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Original Article

COVID-19 hip fracture outcomes: The role of Ct values and D-dimer levels?

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ABSTRACT

Introduction: The COVID-19 pandemic has caused high mortality rates in hip fracture patients, but data for Asian patients are lacking. Whilst Cycle threshold (Ct) values and D-dimer have been reported as predictors of mortality in COVID-19 patients, their prognostic roles in those with concomitant hip fracture remain unknown. The objectives of this study were to i) assess the clinical outcomes of COVID-19 hip fractures patients in the Chinese population, ii) identify risk factors of mortality and complications, and iii) determine the prognostic roles of Ct values and D-dimer levels.

Methodology: This cohort study was conducted during the 5th wave of the COVID-19 pandemic. Inclusion criteria were 1) hip fracture 2) $\geq$ 60 years old 3) low-energy trauma. Outcomes were 90-day all-cause mortality, complications, length of stay, discharge destination and mobility status. Logistic regression analysis was performed to identify risk factors for mortality and complications. Subgroup analysis was performed for patients with Ct $<$ 30 and Ct $>$ 30, comparing their outcomes of operations performed within 48 h vs beyond 48 h.

Results: 159 hip fracture patients were included, 42 patients were COVID-19 positive. COVID-19 group had significantly higher 90-day mortality rates (21.4% vs 9.4%), complication rates (45.2% vs 28.2%) and longer length of stay (17.06 vs 10.84 nights). COVID-19 was an independent risk factor for mortality and complications. Amongst the COVID-19 group, risk factors for poor outcomes were advanced age, steroids use, conservative treatment and American Society of Anaesthesiologists (ASA) score $\geq$ 3. Conservative treatment was associated with higher mortality (OR = 16.00; p = 0.025) in COVID-19 hip fracture patients. There was no significant difference between Ct values $<$ 30 and $>$30 regarding mortality and complication rate. D-dimer and timing to operation did not affect outcomes.

Conclusions: Patients with concomitant COVID-19 and hip fracture are at high risk of mortality and complications. Ct values and D-dimer levels have no prognostic roles for hip fracture outcomes. Early operative treatment is recommended as soon as patients are medically fit.

1. The Translational potential of this article

COVID-19 hip fracture patients had much higher mortality if treated conservatively, whilst Ct values, D-dimer levels and timing to operation did not affect outcomes. We would still advocate early operative treatment.

2. Introduction

The 5th wave of COVID-19 reached Hong Kong in January 2022, with over 1.2 million cases and 9300 deaths reported [1]. The death rate was one of the highest globally in March 2022 [2], with relatively low vaccination coverage among elderly persons and waning immunity since the last vaccine dose [3]. Expectedly, there was also a surge in hip fracture patients with concomitant COVID-19 infection. Although meta-analyses have illustrated a significantly higher mortality rate in COVID-19 patients with a hip fracture [4–6], most studies were of Caucasians. High quality cohort data regarding mortality and complications is still lacking amongst Asian populations [7–9].

Cycle threshold (Ct) value and serum D-dimer level are two

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commonly described parameters in the management of COVID-19 patients. Ct value refers to the number of cycles required to amplify viral RNA to a detectable level, providing an estimate of viral load [10]. D-dimer represents the activation of coagulation and fibrinolysis systems, which is seen in various inflammatory conditions [11]. Ct values < 26 [12] and D-dimer levels >2010 ng/ml [13] have been reported as predictors of mortality in COVID-19 patients. However, the prognostic roles in COVID-19 hip fracture patients remains unknown. Given the high mortality rates of these patients, determining whether these two parameters can be used for risk stratification or provide guidance for timely intervention would be important [14].

The objectives of this study were to i) assess the clinical outcomes of COVID-19 hip fractures patients in the Chinese population, ii) identify risk factors of mortality and complications, and iii) determine the prognostic roles of Ct values and D-dimer. We hypothesize that Asian population also carry high mortality and complication rates, with low Ct values and high D-dimer being risk factors and signify poor prognosis in COVID-19 hip fracture patients.

