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De, C, Wignall, A, Giannoudis, V et al. (6 more authors) (2020) Peri-operative Outcomes and Predictors of Mortality in COVID-19 Positive Patients with Hip Fractures: A Multicentre Study in the UK. Indian Journal of Orthopaedics, 54 (S2). pp. 386-396. ISSN 0019-5413

https://doi.org/10.1007/s43465-020-00272-7

Peri-operative outcomes and predictors of mortality in COVID-19 positive patients with hip fractures – A multicentre study in the UK.

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Abstract

Aim

This UK based multi-centre study reports clinical characteristics, early outcomes and predictors of mortality in 34 consecutive COVID-19-positive hip fractures so that the lessons learnt could be utilised in other parts of World who are at a different phase of the pandemic.

Methods

This study analysed patient admitted with hip fractures with COVID positive swabs, between March and May'2020 in three large hospitals covering a population of nearly two million. Data was collected on demographic profile, peri-operative variables, post-operative complications and mortality. The specific aim was to identify any variables, which could predict high 30-day mortality.

Results

Overall, 12% of hip fractures were COVID positive with the mortality rate of 41.2%. The higher age (p=0.036) and male gender (p=0.025) was significantly associated with mortality and most of the deaths were between American Society of Anaesthetiologists (ASA) Grade 3 and 4 patients. The patients having intramedullary (IM) nailing were more likely to die (p=0.02). There was no difference in laboratory parameters but there was significant difference in findings on chest radiographs (p<0.001), post-operative oxygen requirements (p=0.006) and early respiratory complications (p=0.006).

Conclusion

This study suggests that the mortality following surgery for a hip fracture in COVID-positive patients is strikingly high and is associated with higher age and male gender. Higher mortality has been observed for extracapsular fracture operated with intramedullary nailing. In the immediate post-operative period, rapid deterioration of chest imaging, higher oxygen requirement and early pulmonary complications can serve as warning signs and predicting factors for higher mortality.

Introduction

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was declared as pandemic on March 11, 2020 by the World Health Organization (WHO) and since that time, it has rapidly spread to most parts of the world with some areas more severely affected than the others[1]. The pandemic has tested the resilience, responsiveness and adaptability of various healthcare systems, including hospitals, which were largely unprepared for this much scale of the population affected[2]. Multiple new guidelines have been proposed and several existing models of social, domestic and hospital care are being challenged.

In the United Kingdom (UK), more than 290,000 cases have been confirmed positive for COVID-19 and almost 45,000 have died[3,4]. Several co-morbidities are associated with a higher mortality rate in general population. Although patients can contract the virus in the community, a significant number of patients having surgery are, in particular, a vulnerable group and are at a higher risk of being exposed to SARS-CoV-2(COVID-19) in the hospital environment. They are also more susceptible to higher rate of post-operative complications as a result of exaggeration in their pro-inflammatory cytokine and immunosuppressive response following the surgery[5,6].

Hip fractures are one of the most common fragility fractures treated by trauma units across the world[7]. A number of well-known factors lead to higher mortality in such patients[8]. Patients are often frail and elderly with limited physiological reserves and multiple comorbidities. Various pathways and guidelines exist to minimise this and improve functional outcome in patients receiving treatment for hip fractures. The advent of COVID-

19 pandemic, however, has led to a major uncertainty in several aspects of 'routine' care provided to these patients.

Before the onset of the pandemic, one-year mortality rate for hip fractures has been approximately 30%, while the 30-day mortality rate has been reported to be 5%–7%[9]. It has been largely unknown as to what impact will the COVID-19 infection have on the outcome of one of the most frequently managed fragility fractures. A few single-centre studies have shown that COVID-positive patients with hip fractures may have a higher mortality rate [10-12]. Neither of them, however, have specifically explored and analysed their peri-operative outcomes. This multi-centre study aims to report the clinical characteristics, early outcomes and predictors of mortality in a series of COVID-19-positive hip fracture patients who underwent surgery during the COVID-19 pandemic in the UK so that the lessons learnt could be utilised in other parts of world who are at a different phase of the pandemic.

Patients and Methods

This retrospective multi-centre case series study analysed 34 patients admitted with hip fractures who were subsequently found to be covid-19 positive, between 1st March and 30th May in 2020, in three large hospitals covering a population of nearly two million. Approvals were taken from the corresponding institutional review boards by all the participating hospitals.

Several variables were recorded including demographic parameters like age, gender, American society of Anesthesiologists (ASA) grade. To assess preoperative comorbid factors,

we documented Charlson Comorbidity Index (CCI), Nottingham Hip Fracture Score (NHFS) and Frailty score for all the hip fractures on admission. Patients were considered to be COVID-positive based on their quantitative Reverse Transcriptase-Polymerase Chain reaction (RT-PCR) SARS-CoV-2 swab results as per standardized protocol using nasal swabs and oropharyngeal swabs. This study involved symptomatic patients only and local guidelines for targeted testing of symptomatic patients. However, due to variability of existing classification systems and wide inter-observer and intra-observer variations, symptomatic patients were not further classified into different grades. Patients were considered to stay in high infection risk zone (Red ward) and planned to be operated in designated 'COVID Theatre' based on either clinical or radiological findings initially if definitive test results were not available by that time. Clinical diagnosis consistent with COVID-19 infection was made by senior physicians and was based on clinical presentation of symptoms highly indicative of COVID-19 infection, including cough, fever, and myalgia[13]. Radiological diagnosis was based on thorax CT, in keeping with locally implemented protocols. However, all patients suspected with clinical or radiological criteria, subsequently had laboratory testing for COVID-19 infection immediately after admission and it was attempted that test results to be available before surgery. Although the patients were tested pre-operatively, their results were not consistently available before surgery. Initially due to lack of testing capacity, patient without any suspected clinical or radiological symptoms were not tested. However, patient with negative test results and with consistent suggestive clinical symptoms were retested up to third sample to clarify the laboratory diagnosis.

