

The Impact of the Coronavirus Pandemic on Patients With Acute Proximal Femoral Fracture: a Retrospective, Observational, Cohort Study

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Abstract

- **Background** – During the initial peak of the COVID-19 pandemic in the United Kingdom (UK) admissions related to acute proximal femoral fracture (APFF) remained consistent.
- **Aims** – This aim of this research is to demonstrate the impact of the COVID-19 pandemic on this cohort of high-risk patients and provide revenues for improvement in their care as we globally progress through further peaks of viral transmission and illness.
- **Methods** – Retrospective, observational, cohort study of 112 patients with APFF; sustained during the first peak of the pandemic (1st March – 15th May, 2020). Following ethical approval, data was collected from electronic records. Included patients were those who had been admitted to one of two district general hospitals in Northwest England. Only patients with APFF were included – chronic, peri-prosthetic, femoral shaft and open fractures were excluded. Patients were split into two groups: COVID-positive (N = 17) and COVID-negative (N = 95) with the primary outcome measure being 30-day mortality.
- **Results** – 17.9% overall mortality (29.4% for COVID-positive and 15.7% for COVID-negative). The odds ratio for mortality was 2.2 in the COVID-positive group compared to the COVID-negative group (95% confidence level; 0.68–7.23).
- **Conclusions** – Patients with APFF suffered increased mortality during the initial peak of the COVID-19 pandemic. However, increased mortality in COVID-positive patients, compared to the COVID-negative patients, was not statistically significant. Increased mortality in COVID-negative patients may have been due to other pandemic related factors including: undiagnosed COVID-19; patient demographics and the effects of changes to the service provision structure of the orthopaedic department during this time. Moving forward, as the global fight against COVID-19 continues, we provide the below recommendations as suggested revenues to improve 30-day mortality for these patients during pandemic times:
 - repeated COVID-19 testing for all APFF patients;
 - strict separation of COVID-suspected, COVID-positive, and COVID-negative patients;
 - preservation of acute trauma services, including protected theatre time; and
 - maintenance of experienced orthopaedic teams on wards throughout periods of re-deployment.

Further research with larger sample sizes is needed to assess the national and international applicability of these recommendations.

Background

In December 2019, a collection of patients experiencing a pneumonia of unknown cause were eventually associated with a seafood market in Wuhan, China.[1] This marked the beginning of a global pandemic which continues to affect the daily lives of people internationally. With the novel virus continuing to cause particularly chaotic disruption in Europe, North America and Brazil.

This new coronavirus was of course responsible for a collection of respiratory symptoms and typical findings on chest radiographs and computer tomography scans. The respiratory disease caused by this new betacoronavirus (severe acute respiratory syndrome coronavirus 2) was soon defined by the World Health Organization (WHO), and pronounced a global health pandemic on 11th March, 2020.[2] It became the latest member of a small family of coronaviruses which have infected humans; including the Middle East Respiratory Syndrome-related coronavirus (MERS-CoV) and Severe acute respiratory syndrome-related coronaviruses (SARS-CoV).[1]

The first two British cases of this respiratory illness (COVID-19) were diagnosed in the week commencing January 27, 2020. By mid-March, the British Government began instilling measures to prevent the rapid spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2/2019-nCoV). The virus peaked for the first time in the United Kingdom (UK) at the beginning of April with the daily death rate reaching > 1000, and it then began to plateaued by mid-May.[3] By this point there had been 298,136 confirmed cases of COVID-19 infection in the UK and 41,736 deaths associated with it.[3]

In an attempt to control spread, the National Health Service (NHS) modified its activities.[3] Making amendments to the staffing and architecture of its hospitals, it focussed its service provision on the medical division. Elective operating was suspended; some surgical wards were re-located and theatres were used as space for extra intensive care beds.[4, 5] In Northwest England where our centre is located, COVID-19 exhibited a high incidence rate which was only second to that of London.[3] Service managers at many centres, including ours, used models based on the experiences of centres located in London to forecast admissions and modified their service provision activities accordingly.

The highest rates of confirmed COVID-19 infection were seen in those over the age of 80.[3] This cohort represents a high-risk group for infection and mortality from the novel coronavirus.[6] These patients also have a higher incidence of co-morbid disease, specifically diabetes and dementia, which have been associated with poorer outcomes in COVID-19 infection and neck of femur fracture respectively.[6, 7] This is also the cohort of patients who are most commonly affected by acute proximal femoral fracture (APFF).