3. Materials and methods

3.1. Study participants

This retrospective cohort study was conducted in a tertiary hospital academic unit in Hong Kong. Patients included were between January 31st and May 12th 2022, corresponding to the period of the 5th wave COVID-19 outbreak in Hong Kong. This study was approved by The Joint Chinese University of Hong Kong—New Territories East Cluster Clinical Research Ethics Committee (CREC Ref. No. 2022.313). As this was a retrospective study, consent forms for the study were not included. The inclusion criteria were (1) acute hip fracture patients; (2) aged 60 years or older (3) fragility fracture due to low-energy trauma. Exclusion criteria were (1) pathological fracture; (2) open fracture; (3) high-energy trauma; (4) other concomitant fracture. Data of all our records are recorded into the Clinical Management System database prospectively [15,16].

Data was collected on demographics, hip fracture pattern, premorbid mobility, American Society of Anaesthesiologists (ASA) score, COVID-19 status, treatment and timing to operation. All recruited patients received COVID-19 test with Reverse Transcription-Polymerase Chain Reaction (RT-PCR) upon admission, which has been performed routinely during the pandemic. Patients with Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) specific RNA detected by RT-PCR were defined as COVID-19 positive. On admission, their vaccination status, Ct values, D-dimer levels, use of antiviral agents and systemic steroids were also documented.

3.2. Patient treatment

All hip fracture patients received Ortho-Geriatric co-care at our hospital unit [15]. We aimed for operative treatment within 48 h for all recruited patients unless anaesthetically unfit as per international standards [17]. Undisplaced femoral neck fractures were treated with cannulated hip screws fixation. Displaced femoral neck fractures were treated with hemiarthroplasty or total hip arthroplasty. Intertrochanteric femoral fractures were treated with a cephalomedullary nail. Early mobilisation with physiotherapy were performed for all patients after operation. Anaesthetically unfit patients were treated conservatively, where a hip spica brace was given while mobilisation exercise was still encouraged with maintenance limb physiotherapy and sitting [18,19]. Neurolysis, if not contraindicated, was performed by the pain team for better pain control in these patients [20–22].

For COVID-19 patients, oral antiviral agents and systemic steroids were given to selected patients. Paxlovid or Molnupiravir was initiated if the onset of symptoms were within 5 days and without major drug–drug interactions or contraindications [23]. Remdesivir and systemic steroids were reserved for patients with moderate to severe disease who required oxygen supplements or developed deterioration with impending respiratory failure [24–29].

All hip fracture patients on aspirin for pre-existing medical indications would continue on aspirin thorough the peri-operative period. Patients on anticoagulants were switched to subcutaneous low molecular weight heparin (LMWH) as bridging therapy before the operation, and resumed 1–2 days after the operation. For patients with COVID-19 co-infection and poor premorbid mobility status or operation anticipated for delay due to medical complications, subcutaneous LMWH was given until mobilised well. Chemoprophylaxis for venous thromboembolism was otherwise not routinely given for non-COVID-19 hip fracture patients as the incidence is low amongst Chinese geriatric patients [30].

3.3. Outcome measures

Our primary outcome was 90-day all-cause mortality. Secondary outcomes were complications, length of hospital stay, discharge destination and mobility status at 1 month and 3 months. Complication was defined as any occurrence of pulmonary-related events including chest infection or deterioration of COVID-19, venous thromboembolic events including deep vein thrombosis and pulmonary embolism, urinary tract infection, wound infection, cerebrovascular accidents and myocardial infarction.

Ct value reflects COVID-19 infectiousness and a cut-off of 30 is often used for determining need for isolation and stratifying risks for intensive care unit admission [12], thus analysis of Ct < 30 vs Ct > 30 was performed to investigate any correlation with mortality and complications in COVID-19 group. Subgroup analysis was also conducted for patients with Ct < 30 and Ct > 30, comparing their outcomes of operations performed within 48 h vs beyond 48 h.

3.4. Statistical analysis

Student's T-test and Chi-square test were used in comparing baseline characteristics, surgical details, 90-day all-cause mortality, complications, hospital length of stay and mobility status between COVID-19 and non-COVID-19 groups. Stepwise logistic regression models were used in analyzing potential risk factors, including D-dimer, for 90-day all-cause mortality and complications in all patients and in COVID-19 group specifically. The effects of the different covariates were quantified by odds ratio values and a p-value <0.05 was considered statistically significant. When comparing COVID-19 patients with Ct value < 30 vs > 30, Chi-square test was used in each subgroup for their correlations with mortality and complications. The comparisons were further stratified by the timing to operation at the cut-off of 48 h.