We also documented operative factors like time from injury to surgery, laterality of surgery, fracture configuration (extracapsular/intracapsular), operative intervention performed and anesthesia used during surgery. Specific note was taken whether patients were operated in COVID-designated trauma theatre or conventional trauma theatre. All the patients were operated by consultants or supervised or assisted by consultants scrubbed in. Post-operative outcomes were measured in terms of post-operative complications, location of post-operative treatment, chest radiograph changes, post-operative oxygen requirement, final outcome at 30 days after surgery and length of hospital stay or mortality (if appropriate). Pre-operatively patients were medically optimised to ensure a safe surgery and none of our patients needed critical care admission or invasive ventilation. 'Do Not Attempt Resuscitation' (DNAR) status and ceiling of critical care and invasive procedures were ensured as per standardised protocol. It was ensured that all patients should receive subcutaneous injection of enoxaparin sodium in appropriate dose as thromboprophylaxis unless contraindicated.

Specific data on clinical symptoms indicative of COVID-19 infection, blood laboratory tests and pulmonary complications were also analyzed. In terms of laboratory parameters, we documented lymphocyte count on admission and lowest lymphocyte count during management, lowest blood albumin level, pre-operative and post-operative hemoglobin level with post-operative drop and key parameters for liver function test.

Once the above information was obtained, the patients were then divided into two groups: 1) those who survived [Survivor Group] and 2) those who died within 30 days of surgery [30-

day Mortality Group]. The specific aim was to identify any variables, which could predict or correlate with 30-day mortality.

For 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 to express correlation. Statistical analyses were performed using SPSS 16.0 statistics software (SPSS Inc. Chicago, IL, USA).

Results

276 consecutive hip fracture patients were screened to identify a study cohort of 34 patients, who had a hip fracture along with a positive COVID-19 test.

The overall mortality rate for COVID-19 positive patients with hip fractures was 41.2% (14 of 34). In the study, 85.7% (12 of 14) deaths were due to pulmonary complications.

Table-1: COVID-positive patients (N=34) with demographic and per-operative variables.

Variable	Total no of patients	Survivor Group	30-Day Mortality Group	p-value
Number of patients	34	20 (58.8%)	14 (41.2%)	
Mean Age (years)	85.9 (SD 7.7)	84 (SD 7.7)	88.8 (SD 8.3)	0.037

Gender M:F (%)	12:22 (35%/65%)	4:16 (20%/80%)	8: 6 (57%/43%)	0.026
ASA Grade				
ASA-2	5	4 (80%)	1 (20%)	0.298
ASA-3	20	11 (55%)	9 (45%)	0.588
ASA-4	9	5 (55.5%)	4 (44.9%)	0.816
Co-morbidity Scores				
CCI(Mean)	5.5 (SD 1.4)	5.3 (SD 1.4)	5.8 (SD 1.4)	0.319
Frailty Score	5.86 (SD 1.5)	5.85 (SD 1.5)	5.87 (SD 1.5)	0.905
NHFS	6 (SD 1.1)	5.9 (SD 1.1)	6.2 (SD 0.9)	0.201
Fracture Diagnosis				
Extracapsular	16	6 (37.5%)	10 (62.5%)	0.017
Intracapsular	18	14 (77.7%)	4 (22.3%)	
Operative Procedures				
DHS	10	6 (60%)	4 (40%)	0.928
Hemiarthroplasty	16	12 (75%)	4 (25%)	0.071
IM Nail	6	1 (16.7%)	5 (83.3%)	0.021
THR	1	1 (100%)	0	
Conservative	1	0	1 (100%)	
Anaesthesia				
Spinal Anaesthesia	23	14 (60.9%)	9 (39.1%)	0.963
General Anaesthesia	7	5 (71.4%)	2 (28.6%)	0.509
Spinal with block	2	1 (50%)	1 (50%)	0.751

General with spinal	1	0	1 (100%)	
Theatre Status				
Hot (COVID Designated theatre)	20	12 (60%)	8 (40%)	0.930
Cold (Clean Trauma theatre)	13	8 (61.5%)	5 (38.5%)	
Mean time to surgery (Hrs)	49.6 (SD 39.7)	46.7 (SD 39.7)	54.1 (SD 43.2)	0.608
Mean Operative Time (Mins)	69.1 (SD 16.7)	70.2 (SD 17.2)	67.1 (SD 15.7)	0.714
Mean length of stay (Days)	21.4 (SD 11.5)	20.7 (SD 11.5)	22.4 (SD 11.8)	0.665

Standard Deviation (SD); American Society of Anaesthesiologist (ASA); Male (M); Female (F); Charlson Comorbidity Index (CCI); Nottingham Hip Fracture Score (NHFS)

Table-1 shows that the higher age (p=0.036) and male gender (p=0.025) were significantly associated with mortality and most of the deaths in American Society of Anaesthesiologist (ASA) Grade 3 and 4 patients. There was no statistically significant difference in comorbidity level and frailty between two groups. However, the mortality group had higher mean CCI, NHFS and Frailty scores.

The study observed statistically significant higher mortality for patients having intramedullary (IM) nailing (p=0.02) as surgical fixation. On the other hand, the patients having hip hemiarthroplasty for intracapsular hip fracture were three times more likely to survive. There was generally no difference in the type of anaesthesia and the mortality rate, however, the only patient who received combined GA with Spinal Anaesthesia died.

As shown in Table-1, the patients in the mortality group were operated later than the survivors (54.1 hours Vs 46.7 hours) and their hospital stay was longer (22.4 Vs 20.7 days). Moreover, mean operative time was lesser in mortality group than the survivors (67.1 mins Vs 70.2 mins). However, these parameters had no statistically significant bearing with the mortality in the study.

Table-2 elaborates correlation with the different laboratory parameters. There was, a statistically significant difference in post-operative oxygen requirements (p=0.006), early findings on chest radiographs as compared to the baseline film on admission (p<0.001) and early respiratory complications (p=0.006) between the groups. These factors were more associated with higher mortality and found to be statistically significant. On admission lymphocyte count, the lowest lymphocyte count, pre-operative and post-operative haemoglobin levels, drop in post-operative haemoglobin, lowest albumin level and LFT parameters were similar amongst the two groups.