APFF is a life-changing and life-threatening event. Patients with an acute fractured neck of femur suffer significant morbidity (such as myocardial infarction, pulmonary embolism and pneumonia), and a 6.1% mortality rate at 30-days.[8, 9] To ensure good outcomes in these patients, excellent care

and clear standards are required. These patients benefit from early operation, early mobilisation and multi-disciplinary care between orthopaedic and geriatric physicians.[8] Surgical management has been shown to be most appropriate for these patients.

The sudden outbreak of the coronavirus pandemic put unprecedent pressures on healthcare providers globally. Given that patients with APFF continue to present to emergency departments in similar numbers to pre-pandemic times it is essential that we analyse the quality of their care and outcomes during this time. As the virus continues to peak and spread in a similar way to the when this data was collected, this study is crucial in highlighting the impact of the outbreak of COVID-19 on patients with APFF. In turn, it demonstrates the importance of optimisation and prioritisation of the care of patients with APFF throughout continued peaks of the virus. The study also calls for further research to make internationally applicable recommendations. The study received full ethical approval from the Research and Development Department at our hospital.

Methodology

In this retrospective, observational, cohort study we analysed data relating to 112 patients with acute proximal femoral fractures; sustained during the first peak of the coronavirus pandemic in the UK. All patients were admitted to one of two district general infirmaries in Northwest England.

Patients with non-united femoral neck fracture (chronic), peri-prosthetic fracture, femoral shaft fractures and open fracture were excluded from the study.

Proximal femoral fractures were diagnosed by the admitting team using plain film radiographs. No further imaging was required to identify fractures in this cohort. Management of each case, including choice of implant used, was decided by the responsible orthopaedic consultant following review of plain films and discussion of each patient case. These decisions were made as per the National Institute for Health and Care Excellence (NICE) guidance. [10] Fitness for theatre was dictated by the responsible anaesthetic team. All operative procedures undertaken during the peak of the pandemic were subject to the hospital's in-theatre COVID-19 protocol. All staff wore appropriate personal protective equipment, with donning and doffing completed as per guidance. Patients were anaesthetised in the main operating room where entry and exit from the operating room was prohibited for 10 minutes following all aerosol generating procedures, allowing a full air cycle within the room. Laminar flow through the operating room was kept on at all times as per coronavirus operating guidance.[11]

Detection of COVID-19 infection was done via nasal and/or throat Real Time – Polymerase Chain Reaction (RT-PCR) tests. Swabbing was only carried out in patients who displayed any of the symptoms of COVID-19 on the WHO's listed symptoms,[12] at any point during their index admission. Chest radiographs and some thoracic computed tomography scans were also done to aid diagnosis, but these were never used as a substitute for RT-PCR viral swabs. Some patients who were discharged back to nursing homes were swabbed prior to discharge as a condition of their discharge arrangements.

Following admission, care of the majority of these patients who were aged over 65 years, was shared between the orthopaedic team and the orthogeriatric team. Physiotherapists were involved in post-operative care and early mobilisation.

The primary outcome measure was 30-day mortality. Alongside mortality, delay to surgery (> 36 hours/the day of or the day following admission),[8, 10, 13, 14] length of operating time (split by intervention performed, and including anaesthetic time), post-operative complications and length of inpatient stay were measured as secondary outcomes. Data on key prognostic indicators including: patient demography (age, sex and Abbreviated Mental Test Score [AMTS]); medical co-morbidities (including American Society of Anaesthesiology [ASA] grade); and mechanism of injury (mechanical fall or otherwise) was also collected.

All data used in the study was collected from electronic patient records. The reported AMTS relate to admission assessment, completed by the clerking doctor. Cause of death for those patients who died outside of hospital within 30-days following operative intervention was not accessible via the electronic patient records and could not be included in the results of the study.

Results

During the initial peak of the pandemic (1st of March 2020 to 15th of May 2020), we identified 112 patients who were diagnosed with APFF and treated at our institutes. In reflection of population demographics in this area of Northwest England, 100% of patients included in the study were of Caucasian ethnicity. 17 of the 112 patients had at least one positive COVID-19 RT-PCR swab, confirming positive infection, and these patients formed the COVID-positive group (N = 17). The remaining 95 patients had no laboratory confirmation of COVID-19 infection, and formed the COVID-negative group (N = 95). Of the 95 patients in COVID-negative group, 43 were never swabbed for the virus as they did not exhibit any symptoms of COVID-19 infection listed by the WHO.[12] Two patients from this COVID-negative group did not have surgery: one passed away before the surgery and another patient was unfit for any surgical intervention. These two patients were excluded from subsequent analyses. The mean age, AMTS at admission and ASA grade was similar in both groups (Table 1). There was female predominance in both the groups.