4. Results

4.1. Baseline characteristics

A total of 159 hip fracture patients were included, 42 patients (26.4%) had COVID-19 infection and 117 patients (73.6%) did not have COVID-19 infection. There were significantly more proportion of male patients in the COVID-19 group (52.4%) than non-COVID-19 group (24.8%), while other baseline characteristics showed no significant difference. The mean age was 85.8 years old in COVID-19 positive group and 83.8 years old in non-COVID-19 group ($p = 0.199$). The majority of both groups had ASA score of 3 or 4 (60.5% in COVID-19 group; 58.0% in non-COVID-19 group) ($p = 0.850$). Hip fracture pattern and premorbid mobility status showed no significant difference in both groups. Refer to Table 1.

4.2. Clinical outcomes

The clinical outcomes were presented in Table 2. There was a significant difference in 90-day all-cause mortality rate, with 9 (21.4%)

Table 1
Characteristics of patients with hip fractures.

Characteristics	COVID-19 (N = 42)	Non-COVID-19 (N = 117)	p value
Age (yr) (Mean ± SD)	85.76 ± 8.91	83.82 ± 8.17	0.199
Gender, n (%)			
Male	22 (52.4%)	29 (24.8%)	<0.001*
Female	20 (47.6%)	88 (75.2%)	
Smoker	7 (16.7%)	13 (11.1%)	0.352
Obesity	4 (9.5%)	4 (3.42%)	0.121
Pre-existing lung disease	6 (14.3%)	19 (16.2%)	0.765
Diagnosis, n (%)			
Fracture neck of femur	11 (26.8%)	50 (42.7%)	0.159
Fracture trochanter of femur	30 (73.2%)	64 (54.7%)	
Others	0	3 (2.6%)	
Premorbid mobility status, n (%)			
Unaided	13 (31.0%)	44 (37.6%)	0.457
Stick or quadripod	16 (38.1%)	46 (39.3%)	
Frame or rollator	12 (28.6%)	21 (17.9%)	
Chair/bedbound	1 (2.4%)	6 (5.1%)	
Pre-operative ASA Score, n (%)			
1-2	15 (39.5%)	47 (42.0%)	0.850
3-4	23 (60.5%)	65 (58.0%)	
Not fit for operation	4 (9.5%)	5 (4.3%)	
Conservative vs Operative, n (%)			
Conservative	4 (9.5%)	5 (4.3%)	0.245
Operative	38 (90.5%)	112 (95.7%)	
Operation types, n (%)			
Cephalomedullary nail	27 (71.1%)	62 (55.4%)	0.055
Screw fixation	0	13 (11.6%)	
Arthroplasty	11 (28.9%)	37 (33.0%)	
Timing to operation, hours (Mean ± SD)	85.18 ± 80.75	84.11 ± 59.02	0.930
Duration of operation, mins (Mean ± SD)	73.32 ± 28.90	74.64 ± 35.81	0.837
Estimated blood loss, ml (Mean ± SD)	113.33 ± 61.18	125.68 ± 132.83	0.448

ASA Score: American Society of Anesthesiologists Score
*p value < 0.05 is considered statistically significant

Table 2
Clinical outcomes of COVID vs non-COVID group.

Outcomes	COVID-19 (N = 42)	Non-COVID-19 (N = 117)	p value
90-day all-cause mortality, n (%)	9 (21.4%)	11 (9.4%)	0.044*
Complications, n (%)	19 (45.2%)	33 (28.2%)	0.045*
Pulmonary infection or COVID-19 deterioration	12 (28.6%)	9 (7.7%)	<0.001*
Venous thromboembolic events	3 (7.1%)	2 (1.7%)	0.116
Urinary tract infection	7 (17.1%)	18 (15.4%)	0.806
Wound complications	2 (4.8%)	6 (5.1%)	1.000
Acute coronary syndrome	0	2 (1.7%)	1.000
Cerebrovascular accident	1 (2.4%)	2 (1.7%)	1.000
Length of stay, nights - Mean ± SD	17.06 ± 15.86	10.84 ± 7.27	0.030*
Discharge destination, n (%)			
Home	15 (44.1%)	67 (60.9%)	0.111
Old age home	19 (55.9%)	43 (39.1%)	
1-month mobility status, n (%)			
Stick or quadripod	2 (5.9%)	7 (6.1%)	0.651
Frame or rollator	25 (73.5%)	91 (79.8%)	
Chair/bedbound	7 (20.6%)	16 (14.0%)	
3-month mobility status, n (%)			
Unaided	0	2 (1.9%)	0.857
Stick or quadripod	8 (23.5%)	22 (20.6%)	
Frame or rollator	20 (58.8%)	65 (60.7%)	
Chair/bedbound	6 (17.6%)	18 (16.8%)	