Table-2: Comparison of peri-operative variables in the study cohort.

Variable	Total no of patients	Survivor	30-Day Mortality	p-value
On admission Lymphocyte count	1.01 (SD 0.7)	1.1 (SD 0.7)	0.86 (SD 0.6)	0.317
Lowest Lymphocyte count	0.71 (SD 0.5)	0.76 (SD 0.5)	0.63 (SD 0.4)	0.530
Pre-operative Hb	119 (SD 18.5)	120.9 (SD 18.5)	116.2 (SD 19.8)	0.471
Post-operative Hb	102.8 (SD 18.6)	101.7 (SD 18.6)	104.4 (SD 20.3)	0.682
Drop in Post-operative Hb	18.1 (SD 16.1)	20.4 (SD 16.1)	14.9 (SD 17.0)	0.337

Albumin	30.1 (SD 5.4)	29.6 (SD 5.4)	30.9 (SD 5.4)	0.489
Total Bilirubin	15.8 (SD 14.1)	12.8 (SD 12.1)	20.1 (SD 15.3)	0.140
ALP	121.2 (SD 81.2)	102.9 (SD 81.2)	147.2 (SD 88.6)	0.119
ALT	28.2 (SD 24.6)	26.2 (SD 24.6)	31 (SD 26.6)	0.584
Highest O2 Requirement	4.61 (SD 4.6)	2.85 (SD 4.7)	7.14 (SD 5.1)	0.007
Post-operative/Early Respiratory Complication				
Present	16	6 (37.5%)	10 (62.5%)	0.006
Absent	18	15 (83.3%)	3 (16.7%)	
Post-operative/Early CXR Change				
Present	16	4 (25%)	12 (75%)	<0.001
Absent	18	16 (88.8%)	2 (11.2%)	

Standard Deviation (SD); Chest Radiograph (CXR)

Table 3A: Demographics and clinical data for patients who tested positive for COVID-19 and died (Case 1 – Case 7).

Variables	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Gender	Female	Female	Male	Female	Female	Male	Male
Age	89	91	93	95	94	92	90
ASA Grade	3	3	3	3	4	4	3
NHFS	7	7	6	7	5	6	6
Mobility	Zimmer frame	one Stick	One Stick	Unaided	One stick	Unaided	One stick
Frailty Score	7	6	7	6	5	3	5
Charlson's Score	6	6	6	5	5	5	5
Residence	Residential home	Nursing home	Own home	Care Home	Own home with care	Own home without care	Own home without care
Length of Stay (in days)	21	17	64	18	16	13	20
Side	Left	Left	Right	Right	Right	left	left
Type of hip fracture	Intracapsular	Extracapsular	Extracapsular	Extracapsular	Extracapsular	Intracapsular	Intracapsular
Type of surgey	Hemiarthroplasty	DHS	DHS	DHS	Intramedullary Nail	Cemented Hemiarthroplasty	Cemented Hemiarthroplasty
Anaesthesia	Spinal	GA	GA	Spinal	Spinal	Spinal	Spinal
Temperature on admission	37.4	36.7	37	36.5	36.2	36.7	38.1
Highest temperature during stay	38.4	38.9	38.4	39	36.8	36.8	38.1
Cough on admission	Yes	Yes	No	No	Yes	Yes	No
Anosmia on admission	No	No	No	No	No	No	No
Lymphocyte count on admission	0.62	1.29	0.7	0.83	0.91	0.34	0.85
Lymphocyte count (lowest)	0.54	0.73	0.52	0.31	0.36	0.18	0.85
Chest Radiograph Findings	Inderterminate changes COVID Pneumonia	No abnormal findings	Inderterminate changes COVID Pneumonia	No abnormal findings	Opacification right upper zone	Patchy consolidation, Viral pneumonitis	Airspace narrowing , viral pneumonitis
Pre-operative Haemoglobin	132	134	131	102	111	131	127
Post-operative Haemoglobin	119	82	106	97	83	88	128
Drop in Haemoglobin	13	52	25	5	28	43	
Albumin (lowest)	26	23	33	33	27	25	31
Total Bilirubin	10	5	12	6	21	53	27
ALP	273	46	118	115	135	129	109
ALT	33	14	16	9	42	23	43
COVID diagnosis	Positive	Positive	Positive	Positive	positive	positive	positive
Time to surgery since admission (in hrs)	48	48	24	96	36	94	16
Theatre status (Hot/Cold)	Cold	Cold	Cold	Hot	Cold	Hot	Hot
Respiratory complication	viral/bacterial pneumonia	No	No	No	SOB	SOB	SOB
Highest O2 requirement dose(L/min)	15	15	2	2	6	15	8
Duration of O2 Requirement	22 days	5 days	1 Day	4 hours	17 days	13 days	20 days
Peri-operative complication	pneumonia	Nil	Delerium	Delerium	N/A	AKI	developed fever, low oxygen saturation, COVID pneumonia
Secondary intervention	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Readmission	No	No	No	No	No	No	No
Cause of death	1a- bacterial chest infection, 1b- COVID-19, 2- old age, COPD	1a- COVID-19	Awaiting Coroner's outcome	1a- COVID-19, 2- Dementia	1a- COVID-19 pneumonia	1a- COVID pneumonia	1a- COVID-19, 2- Dementia, T2DM
Peri-death incidents	EOL care pathway	EOL care pathway	EOL care pathway	EOL care pathway		Acute kidney injury	developed fever, low oxygen saturation, COVID-pneumonia

Table 3B: Demographics and clinical data for patients who tested positive for COVID-19 and died (Case 8 – Case 14).

