomatic and had negative COVID PCR swabs tests at day 13 and 16 respectively.

Nine (9) patients either did not attend their follow up appointment or did not required a hospital follow up appointment. These patients were reviewed via telephone consultation and screened for symptoms. All had remained asymptomatic throughout the post-operative period.

Additionally, a random sample group of ten (10) patients were offered an Anti-SARS-CoV-2 IgG antibody blood test during their first follow up appointment. All 10 patients accepted the test, and all 10 patients (100%) had a negative result.

There was a single mortality 1/103 (0.97%) recorded at 60 days post-surgery. This was a patient with known metastatic disease with poor prognosis who died as a result of her metastatic disease. She had multiple negative COVID-19 swabs following her operation and the death was not directly related to her surgery or COVID-19.

Hip fracture patients (n = 35): The mean age of the cohort was 78.5 years (37–96 years, SD 11.3). The operation types are summarised in Table 3. Of the fractures presented, 51% were intracapsular, 45% extracapsular and 4% periprosthetic. 38% of patients received a hemiarthroplasty, 26% intramedullary nailing and 19% dynamic hip screws (DHS). The mean length of stay was 8.7 days and mean follow-up was 24.7 days.

These patients are not routinely followed up in an outpatient setting, however, during their admission patients were tested for COVID-19 infection if they developed symptoms post-operatively or if it was later required for safe discharge. As a result, 26 of these 35 patients (74%) were ultimately tested for COVID-19 infection and none were positive.

Two (2) patients developed symptoms consistent with COVID-19 infection and were therefore isolated and subsequently transferred out of the 'COVID-free' site. Both patients tested negative for COVID-19 infection but due to ongoing deterioration, the clinical suspicion remained high and both continued to be treated as such. Both patients were treated in a COVID cohort ward and unfortunately recorded mortalities on post-operative days 6 and 8: both attributable to a clinical diagnosis of COVID-19 infection.

Table 3
Hip fracture cohort - Summary of results and outcomes (DHS = dynamic hip screw, IM Nail = intramedullary nail, THR = total hip replacement, Revision = revision operation for periprosthetic fracture or failure).

Patients	35
Male	23
Female	12
Age (years)	
Mean	78.5 (SD 13.3)
Range	37–96
Operations	**35**
DHS	6
Cannulated screws	3
Hemiarthroplasty	9
IM Nail	12
THR	3
Revision	2
Time to surgery (hrs)	
Mean	29.8 (SD 26.1)
Range	4.6–152.4
Length of stay (days)	
Mean	8.7 (SD 26.1)
Range	3–24
Tested for COVID-19	**26**
Positive swab result	0
Negative swab result	26
Follow-up period (days)	
Mean	24.7
Range	12–41
Mortalities	**2**

There was a 5.7% (2/35) mortality rate recorded at 30 days post-surgery.

4. Discussion

As the COVID-19 pandemic started to affect the UK population, UK hospitals were forced to adjust and reallocate resources to cope with the increasing demand. Our trust was one of the earliest and most severely affected within the UK.[1] Non-essential services including elective surgery were suspended to increase capacity for COVID-19 cases with 20 wards repurposed to manage COVID-19 patients.[10] Transferring the acute trauma service to a novel site helped enable this increase in capacity, while also allowing us to treat non-COVID patients in a COVID-free environment. Previous experiences in Italy have shown that the reorganisation of trauma services into COVID and COVID-free sites can be effective in providing non-COVID trauma patients urgent care during the pandemic.[11]

Lei at al produced a retrospective study reviewing the post-operative outcomes of a cohort of 34 elective patients who underwent surgery during the incubation period for COVID-19.[3] 44.1% of this cohort required ICU admission due to complications of COVID-19 infection and 20.5% patients died. A further paper from the Wuhan area suggested 41% of all hospital patients with COVID-19 were infected in hospital.[2] These case series raise serious questions regarding the risks and consequences of contracting COVID-19 when admitted to hospital, particularly if a surgical procedure was required. As infection rates rose within the UK, British Orthopaedic Association (BOA) guidance for

management of urgent patients advised carrying out only essential surgery and advised surgeons to opt for conservative management where possible.[12] Patients were actively discouraged from attending hospitals unless necessary. Our aim was, therefore, to determine whether a COVID-free setup could protect patients requiring admission for urgent surgery.