*p value < 0.05 is considered statistically significant

patients in COVID-19 group and 11 (9.4%) patients in the non-COVID-19 group (p = 0.044). In COVID-19 patients, the mortality rate was 18.5% for cephalomedullary nail and 9.1% for arthroplasty. No hip screws fixation was performed in COVID-19 patients. In non-COVID-19 patients, the mortality rate was 11.3% for cephalomedullary nail, 7.7% for hip screws fixation and 5.4% for arthroplasty. Amongst the 9 mortality cases in COVID-19 group, 4 (44.4%) patients were smokers, none were obese, and 2 (22.2%) had pre-existing lung disease. Amongst the 11 mortality cases in non-COVID-19 group, 3 (27.3%) were smokers, 2 (18.2%) were obese, and 5 (45.5%) had pre-existing lung disease.

Table 3
Causes of death in COVID-19 and non-COVID-19 group.

Causes of death	COVID-19 (N = 42)	Non-COVID-19 (N = 117)	p value
Pulmonary infection	7 (16.7%)	7 (6.0%)	0.036*
Sepsis other than pulmonary source	0	1 (0.9%)	0.548
Cerebrovascular accidents	1 (2.4%)	0	0.094
Cardiac related (acute coronary syndrome, heart failure)	0	1 (0.9%)	0.548
Renal failure	1 (2.4%)	0	0.094
Others (e.g. pre-existing terminal illness, GI related)	0	2 (1.7%)	0.394
Total	9 (21.4%)	11 (9.4%)	0.044*

*p value < 0.05 is considered statistically significant

The causes of death are shown in Table 3. Patients with COVID-19 had significantly higher pulmonary infection cause of death compared to those without COVID-19 (p = 0.036).

The overall complication rate in COVID-19 group (45.2%) was significantly higher compared to non-COVID-19 group (28.2%) (p = 0.045). Pulmonary-related complication was the commonest complication in the COVID-19 group with an incidence of 28.6%, which was significantly higher than only 7.7% in non-COVID-19 group (p < 0.001). There was also higher rate of venous thromboembolic event in the COVID-19 group (7.1%) compared to non-COVID-19 group (1.7%), although it was not statistically significant (p = 0.116). The complication rates of urinary tract infection, wound complications, cerebrovascular accidents and myocardial infarction had no significant difference in both groups.

Regarding hospital length of stay, COVID-19 group patients spent 17.06 nights in acute hospital, which was significantly higher than 10.84 nights in non-COVID-19 group (p = 0.030). A higher proportion of patients in COVID-19 group (55.9%) was discharged to old age home when compared to non-COVID-19 group (39.1%), however the difference was not statistically significant (p = 0.111).

At 1 month after injury, the majority of patients in both groups required frame or rollator for walking (73.5% in COVID-19 group; 79.8% in non-COVID-19 group), whilst only a small proportion could walk with a stick or quadripod (5.9% in COVID-19 group; 6.1% in non-COVID-19 group). At 3 months after injury, more patients were able to walk with a stick or quadripod (23.5% in COVID-19 group; 20.6% in non-COVID-19 group). The overall mobility status was similar in both groups at 1-month (p = 0.651) and 3-month (p = 0.857) after injury with no significant difference.

4.3. Risk factors for mortality and complications in all hip fracture patients

Several risk factors were found to be significantly associated with mortality and complications after logistic regression analysis. Identified risk factors for 90-day all-cause mortality included COVID-19 positive status (OR = 2.63; p = 0.049), advanced age (OR = 1.13; p = 0.002), poor premorbid mobility (OR = 9.94 for chairbound or bedbound patients; p = 0.013) and conservative treatment (OR = 6.70; p = 0.008). Risk factors for complications include COVID-19 positive status (OR = 2.10; p = 0.046), advanced age (OR = 1.06; p = 0.015), ASA score ≥ 3 (OR = 3.43; p = 0.003) and conservative treatment (OR = 8.17; p = 0.011). COVID-19 positive status was an independent risk factor for both mortality and complications. See Table 4.