Variables	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13	Case 14
Gender	Female	Male	Female	Male	Male	Male	Male
Age	82	80	87	96	79	92	83
ASA Grade	3	3	3	3	4	4	2
NHFS	5	6	6	7	6	7	6
Mobility	Frame	Unaided	Independently mobile	Independently mobile	Independently mobile	Independently mobile	Independently mobile
Frailty Score	7	6	5	7	6	5	6
Charlson's Score	5	5	6	4	7	7	9
Residence	Residential care home	Residential care home	Own Home (carers)	Own Home (carers)	Own Home	Own Home	Own Home
Length of Stay (in days)	21	21	22	11	28	29	13
Side	left	left	Left	Rigth	Rigth	Rigth	Left
Type of hip fracture	Extracapsular	Extracapsular	Extracapsular	Extracapsular	Intracapsular	Extracapsular	Extracapsular
Type of surgey	DHS	Intramedullary Nail	Intramedullary Nail	Conservative management	Cemented hemiarthroplasty	Intramedullary nail	Intramedullary nail
Anaesthesia	Spinal	Spinal	Spinal	N/A	General and Spinal	Spinal and Femoral Nerve Block	Spinal
Temperature on admission	38.0	38.2	38.6	38.2	37.5	37.7	37.4
Highest temperature during stay	37.9	38.6	38.1	39.2	36.5	37	37.4
Cough on admission	Yes	No	No	Yes	Yes	No	Yes
Anosmia on admission	No	No	No	No	No	No	No
Lymphocyte count on admission	3.02	0.79	0.55	0.38	0.61	0.74	0.47
Lymphocyte count (lowest)	2.54	0.69	0.4	0.38	0.3	0.7	0.43
Chest Radiograph Findings	Bibasal airspce opacification	Ground glass opacification	Inderterminate changes COVID Pneumonia	Viral(COVID) Pneumonitis	Viral(COVID) Pneumonitis	Viral(COVID) Pneumonitis	Viral(COVID) Pneumonitis
Pre-operative Haemoglobin	143	90	108	136	109	84	89
Post-operative Haemoglobin	132	84	89	136	102	120	95
Drop in Haemoglobin	11	6	19		7		
Albumin (lowest)	41	37	27	30	28	31	41
Total Bilirubin	29	47	11	11	8	12	29
ALP	158	490	102	60	112	108	106
ALT	29	139	9	12	24	15	26
COVID diagnosis	positive	positive	Positive	Positive	Positive	Positive	Positive
Time to surgery since admission (in hrs)	27	183	49	Conservative	26	13	43
Theatre status (Hot/Cold)	Cold	Hot	Hot	N/A	Hot	Hot	Hot
Respiratory complication	Sever SOB	SOB	COVID Pneumonia	Pneumonia with patchy consolidation	Bilateral pleural effusions. Treated as superimposed LRTI with Abx.	Treated with IV Abx for COVID and LRTI. Note patient also had pulmonary fibrosis	Deterioration of COVID pneumonia
Highest O2 requirement dose(L/min)	15	2	4	4	4	4	4
Duration of O2 Requirement	12 days	8 days	3 days	6 days	9 days	23 days	3 days
Peri-operative complication	NSTEMI, worsening COVID Pneumonia	hypernatraemia	AKI Stage 2, Oozing wound	N/A	Alcohol withdrawal (started on Chlordiazepoxide regime), dyselectrolytemia	Significant Hb Drop unable to establish if upper or lower GI cause	Grade-4 pressure sore, post op reviewed by Tissue Viability Nurse. AKI on CKD.
Secondary intervention	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Readmission	No	No	No	No	No	No	No
Cause of death	1a- COVID pneumonia, 2- dementia, MI, fractures left hip.	1a- COVID pneumonia	1a- COVID-19 Pneumonia	1a- COVID-19 Pneumonia	1a- COVID-19 Pneumonia	1a- COVID-19, Respiratory Failure, 1b- Pulmonary Fibrosis	1a- COVID-19 Pneumonia
Peri-death incidents	NSTEMI, worsening of COPD,COVID-PNEUMONIA	hypernatraemia	Respirartory secretions, Tachypnoeic. Reviwed by orthogeriatric teams patient placed on ICOD.	C.Diff +ve (Had loose stools)	Deterioration in breathing.	Deterioration in breathing and cognition	Patient became unresponsive and had increasing O2 requirements

Discussion

This study has demonstrated the mortality for COVID-positive hip fracture patients to be over 40%, which is significantly higher than the reported overall UK mortality rate (15.4%, p<0.001) and the age specific (>80years) mortality rate (21.9%, p<0.001) for COVID positive patients without hip fractures[3,4,14]. Before the pandemic, as per the National Hip Fracture Database (NHFD), the 30-day mortality after hip fracture surgery was recorded as 7.5% between 2011-2017 and 6.1% in 2018[9]. The case-mixed-adjusted 30-day mortality for patients aged between 80-89 years as per NHFD annual report-2019 was under 10%[9]. In the same age distribution, we found that the COVID-positive patients with hip fractures were almost eight times more likely to die than their COVID-negative counterparts. The recorded mortality for COVID-positive hip fracture patients was 52.9% in New York city[10] and 30.4% in Spain[12], but both these studies had limited number of patients.

Although the ASA grade of the patients had no statistically significant correlation with mortality in our study, 92.8% (13 out of 14) of patients who died within a month of the surgery were from ASA Grade 3 and 4 groups. This is not surprising and even before the pandemic, some studies have illustrated up to 85% of the 30-day post-operative deaths were amongst ASA grade 3 and 4 patients[15]. A study of Spanish outcomes during the pandemic by Vives et al[12], with similar population demographics like ours, showed all (100%) the mortalities among ASA 3-5 with share of ASA 3, 4, 5 of 63.6%, 18.2%, 18.2% respectively.

We specifically wanted to identify if there was any correlation between the higher mortality and Charlson comorbidity index, Frailty score and Nottingham Hip Fracture Scores.

Although, these variables were higher in the patients who did not survive, none of these were statistically significant. It is quite possible that this is due to Type 2 error. A multicentre cohort study by Kayani et al[16] categorised the COVID-positive patients according to the numerical count of comorbid conditions and found that patients with COVID-19 infection who have greater than three comorbidities, have statistically significant higher mortality rate.

In our study, we observed 71.4% of the mortalities were for extracapsular hip fracture and it was statistically significant (p=0.017). These findings are similar to those of LeBrun et al[11] and Vives et al[12] who have reported 66% and 69% 30-day post-operative mortality rate for patients with extracapsular hip fractures respectively. Some studies[10-12], however, have found weaker correlation between mortality and fracture geometry. The New York COVID Hip Fracture Research Group[10] reported nearly 52% patients with extracapsular fracture in the mortality group.