Table 1
Patient Demographics

Parameters	COVID-positive	COVID-negative
Mean Age (years)	82.4	82.5
Sex (F:M)	16 : 1	62 : 33
Mean AMTS	6	7
Mean ASA grade	3	2.9

All patients in this study suffered APFF following a trivial fall from standing height except six patients: three patients were involved in a road traffic accident and another three were diagnosed with stress fractures.

After confirmed diagnosis of APFF, 59% of patients in the COVID-positive group had surgery without delay, as per recommendations,[8, 10, 13, 14] and 54% in COVID-negative group. Overall 46% patients had delayed surgery: 22% due to unavailability of theatre slots, and 24% due to not being considered medically fit for surgery. The mean operating time for specific fixations and arthroplasties in each group is described in Table 2. As the pandemic had broader effects on the clinical practice, the length of operating time describes total anaesthetic, patient positioning and the operating time.

Table 2
Length of Operative Time (in minutes)

Procedure	COVID-positive	COVID-negative
THR Cemented	NIL	180
THR Uncemented	NIL	144
THR Hybrid	NIL	157
Cemented hemiarthroplasty	147	130
Uncemented hemiarthroplasty	140	130
DHS	120	113
IMIL Nail Long	189	163
IMIL Nail Short	NIL	139
Cannulated Cancellous Screws	NIL	112
THR – total hip replacement; DHS – dynamic hip screw; IMIL – intramedullary interlocking		

All patients were mobilised full weight bearing over the operated limb on post-operative day 1 with the help of physiotherapists, except 31 patients who were not medically fit. 27 of these patients were from the COVID-negative group and four patients were from the COVID-positive group.

The post-operative complications noted in both groups included urinary tract infection (UTI), bacterial chest infection, post-operative anaemia, delirium, stroke, superficial wound infection and pulmonary embolism (Table 3).

Table 3
Post-operative Complications

Complication	COVID-positive	COVID-negative
UTI	1	2
Bacterial chest infection	1	4
Post-op COVID infection	8	0
Post-op anaemia	1	4
Pulmonary embolism	1	1
Stroke	0	1
Delirium	5	0
Superficial wound infection	1	2
Re-operation	0	1
Periprosthetic fracture	1	0
UTI – urinary tract infection		

In the COVID-positive group, nine patients were diagnosed with coronavirus infection in pre-operative period, whereas the rest (N = 8) became positive whilst being admitted as inpatients. One patient in the COVID-negative group had revision surgery following cutout of a TFN-ADVANCED™ Proximal Femoral Nailing System (TFNA) blade due to poor quality of the bone. This patient subsequently underwent cemented hemiarthroplasty. Another patient in the COVID-positive group had an inpatient fall and suffered a Vancouver Type B1 fracture, for which open reduction and internal fixation was subsequently performed.

The combined 30-day mortality rate for all patients was 17.9% (29.4% in COVID-positive and 15.7% in the COVID-negative group). The odds ratio for mortality was 2.2 in the COVID-positive group compared to the COVID-negative group (95% confidence level 0.68–7.23). This was not statistically significant. All the patients in the COVID-positive group died directly as a result of COVID-19 infection (as registered on their death certificates). The causes of death in the COVID-negative group are described in Table 4.

Table 4
Cause of death

Cause of Death	COVID-negative Group
Covid-19 Pneumonia	0
Pulmonary Embolism	2
Bacterial Pneumonia	3
Frailty	3
Stroke	1
In community	6

15 patients died in the COVID-negative group and 5 patients died in the COVID-positive group. Patient demographics for those who died at 30-day follow-up are described in Table 5. Patients who died at 30-days follow-up suffered a combination of pre-existing co-morbid disease, as described in Table 6.

Table 5
Deceased Patient Demographics

Parameters	COVID-positive	COVID-negative
Mean Age	83.6	89.6
Sex (F:M)	4 : 1	7 : 8
Mean AMTS	6	4
Mean ASA grade	3.2	3.5

Table 6
Deceased Patient Co-morbidities

Co-morbidities	COVID-positive	COVID-negative
Cardiovascular	3	6
Respiratory Disease	0	4
Type 2 Diabetes Mellitus	2	4
Dementia	1	10
Chronic Kidney Disease	1	5

10 of the patients who died in the COVID-negative group had their surgery within the recommended time-frame, while two of patients who died in the COVID-positive group had surgery within this time-frame. All delays experienced by patients in the COVID-positive group who died were because patients were not medically fit (they did not have to wait for RT-PCR swab results before theatre). Three patients in the COVID-negative group who died had delayed surgery because they were not medically fit and two suffered delays due to insufficient theatre capacity.