Table 4
Risk factors for mortality and complications in ALL hip fracture patients.

Potential risk factors	90-day all-cause mortality		Odds ratio for complications	
	OR (95% CI)	p value	OR (95% CI)	p value
COVID-19 positivity	2.63 (1.00, 6.89)	0.049*	2.10 (1.01, 4.36)	0.046*
Gender (male)	1.89 (0.73, 4.90)	0.190	1.53 (0.76, 3.08)	0.231
Age	1.13 (1.05, 1.22)	0.002*	1.06 (1.01, 1.10)	0.015*
Premorbid mobility		0.036*		0.057
Stick or quadripod	1.42 (0.38, 5.31)	0.603	1.92 (0.84, 4.39)	0.121
Frame or rollator	3.57 (0.96, 13.29)	0.058	3.13 (1.23, 7.96)	0.017*
Chair/Bedbound	9.94 (1.63, 60.68)	0.013*	5.00 (0.98, 25.44)	0.052
ASA ≥ 3	0.00 (0.00, 0.00)	0.997	3.43 (1.54, 7.64)	0.003*
Conservative treatment	6.70 (1.63, 27.53)	0.008*	8.17 (1.63, 40.85)	0.011*
Timing to operation >48 h	0.71 (0.22, 2.32)	0.564	0.53 (0.23, 1.18)	0.119

ASA Score: American Society of Anesthesiologists Score
*p value < 0.05 is considered statistically significant

4.4. Subgroup analysis for COVID-19 positive patients with hip fracture

The characteristics of COVID-19 group patients were shown on Table 5. Amongst them, 35 (83.3%) patients received either none or only one dose of vaccination. Antiviral agents and systemic steroids were used in 8 (19.0%) and 10 (23.8%) of patients, respectively. The mean Ct value on admission was 24.72 ± 6.78, and the mean D-dimer was 6260.2 ± 3260.1 ng/ml.

Logistic regression analysis showed that risk factors for 90-day mortality amongst COVID-19 positive group were advanced age (OR = 1.13; p = 0.044), use of systemic steroids (OR = 7.00; p = 0.019) and conservative treatment (OR = 16.00; p = 0.025). Risk factors for complications were advanced age (OR = 1.10; p = 0.030), use of systemic steroids (OR = 7.64; p = 0.020) and ASA ≥ 3 (OR = 5.20; p = 0.032). D-dimer, vaccination status and use of antiviral agents were not shown to be associated with either mortality or complications. Refer to Table 6.

Subgroup analysis was performed comparing COVID-19 patients with Ct values of <30 to those with Ct values > 30. There was no significant difference in mortality rate (21.4% vs 20.0%; p = 1.000) and complication rate (42.9% vs 20.0%; p = 0.709). For patients with Ct values < 30, those who had operations performed within 48 h or beyond 48 h showed no significant difference in mortality rate (14.3% vs 11.8%; p = 0.872) and complication rate (42.9% vs 35.3%; p = 1.000). For those with Ct values > 30, operations performed within 48 h or beyond 48 h also showed no significant difference in mortality rate (60% vs 40%; p = 0.533) and complication rate (60% vs 60%; p = 1.000). Refer to Tables 7a and 7b.

Table 5
Characteristics of COVID-19 positive patients with hip fractures.

Characteristics of COVID-19 patients	n (%)
Doses of vaccination received	
Never	18 (42.9%)
1	17 (40.5%)
2	4 (9.5%)
3	3 (7.1%)
Use of anti-virals for COVID	
Yes	8 (19.0%)
No	34 (81.0%)
Use of systemic steroids for COVID	
Yes	10 (23.8%)
No	32 (76.2%)
Cycle threshold (Ct) value	
On admission (Mean ± SD)	24.72 ± 6.78
Before operation (Mean ± SD)	26.02 ± 6.80
Ct value < 30, n (%)	28 (73.7%)
Ct value ≥ 30, n (%)	10 (26.3%)
D-dimer, ng/ml (Mean ± SD)	6260.17 ± 3260.08

Table 6
Risk factors for mortality and complications in COVID-19 positive hip fracture patients.