Egol et al[10] and LeBrun et al[11] found weak association of mortality with the type of surgical procedure. The authors reported 50% and 44% mortality for patients treated by intramedullary nailing. In our study, this rate was 83.3%, which was statistically significant (p=0.02). The exact reason for this remains unknown. We could have hypothesised that this might be related to the intramedullary procedure in the femoral canal causing a 'second hit' in patients who are already physiologically compromised. However, this is a multifactorial issue and type of implant is just one of the multiple factors. Management of every hip fracture in this situation were discussed in multidisciplinary meeting involving hip surgeons and decisions were taken considering local guidelines, logistics and expertise available. This

study was mostly oriented on overall management of hip fractures during the COVID-19 pandemic to figure out any key factors in the practice which could have contributed to the outcome. The mortality rate following hip hemiarthroplasty in our study (28.6%) was comparable to 28% and 22% reported values by the New York COVID Hip Fracture Research Group[10] and LeBrun et al[11] respectively. The patients having hip hemiarthroplasty for intracapsular hip fracture were three times more likely to survive.

Egol et al[10] observed strong association ($p<0.01$) between mortality and time to surgery from initial presentation while LeBrun et al[11] ($p=0.11$) and Spanish HIP-COVID Observational Study[12] ($p=0.844$) did not observe such difference. In our study, although the patients in the mortality group were operated later than the survivors (54.1 hours Vs 46.7 hours), this was not statistically significant ($p=0.607$). The standard deviation for the delay in surgery was much higher in the mortality group (SD 43.2hrs) compared to the survivors (SD 39.7hrs) indicating wide variability in time taken for medical optimisation of sick patients before surgery. Some recent evidence reports weak correlation between length of hospital stay and mortality, similar to our study, due to prolonged post-operative care for medical stabilisation[11,12].

We analysed carefully all the laboratory parameters to identify any predicators for high mortality in COVID–positive hip fracture patients. Although recent evidence claimed that lymphopenia might be one of the predictors of disease severity and mortality for COVID-positive patients[17], our study did not observe this difference. A multicentre Spanish study involving 136 hip fractures with 23 COVID-positive patients also reports similar finding ($p=0.666$). It is possible that biochemical and metabolic insult from a hip fracture has acted

as a confounder in this regard. Similarly, some studies have reported that deranged liver function tests might be predictor of higher mortality[18] for COVID-19 positive patients. Our study has also demonstrated higher values for key LFT parameters for the mortality group although this was not statistically significant. The evidence from pre-COVID-19 period has suggested that mean post-operative haemoglobin drop of 31.5g/L for hip fractures might be detrimental[19]. However, we observed mean 14.9 g/L (SD 17.0) drop in post-operative haemoglobin level in the mortality group, which was statistically not significant (p=0.337).

Cheung et al[20] found that COVID-positive hip fracture patients had increased oxygen demands post-operatively and required prolonged supplemental oxygen therapy beyond second post-operative day. Furthermore, in patients who proceed to hip fracture surgery, pulmonary complications are known to be a significant contributor to post-operative morbidity, with the incidence of these complications estimated to be approximately 4%-9%[21,22]. Mi et al. published one of the early studies from China which showed higher mortality for post-operative hip fracture patients with early respiratory complications, higher oxygen requirement and CT scan findings post-operatively[23]. Our study found similar features. The higher dose of oxygen requirement in early post-operative period and early onset respiratory complications were significantly associated with higher mortality for COVID-positive hip fracture patients.

The international study of COVID-19 and emergency surgery published in The Lancet[24] reported a considerable increase in mortality due to pulmonary complications which accounted for 82.8% of the deaths. Overall, 30-day mortality was 23%. In our study, 85.7% (12/14) deaths were due to pulmonary complications and early changes in chest

radiograph were significantly associated with mortality. Early recognition and treatment of these parameters might help in prevention of some deaths.

This study has some limitations. This is a relatively small study of 34 patients although it is one of the largest case series of COVID- positive patients with hip fractures currently in the literature. One has to be cautious about drawing strong conclusions based on this number of patients but clear trends and observations can be noted and this may provide helpful guidance when discussing issues of complications including mortality with patients and their family as part of the consent process for surgery. The data on delayed complications and revision rates were not available in the short time frame analysed.

This study has several strengths including its multi-centre design covering large part of England as well as providing detailed data on each hip fracture patient who was COVID-positive, in order to identify trends in clinical presentation and outcomes.

Conclusion

In conclusion, the mortality following surgery for a hip fracture in COVID-positive patients is strikingly high. This study observed higher mortality for extracapsular fractures operated with intramedullary nail. In the immediate post-operative period, rapid deterioration of chest imaging, higher oxygen requirement and early pulmonary complications can serve as warning signs and predicting factors for higher mortality.

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Table

Click here to access/download;Table;Mortality Only-COVID19Positive.xlsx

Variables	Gender	Age	ASA Grade	NHFS	Mobility	Frailty Score	Charlson's Score
Case 1	Female	89	3	7	Zimmer frame	7	6
Case 2	Female	91	3	7	one Stick	6	6
Case 3	Male	93	3	6	One Stick	7	6
Case 4	Female	95	3	7	Unaided	6	5
Case 5	Female	94	4	5	One stick	5	5
Case 6	Male	92	4	6	Unaided	3	5
Case 7	Male	90	3	6	One stick	5	5
Case 8	Female	82	3	5	Frame	7	5
Case 9	Male	80	3	6	Unaided	6	5
Case 10	Female	87	3	6	Independently mobile	5	6
Case 11	Male	96	3	7	Independently mobile	7	4
Case 12	Male	79	4	6	Independently mobile	6	7
Case 13	Male	92	4	7	Independently mobile	5	7