Hospital inpatient stay was an average of 25 days in the COVID-positive group and 21.7 days in the COVID-negative group. Of the patients that died in the COVID-positive group, all died in hospital during their admission. In the COVID-negative group, 8 died in the hospital and the remaining seven died in the community (nursing home or own residence).

Discussion

Despite the imposed lockdown during the study period (1st March – 15th May), admission rates at our centre related to APFFs remained stable (based on our data from previous years). The overriding majority of these patients suffer APFF as a result of falls experienced in their own homes, meaning lockdown measures had minimal effects on reducing APFF risk and rate.[11] We experienced a situation where these multimorbid patients at high-risk of COVID-19, presented to a stripped-back acute trauma and orthopaedic service in similar numbers to pre-pandemic times.

Regarding the primary outcome measure, compared to pre-pandemic mortality rates, our results indicate increased mortality directly related to concurrent infection with COVID-19 in patients admitted to our trust with APFFs during the first peak of the coronavirus pandemic. All patients in the COVID-positive group who were deceased at 30-day follow up had COVID-19 documented as Part Ia (Disease or Condition directly leading to death) on their death certificate, with the exception of one patient who's documented Part Ia was post-operative pulmonary embolus. However, in this patient's case, COVID-19 was documented as Part II (contributing factor to death). COVID-19 has also been associated with increased risk of pulmonary embolism.[15] Despite the majority of patients in the COVID-positive group surviving to 30-day follow up, it is unsurprising that we found a higher mortality in this group; given that they represent a high-risk group for mortality from COVID-19, as a result of their demographics.[6]

Increased mortality was also observed in the study group as a whole. We report an overall 30-day mortality rate during the study period of 17.9%, which is triple the reported rate for the UK in the National Hip Fracture Database's (NHFD) latest report – 6.1%. [8]

Patient demographics is a likely contributor to this overall mortality, with deceased patients in the COVID-negative group exhibiting various characteristics associated with poor prognosis from APFF (advanced age, cognitive decline, male gender etc.).[6] Deceased patients from the COVID-negative group also had a higher incidence of dementia and were on average 6-years older than others in the study. In addition, patients who died in the negative group were predominantly admitted from nursing homes (73%), with a lower mean AMTS, indicating a level of dependency and significant cognitive impairment on admission. The ratio of men to women in the COVID-negative group was 2:1 and 1:1 in the sub-group of these patients who died, therefore, men disproportionately died compared to women in this group, although the sample size is too small for this to be of any significance. Nottingham Hip Score is a reliable predictor of 30-day mortality and functional outcomes.[16] The score for those who died in the COVID-negative group was almost 10% higher than that in the COVID-positive group (4.2% in the COVID-positive & 13.3% in COVID-negative), indicating that patients who died in the COVID-negative group were at higher risk for mortality based on their demographics.

RT-PCR is continues to be the predominant testing method for active COVID-19 infection, with reported sensitivities of 71–98%. [17] This indicates that 2–29% of patients with negative test results may in fact be infected. The likelihood of undiagnosed infection decreases in patient with multiple negative tests; [17] however, the possibility of undiagnosed infection is never fully negated. The increased mortality also observed in the COVID-negative group may be explained to an extent by undiagnosed infection due to false-negative testing. In our study, we are limited in further discussing this point as there were 6 patients for which the cause of death was not accessible from hospital records.

Atypical COVID-19 presentations are also a potential cause of undiagnosed infection and are becoming more recognised, especially in the elderly.[18] Reported incidences of asymptomatic COVID-19 infection within sample populations is highly variable and ranges from 1.6–51.7%. [19] 45.3% of patients in our study's COVID-negative group were not tested at all for the infection due to not displaying classic symptoms. Atypical infection could have contributed to the mortality in this group.

Mortality and other secondary outcome measures (delay to surgery, length of operating time, post-operative complications and length of inpatient stay) were also affected by the functional changes to orthopaedic and all other health care services during the peak of the pandemic.