Out of our cohort of 104 non-hip fracture patients, only one patient developed symptoms and was found to have tested positive on pre-operative COVID-19 PCR swabs. This patient, who was admitted from a care home, had initially screened negative and developed symptoms postoperatively within two days of transfer from our main hospital site to the COVID-free site. Given the high rate of COVID infection in care homes, when transferred to the COVID-free site this patient was nursed in a separate room, pending admitting PCR swab results, despite initially being symptom-free. We would recommend similar precautions when setting up a two-site system. Potential increases in testing availability and speed may be able to avert this problem in the future.

The median incubation period for COVID-19 is five days and most patients develop symptoms within 12 days of contracting the virus.[8] We opted to collect our data from day 14 onwards from the discharge date as this was the usual follow-up required for a post-operative trauma patient within our trust. Some patients had earlier or later appointments as requested by the operating surgeon. The follow-up appointments allowed us the opportunity to screen patients for COVID-19 symptoms and perform a temperature check in addition to their routine post-op care. We accept that a proportion of patients infected with COVID may remain asymptomatic.[13] We offered optional antibody tests to a small sample of patients when the test became available. Ten (10) patients accepted the tests. A further 4 patients who were either re-admitted or stayed as in patients had repeat PCR swab tests as routine. All antibody and swab tests were negative. The IgG antibody test that was used in our study was shown to be 97% sensitive and 98% specific.[14] The accuracy of nasopharyngeal and oropharyngeal PCR swab tests is less than antibody testing and variable results have been published.[15]

We separated patients with neck of femur fracture in this study as this group of patients have an inherent mortality rate and were high risk for COVID, with a large proportion of patients coming from a care home setting. This group of patients from our trust was reported in a separate study by Chui et al. reporting a mortality rate of 10.6% (5/47 patients) with a mean follow-up of 24.7 days.[5] This mortality rate is slightly higher than the 8.4% 30-day mortality rate reported by Sheikh et al. in a cohort of 1356 patients treated at Leeds General infirmary from 2008-2011.[16] Due to the inherently higher morbidity and mortality rate associated with fragility hip fracture patients, it is likely most of these patients would not be suitable candidates to be offered high risk elective operations. Hip fracture patients usually require prolonged hospital admissions where post-operative infections, including pneumonia, are contracted relatively commonly. Therefore, they do not represent the cohort of patients likely to be offered elective surgery. We feel that the risk of mortality in the non-hip fracture patients can be better extrapolated to the elective surgery ambulatory patients.

We recognise that there are some higher ASA group patients within our study and this would potentially increase the mortality rate results. However, we had not underestimated our mortality rate by including these patients.

The principles of treatment for suspected and confirmed cases should be supportive therapy and isolation in designated hospitals with sufficient protective conditions.[17] Hence having a separate COVID free site for operative procedures with stringent screening for COVID infection will markedly reduce the risk of infection. Our model during the peak of the crisis showed a successful prevention of symptomatic infection. We accept that a proportion of patients may have asymptomatic infection, but believe that the establishment of a separate COVID-free site will reduce the viral load, if any, to a level that is safe for orthopaedic surgery to be carried out. Of note, as the cohort of patients in our study were patients requiring trauma surgery, none of them had the full 14 days pre-operative self-isolation currently recommended by the BOA prior to elective surgery.[18] With the new guideline of 14 days self-isolation in place, we believe that the risk of infection and mortality will be significantly minimised when recommencing non-urgent elective surgery.

The aim of this study was to determine COVID morbidity and mortality rates in patients admitted for trauma surgery under general and regional anaesthesia in our hospital. This will form a basis for quoting the risk to patients when consenting for elective surgery. Our institute showed 0% morbidity and 0.97% mortality (from a non COVID cause) in general (non-hip fracture) trauma patients having surgery at a COVID-free site with defined admission criteria and screening and PCR swab testing of patients at admission.

5. Limitations

The authors recognise the data collection period was in the early stages of the COVID-19 pandemic, and that the patient numbers for comparison are relatively low. Re-evaluation after the pandemic will certainly add more statistical power to the evaluation of the outcomes.

An environmental confounding factor was that some patients were TCI patients as day case procedures, whereas others were admitted directly from ED straight to the COVID-free site. Equally, patients were recovering post-operatively in different external environments once discharged.

6. Conclusion

The department actively implemented a dual-site system for delivering COVID-free trauma service in a private elective hospital and retaining the COVID trauma service in the main NHS site with HDU support during the pandemic. This produced significant gains in medical bed capacity in response to the COVID-19 demand. One hundred percent (100%) of patients undergoing urgent non-hip fracture trauma surgery in this setting did not develop COVID-19 symptoms as a result of their hospital admission.

The authors propose that establishing a separate site with screening to avoid admission of patients with COVID-19 infection can allow safe emergency surgery. This data can support informed consent and reassure patients of their risks as day case and elective surgery is resumed around the UK and worldwide.