Case 14	Male	83	2	6	Independently mobile	6	9

Residence	LOS in days	Side	Type of hip fracture	Type of surgey	Anaesthesia	Temp on admission
Residential home	21	Left	Intracapsular	Hemiarthroplasty	Spinal	37.4
Nursing home	17	Left	Extracapsular	DHS	GA	36.7
Own home	64	Right	Extracapsular	DHS	GA	37
Care Home	18	Right	Extracapsular	DHS	Spinal	36.5
Own home with care	16	Right	Extracapsular	Intramedullary Nail	Spinal	36.2
Own home without care	13	left	Intracapsular	Cemented Hemiarthroplasty	Spinal	36.7
Own home without care	20	left	Intracapsular	Cemented Hemiarthroplasty	Spinal	38.1
Residential care home	21	left	Extracapsular	DHS	Spinal	38.0
Residential care home	21	left	Extracapsular	Intramedullary Nail	Spinal	38.2
Own Home (carers)	22	Left	Extracapsular	Intramedullary Nail	Spinal	38.6
Own Home (carers)	11	Rigth	Extracapsular	Conservative management	N/A	38.2
Own Home	28	Rigth	Intracapsular	Cemented hemiarthroplasty	General and Spinal	37.5
Own Home	29	Rigth	Extracapsular	Intramedullary nail	Spinal and Femoral Nerve Block	37.7

Own Home	13	Left	Extracapsular	Intramedullary nail	Spinal	37.4

Highest temp during stay	Cough on admission	Anosmia on admission	Lymphocyte count on admission	Lymphocyte count (lowest)	CXR Findings	Pre-op HB	Post-op HB
38.4	Yes	No	0.62	0.54	Inderterminate changes COVID Pneumonia	132	119
38.9	Yes	No	1.29	0.73	No abnormal findings	134	82
38.4	No	No	0.7	0.52	Inderterminate changes COVID Pneumonia	131	106
39	No	No	0.83	0.31	No abnormal findings	102	97
36.8	Yes	No	0.91	0.36	Opacification right upper zone	111	83
36.8	Yes	No	0.34	0.18	Patchy consolidation, Viral pneumonitis	131	88
38.1	No	No	0.85	0.85	Airspace narrowing , viral pneumonitis	127	128
37.9	Yes	No	3.02	2.54	Bibasal airspce opacification	143	132
38.6	No	No	0.79	0.69	Ground glass opacification	90	84
38.1	No	No	0.55	0.4	Inderterminate changes COVID Pneumonia	108	89
39.2	Yes	No	0.38	0.38	Viral(COVID) Pneumonitis	136	136
36.5	Yes	No	0.61	0.3	Viral(COVID) Pneumonitis	109	102
37	No	No	0.74	0.7	Viral(COVID) Pneumonitis	84	120

37.4	Yes	No	0.47	0.43	Viral(COVID) Pneumonitis	89	95

Drop	Albumin (lowest)	Total Bilirubin	ALP	ALT	COVID diagnosis	Time to surgery since admission in hrs	Theatre status (Hot/Cold)	Respiratory complication
13	26	10	273	33	Positive	48	Cold	viral/bacterial pneumonia
52	23	5	46	14	Positive	48	Cold	No
25	33	12	118	16	Positive	24	Cold	No
5	33	6	115	9	Positive	96	Hot	No
28	27	21	135	42	positive	36	Cold	SOB
43	25	53	129	23	positive	94	Hot	SOB
	31	27	109	43	positive	16	Hot	SOB
11	41	29	158	29	positive	27	Cold	Sever SOB
6	37	47	490	139	positive	183	Hot	SOB
19	27	11	102	9	Positive	49	Hot	COVID Pneumonia
	30	11	60	12	Positive	Conservati	N/A	Pneumonia with patchy consolidation
7	28	8	112	24	Positive	26	Hot	Bilateral pleural effusions. Treated as superimposed LRTI with Abx.
	31	12	108	15	Positive	13	Hot	Treated with IV Abx for COVID and LRTI. Note patient also had pulmonary fibrosis

	41	29	106	26	Positive	43	Hot	Deterioration in COVID

Highest O2 requirement dose	Duration of O2 Requirement	Peri-op complication	Secondary intervention	Readmission	Cause of death	Peri-death incidents
15	22 days	pneumonia	Nil	No	1a- bacterial chest infection, 1b- COVID-19, 2- old age, COPD	EOL care pathway
15	5 days	Nil	Nil	No	1a- COVID-19	EOL care pathway
2	1 Day	Delerium	Nil	No	Awaiting Coroner's outcome	EOL care pathway
2	4 hours	Delerium	Nil	No	1a- COVID-19, 2- Dementia	EOL care pathway
6	17 days	N/A	Nil	No	1a- COVID-19 pneumonia	
15	13 days	AKI	Nil	No	1a- COVID pneumonia	Acute kidney injury
8	20 days	developed fever, low oxygen saturation, COVID pneumonia	Nil	No	1a- COVID-19, 2- Dementia, T2DM	developed fever, low oxygen saturation, COVID-pneumonia
15	12 days	NSTEMI, worsening COVID Pneumonia	Nil	No	1a- COVID pneumonia, 2- dementia, MI, fractures left hip.	NSTEMI, worsening of COPD,COVID-PNEUMONIA
2	8 days	hypernatraemia	Nil	No	1a- COVID pneumonia	hypernatraemia
4	3 days	AKI Stage 2, Oozing wound	Nil	No	1a- COVID-19 Pneumonia	Respirartory secretions, Tachypnoeic. Reviwed by orthogeriatric teams patient placed on ICOD.
4	6 days	N/A	Nil	No	1a- COVID-19 Pneumonia	C.Diff +ve (Had loose stools)
4	9 days	Alcohol withdrawal (started on Chlordiazepoxide regime), dyselectrolytemia	Nil	No	1a- COVID-19 Pneumonia	Deterioration in breathing.
4	23 days	Significant Hb Drop unable to establish if upper or lower GI cause	Nil	No	1a- COVID-19, Respiratory Failure, 1b- Pulmonary Fibrosis	Deterioration in breathing and cognition

4	3 days	Grade-4 pressure sore, post op reviewed by Tissue Viability Nurse. AKI on CKD.	Nil	No	1a- COVID-19 Pneumonia	Patient became unresponsive and had increasing O2 requirements