"...and there are no more surgeons, urologists, orthopaedists, we are only doctors who suddenly become part of a single team to face this tsunami that has overwhelmed us..." [11]

Hospitals re-structuring themselves to manage the forecasted influx of medical patients requiring respiratory support led to reduced theatre capacity, which continues to be a problem as we experience further peaks of the virus. A key prognostic indicator for fractured neck of femur patients is prompt operative management.[8, 10] 21% of patients in our study did not undergo surgical management within this recommended period due to decreased theatre capacity. Increased operating time across all surgical interventions also contributed to delays to theatre, as anaesthetic staff followed strict time-consuming protocols and theatres were also deep-cleaned between cases. Provision of prompt surgical management of APFF should be maintained throughout periods of re-deployment and restructuring due to viral surge in order to minimise 30-day mortality in elderly patients. In fact, almost half of patients in both groups of our study (41% of COVID-positive and 46% of COVID-negative) did not receive surgery within the recommended time-frame during the first peak of the pandemic. Given that delayed operative management is associated with increased 30-day mortality[10], this goes someway to explaining the increased 30-day mortality amongst our sample of patients.

In the latest NHFD report a mean acute hospital length of inpatient stay of 15.1 days was reported.[8] Patients in this study had significantly longer inpatient stays than the average reported figures (25 days in COVID-positive and 21.7 days in COVID-negative group). Increased length of inpatient stay is associated with higher risk of post-operative complications and mortality.[20] Patients in this study suffered a number of post-operative complications which may have been contributory to the high 30-day mortality rates. Discharging patients to institutes (residential and nursing homes) was more challenging during the first peak of the pandemic, as a specified number of negative swabs were required before discharge, and each swab result could take up to 72 hours. This created a further barrier to early discharge. Furthermore, amendments to the architecture of trauma and orthopaedic services during the peak of the pandemic meant orthopaedic patients were often moved between different wards and did not always receive continuous care from the same expert team. Both of these factors may also have contributed to the increased rate of mortality at 30-days for our patients during this time. In addition, increased time in hospital is also associated with increased risk of hospital-acquired COVID-19 and possibly increased mortality.

Conclusions

The first peak of the coronavirus pandemic in the UK was associated with an increased 30-day mortality in patients who suffered APFF. These multimorbid patients continued to present to acute medical services in similar numbers to pre-pandemic times, however, the effects of the viral infection and changes to provision of medical care resulted in poorer outcomes and increased mortality for those admitted during this time. As we continue to wage a war against this novel virus it is important that we highlight areas where continue care is required so that improvements in mortality rates can be made.

For our patient with diagnosed COVID-19 infection, mortality at 30-days was directly related to this. For those who did not test positive for the virus the increased mortality rate may be explained by undiagnosed COVID-19 infection and group demographics. Increased 30-day mortality in the study cohort as a whole can be explained by the effects of changes to the service provision structure of the orthopaedic department during this period. These changes led to delayed surgery, increased operating time, post-operative COVID-19 infection and increased length of inpatient stay: all of which are associated with increased 30-day mortality for APFF patients.

This research clearly highlights the need for continued high-quality care for patients who sustain APFF during viral pandemics. Although further research, both nationally and globally, is required to make our points internationally applicable, based on the above research we make the following recommendation for improvements in 30-day mortality of patients who sustain APFF during peaks of the SARS-CoV-2 virus:

- Repeated RT-PCR swabbing of all patients admitted with APFF
- Strict separation of COVID-suspected, COVID-positive and COVID-negative patients throughout hospital inpatient stay
- Preservation of acute trauma services, including protected theatre time and space, with consideration for increased overall *operating time*
- Maintenance of experienced orthopaedic team available on the wards throughout periods of re-deployment

Declarations

- *Funding* – no authors have any information to disclose regarding funding or financial interest
- *Ethics* – this research received full ethical approval from the Research and Development Department at Royal Lancaster Infirmary
- *Conflicts of interest/Competing interests* – there are no conflicts of interest to disclose
- *Availability of data and materials* – all data available on request
- *Author Contribution* – All authors contributed to the study. Study conception and design was performed by Anna Tong, Amit Singh and Victoria Sinclair. Material preparation, data collection and analysis were performed by Anna Tong, Amit Singh, Charlotte Pinder, Wei Hann Toh, Ramesh Ashwanth, Srikanth Gandavaram, Sophie Rogers. The first draft of the manuscript was written by Anna Tong, Amit Singh and Oluwatobi Onafowokan. All authors read and approved the final manuscript for publication.

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