Author contributions

Ms Lilanthi Wickramarachchi: Wrote the paper, collected the data. Mr Jonathan Peters: Wrote the paper, collected the data. Mr Amit Thakrar: Wrote the paper, collected the data. Mr James ML Wong: Senior editor. Mr George Mazis: Senior editor. Ms Verona Beckles: Senior editor. Dr Sandra Lacey: Senior editor. Mr Kuen Chin: Collected the data, senior editor.

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References

1 *Statistics » COVID-19 Daily Deaths [Internet]*. England.nhs.uk; 2020 [cited 27 June 2020]. Available from: https://www.england.nhs.uk/statistics/statistical-work-areas/covid-19-daily-deaths/.

2 Wang D, Hu B, Hu C et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in wuhan, China. J Am Med Assoc. 10.1001/jama.2020.1585.

3 Lei S, Jiang F, Su W et al. Clinical characteristics and outcomes of patients undergoing surgeries during the incubation period of COVID-19 infection. EClinicalMedicine. 10.1016/j.eclinm.2020.100331.

4 *Coronavirus (COVID-19): Guidance [Internet]*. GOV.UK; 2020 [cited 27 June 2020]. Available from: https://www.gov.uk/government/collections/coronavirus-covid-19-list-of-guidance.

5 Chui K, Thakrar A, Shankar S. Evaluating the efficacy of a two-site ('COVID-19' and 'COVID-19-free') trauma and orthopaedic service for the management of hip fractures during the COVID-19 pandemic in the UK. *Bone & Joint Open*. 2020 Jun;1(6):190–197.

6 *Coronavirus [Internet]*. Who.int.; 2020 [cited 27 June 2020]. Available from: https://www.who.int/health-topics/coronavirus#tab=tab_3.

7 *Coronavirus (COVID-19): Personal Protective Equipment (PPE) Hub*. GOV>UK; 2020 [cited 27 June 2020]. Available from: https://www.gov.uk/government/collections/coronavirus-covid-19-personal-protective-equipment-ppe.

8 Lauer SA, Grantz KH, Bi Q, et al. The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application. *Ann Intern Med*. 2020 May 5;172(9):577–582.

9 Abouleish Amr E, Marc L, et al. ASA provides examples to each ASA physical status class. *ASA Monitor*. 2015;79(6):38–49.

10 Iacobucci G. Covid-19: all non-urgent elective surgery is suspended for at least three months in England. *BMJ*. 2020 Mar 18;368:m1106. London.

11 Martino A, Faldini C. Trauma service reorganization in Bologna (Italy) during COVID-19 pandemic. *Injury*. 2020 Apr;51(7):1684.

12 British Orthopaedic Association. Management of patients with urgent orthopaedic conditions and trauma during the coronavirus pandemic. https://www.boa.ac.uk/uploads/assets/ee39d8a8-9457-45339774e973c835246d/COVID-19-BOASTs-Combined-v1FINAL.pdf; 2020.

13 Grant MC, Geoghegan L, Arbyn M, et al. The prevalence of symptoms in 24,410 adults infected by the novel coronavirus (SARS-CoV-2; COVID-19): a systematic review and meta-analysis of 148 studies from 9 countries. *PLoS One*. 2020 Jun 23;15(6), e0234765.

14 Castro R, Luz PM, Wakimoto MD, et al. COVID-19: a meta-analysis of diagnostic test accuracy of commercial assays registered in Brazil. *Braz J Infect Dis*. 2020 Mar-Apr;24(2):180–187.

15 Wang X, Tan L, Wang X, et al. Comparison of nasopharyngeal and oropharyngeal swabs for SARS-CoV-2 detection in 353 patients received tests with both specimens simultaneously. *Int J Infect Dis*. 2020;94:107–109.

16 Sheikh HQ, Hossain FS, Aqil A, et al. A comprehensive analysis of the causes and predictors of 30-day mortality following hip fracture surgery. *Clin Orthop Surg*. 2017 Mar;9(1):10–18.

17 Jin Y-H, Cai L, Cheng Z-S, et al. A rapid advice guideline for the diagnosis and treatment of 2019 novel coronavirus (2019-nCoV) infected pneumonia (standard version). *Military Medical Research*. 2020;7:4.

18 British Orthopaedic Association. Evidence based suggestions for the return to elective orthopaedic surgery following the COVID-19 pandemic. https://www.boa.ac.uk/policy-engagement/journal-of-trauma-orthopaedics/journal-of-trauma-orthopaedics-and-coronavirus/evidence-based-suggestions-for-the-return.html; 2020.