Variables	Case 1	Case 2	Case 3	Case 4	Case 5
Gender	Female	Female	Male	Female	Female
Age	89	91	93	95	94
ASA Grade	3	3	3	3	4
NHFS	7	7	6	7	5
Mobility	Zimmer frame	one Stick	One Stick	Unaided	One stick
Frailty Score	7	6	7	6	5
Charlson's Score	6	6	6	5	5
Residence	Residential home	Nursing home	Own home	Care Home	Own home with care
Length of Stay (in days)	21	17	64	18	16
Side	Left	Left	Right	Right	Right
Type of hip fracture	Intracapsular	Extracapsular	Extracapsular	Extracapsular	Extracapsular
Type of surgey	Hemiarthroplasty	DHS	DHS	DHS	Intramedullary Nail
Anaesthesia	Spinal	GA	GA	Spinal	Spinal
Temperature on admission	37.4	36.7	37	36.5	36.2
Highest temperature during stay	38.4	38.9	38.4	39	36.8
Cough on admission	Yes	Yes	No	No	Yes
Anosmia on admission	No	No	No	No	No
Lymphocyte count on admission	0.62	1.29	0.7	0.83	0.91
Lymphocyte count (lowest)	0.54	0.73	0.52	0.31	0.36
Chest Radiograph Findings	Inderterminate changes COVID Pneumonia	No abnormal findings	Inderterminate changes COVID Pneumonia	No abnormal findings	Opacification right upper zone
Pre-operative Haemoglobin	132	134	131	102	111
Post-operative Haemoglobin	119	82	106	97	83
Drop in Haemoglobin	13	52	25	5	28
Albumin (lowest)	26	23	33	33	27
Total Bilirubin	10	5	12	6	21
ALP	273	46	118	115	135
ALT	33	14	16	9	42
COVID diagnosis	Positive	Positive	Positive	Positive	positive
Time to surgery since admission (in hrs)	48	48	24	96	36
Theatre status (Hot/Cold)	Cold	Cold	Cold	Hot	Cold
Respiratory complication	viral/bacterial pneumonia	No	No	No	SOB
Highest O2 requirement dose(L/min)	15	15	2	2	6
Duration of O2 Requirement	22 days	5 days	1 Day	4 hours	17 days

Peri-operative complication	pneumonia	Nil	Delerium	Delerium	N/A
Secondary intervention	Nil	Nil	Nil	Nil	Nil
Readmission	No	No	No	No	No
Cause of death	1a- bacterial chest infection, 1b- COVID-19, 2- old age, COPD	1a- COVID-19	Awaiting Coroner's outcome	1a- COVID-19, 2- Dementia	1a- COVID-19 pneumonia
Peri-death incidents	EOL care pathway	EOL care pathway	EOL care pathway	EOL care pathway	

Case 6	Case 7	Variables	Case 8	Case 9	Case 10
Male	Male	Gender	Female	Male	Female
92	90	Age	82	80	87
4	3	ASA Grade	3	3	3
6	6	NHFS	5	6	6
Unaided	One stick	Mobility	Frame	Unaided	Independently mobile
3	5	Frailty Score	7	6	5
5	5	Charlson's Score	5	5	6
Own home without care	Own home without care	Residence	Residential care home	Residential care home	Own Home (carers)
13	20	Length of Stay (in days)	21	21	22
left	left	Side	left	left	Left
Intracapsular	Intracapsular	Type of hip fracture	Extracapsular	Extracapsular	Extracapsular
Cemented Hemiarthroplasty	Cemented Hemiarthroplasty	Type of surgey	DHS	Intramedullary Nail	Intramedullary Nail
Spinal	Spinal	Anaesthesia	Spinal	Spinal	Spinal
36.7	38.1	Temperature on admission	38.0	38.2	38.6
36.8	38.1	Highest temperature during stay	37.9	38.6	38.1
Yes	No	Cough on admission	Yes	No	No
No	No	Anosmia on admission	No	No	No
0.34	0.85	Lymphocyte count on admission	3.02	0.79	0.55
0.18	0.85	Lymphocyte count (lowest)	2.54	0.69	0.4
Patchy consolidation, Viral pneumonitis	Airspace narrowing , viral pneumonitis	Chest Radiograph Findings	Bibasal airspce opacification	Ground glass opacification	Inderterminate changes COVID Pneumonia
131	127	Pre-operative Haemoglobin	143	90	108
88	128	Post-operative Haemoglobin	132	84	89
43		Drop in Haemoglobin	11	6	19
25	31	Albumin (lowest)	41	37	27
53	27	Total Bilirubin	29	47	11
129	109	ALP	158	490	102
23	43	ALT	29	139	9
positive	positive	COVID diagnosis	positive	positive	Positive
94	16	Time to surgery since admission (in hrs)	27	183	49
Hot	Hot	Theatre status (Hot/Cold)	Cold	Hot	Hot
SOB	SOB	Respiratory complication	Sever SOB	SOB	COVID Pneumonia
15	8	Highest O2 requirement dose(L/min)	15	2	4
13 days	20 days	Duration of O2 Requirement	12 days	8 days	3 days

AKI	developed fever, low oxygen saturation, COVID pneumonia	Peri-operative complication	NSTEMI, worsening COVID Pneumonia	hypernatraemia	AKI Stage 2, Oozing wound
Nil	Nil	Secondary intervention	Nil	Nil	Nil
No	No	Readmission	No	No	No
1a- COVID pneumonia	1a- COVID-19, 2- Dementia, T2DM	Cause of death	1a- COVID pneumonia, 2- dementia, MI, fractures left hip	1a- COVID pneumonia	1a- COVID-19 Pneumonia
Acute kidney injury	developed fever, low oxygen saturation, COVID-pneumonia	Peri-death incidents	NSTEMI, worsening of COPD,COVID-PNEUMONIA	hypernatraemia	Respirartory secretions, Tachypnoeic. Reviwed by orthogeriatric teams patient placed on ICOD

Case 11	Case 12	Case 13	Case 14	
Male	Male	Male	Male	
96	79	92	83	
3	4	4	2	
7	6	7	6	
Independently mobile	Independently mobile	Independently mobile	Independently mobile	
7	6	5	6	
4	7	7	9	
Own Home (carers)	Own Home	Own Home	Own Home	
11	28	29	13	
Rigth	Rigth	Rigth	Left	
Extracapsular	Intracapsular	Extracapsular	Extracapsular	
Conservative management	Cemented hemiarthroplasty	Intramedullary nail	Intramedullary nail	
N/A	General and Spinal	Spinal and Femoral Nerve Block	Spinal	
38.2	37.5	37.7	37.4	
39.2	36.5	37	37.4	
Yes	Yes	No	Yes	
No	No	No	No	
0.38	0.61	0.74	0.47	
0.38	0.3	0.7	0.43	
Viral(COVID) Pneumonitis	Viral(COVID) Pneumonitis	Viral(COVID) Pneumonitis	Viral(COVID) Pneumonitis	
136	109	84	89	
136	102	120	95	
	7			
30	28	31	41	
11	8	12	29	
60	112	108	106	
12	24	15	26	
Positive	Positive	Positive	Positive	
Conservative	26	13	43	
N/A	Hot	Hot	Hot	
Pneumonia with patchy consolidation	Bilateral pleural effusions. Treated as superimposed LRTI with Abx.	Treated with IV Abx for COVID and LRTI. Note patient also had pulmonary fibrosis	Deterioration of COVID pneumonia	
4	4	4	4	
6 days	9 days	23 days	3 days	

N/A	Alcohol withdrawal (started on Chlordiazepoxide regime), dyselectrolytemia	Significant Hb Drop unable to establish if upper or lower GI cause	Grade-4 pressure sore, post op reviewed by Tissue Viability Nurse. AKI on CKD	
Nil	Nil	Nil	Nil	
No	No	No	No	
1a- COVID-19 Pneumonia	1a- COVID-19 Pneumonia	1a- COVID-19, Respiratory Failure, 1b- Pulmonary Fibrosis	1a- COVID-19 Pneumonia	
C.Diff +ve (Had loose stools)	Deterioration in breathing.	Deterioration in breathing and cognition	Patient became unresponsive and had increasing O2 requirements	

Table

Variable	Total no of patients	Survivor	30-Day Mortality
N=	34	20(58.8%)	14(41.2%)
Mean Age(years)	85.9(SD 7.7)	84(SD 7.7)	88.8(SD 8.3)
Gender % M:F	35.3/64.7	20/80	57.1/42.9
ASA Grade			
ASA-2	5	4(80%)	1(20%)
ASA-3	20	11(55%)	9(45%)
ASA-4	9	5(55.5%)	4(44.9%)
Co-morbidity Scores			
CCI(Mean)	5.5(SD 1.4)	5.3(SD 1.4)	5.8(SD 1.4)
Frailty Score	5.86(SD 1.5)	5.85(SD 1.5)	5.87(SD 1.5)
NHFS	6(SD 1.05)	5.9(SD 1.06)	6.2(SD 0.95)
Fracture Diagnosis			
Extracapsular	16	6(37.5%)	10(62.5%)
Intracapsular	18	14(77.7%)	4(22.3%)
Operative Procedures			
DHS	10	6(60%)	4(40%)
Hemiarthroplasty	16	12(75%)	4(25%)
IM Nail	6	1(16.7%)	5(83.3%)
THR	1	1(100%)	0
Conservative	1	0	1(100%)
Anaesthesia			
Spinal Anaesthesia	23	14(60.9%)	9(39.1%)
General Anaesthesia	7	5(71.4%)	2(28.6%)
Spinal with block	2	1(50%)	1(50%)
General with spinal	1	0	1(100%)
Theatre Status			
Hot(COVID Designated theatre)	20	12(60%)	8(40%)
Cold(Clean Trauma theatre)	13	8(61.5%)	5(38.5%)
Mean time to surgery(Hrs)	49.6(SD 39.7)	46.7(SD 39.7)	54.1(SD 43.2)
Mean Operative Time (Mins)	69.1 (SD 16.7)	70.2 (SD 17.2)	67.1 (SD 15.7)
Meanlenght of stay(Days)	21.4(SD 11.5)	20.7(SD 11.5)	22.4(SD 11.8)

Variable	Total no of patients	Survivor	30-Day Mortality
On admission Lymphocyte count	1.01(SD 0.7)	1.1(SD 0.7)	0.86(SD 0.6)
Lowest Lymphocyte count	0.71(SD 0.5)	0.76(SD 0.5)	0.63(SD 0.4)
Pre-operative Hb	119(SD 18.5)	120.9(SD 18.5)	116.2(SD 19.8)
Post-operative Hb	102.8(SD 18.6)	101.7(SD 18.6)	104.4(SD 20.3)
Dop in Post-operative Hb	18.1(SD 16.1)	20.4(SD 16.1)	14.9(SD 17.0)
Albumin	30.1(SD 5.4)	29.6(SD 5.4)	30.9(SD 5.4)
Total Bilirubin	15.8(SD 14.1)	12.8(SD 12.1)	20.1(SD 15.3)
ALP	121.2(SD 81.2)	102.9(SD 81.2)	147.2(SD 88.6)
ALT	28.2(SD 24.6)	26.2(SD 24.6)	31(SD 26.6)
Highest O2 Requirement	4.61(SD 4.6)	2.85(SD 4.7)	7.14(SD 5.1)
Post-operative/Early Respiratory Complication			

Present	16	6(37.5%)	10(62.5%)
Absent	18	15(83.3%)	3(16.7%)
Post-operative/Early CXR Change			
Present	16	4(25%)	12(75%)
Absent	18	16(88.8%)	2(11.2%)

p-value
0.037
0.026
0.298
0.588
0.816
0.319
0.905
0.201
0.017
0.928
0.071
0.021
0.963
0.509
0.751
0.930
0.608
0.714
0.665

p-value
0.317
0.530
0.471
0.682
0.337
0.489
0.140
0.119
0.584
0.007

0.006
<0.001