Potential risk factors	90-day all-cause mortality		Complications	
	OR (95% CI)	p value	OR (95% CI)	p value
Gender (male)	0.67 (0.15, 2.94)	0.592	1.02 (0.30, 3.44)	0.976
Age	1.13 (1.00, 1.27)	0.044*	1.10 (1.01, 1.20)	0.030*
Premorbid mobility	/	0.576	/	0.222
Doses of vaccination	/	0.994	/	0.633
Ct value < 30	1.09 (0.18, 6.56);	0.924	0.57 (0.12, 2.68)	0.478
D-dimer	1.00 (1.00, 1.00)	0.127	1.00 (1.00, 1.00)	0.091
Use of anti-virals	1.29 (0.21, 7.80)	0.785	2.38 (0.49, 11.63)	0.284
Use of systemic steroids	7.00 (1.38, 35.48)	0.019*	7.64 (1.38, 42.33)	0.020*
ASA score ≥ 3	0.00 (0.00, 0.00)	1.000	5.20 (1.15, 23.54)	0.032*
Conservative treatment	16.00 (1.42, 180.90)	0.025*	4.13 (0.39, 43.38)	0.238
Timing to operation >48 h	0.96 (0.15, 6.06)	0.961	0.48 (0.12, 1.98)	0.311

ASA Score: American Society of Anesthesiologists Score
*p value < 0.05 is considered statistically significant

5. Discussion

This is one of the largest cohorts comparing clinical outcomes of COVID-19 vs non-COVID-19 hip fracture in Asian populations [7–9]. Our results showed that in Chinese patients with hip fracture, co-infection with COVID-19 were associated with higher 90-day all-cause mortality rate, complication rate and longer hospital stay. COVID-19 positive status was an independent risk factor for mortality and complications. Advanced age, the use of systemic steroids, conservative treatment and ASA score ≥ 3 were risk factors for poor outcomes in COVID-19 positive hip fracture patients, whilst Ct values and D-dimer levels had no prognostic role.

COVID-19 pandemic posed challenges to the management of osteoporosis and fragility hip fracture globally [31]. During the initial phase of COVID-19 outbreak in the United Kingdom, Mohamed et al. already reported increased mortality 30- and 60-day mortality in patients undergoing trauma or emergency operations when compared to pre-COVID-19 period [32]. Currently most studies regarding COVID-19 hip fracture outcomes were from European or North American locations, with limited Asian data [7–9]. A meta-analysis by Raheman et al. [4] which included mostly Caucasian patients showed that the overall 30-day mortality for COVID-19 positive patients was 38%, in comparison to 7% for non-COVID-19-positive patients. Patralekh et al. reported the increased mortality risk in COVID-19 hip fracture patients persisted despite treated surgically [33]. A few studies also reported on the 90-day mortality rate, which ranged from 14.7% to 67% [34–36]. Our study demonstrated 90-day mortality rate of 21.4% in COVID-19 hip fracture patients in the Chinese population, which is consistent with overseas studies. Clinicians and nursing staff should be aware of such significant risk when treating these patients.

In our practice, systemic steroids were reserved for COVID-19 patients with clinically moderate to severe symptoms, such as those requiring oxygen supplement. Although proven to be useful in reducing mortality in moderate to severe COVID-19 patients in some studies [24–26], the use of steroids was instead found to be associated with higher mortality and complications in those with concomitant hip

Table 7
a Correlation between Ct values and outcomes.
b Correlation between Ct values and outcomes, subdivided by timing to operation.

Ct values	90-day all-cause mortality, n (%)	(p value)	Complications, n (%)	(p value)
<30	6 (21.4%)	p = 1.000	12 (42.9%)	p = 0.709
>30	2 (20.0%)		3 (30.0%)	

Ct values	Timing to operation (hrs)	90-day all-cause mortality, n (%)	(p value)	Complications, n (%)	(p value)
<30	≤48 h	1 (14.3%)	p = 0.872	3 (42.9%)	p = 1.000
	>48 h	2 (11.7%)		6 (35.3%)	
>30	≤48 h	0	p = 0.333	0	p = 0.167
	>48 h	2 (40%)		3 (60%)	

fracture in our study. This is the first study to report this 'paradoxical phenomenon'. A possible bias existed since patients who were prescribed with steroids usually had more severe COVID-19 compared to those who were not. We postulate that geriatric hip fracture itself is a significant health risk which contributes to the mortality and complications, and it outweighs the beneficial effects of steroids in moderate to severe COVID-19.

Ct values have been used widely in the clinical management of COVID-19 patients. Kurzeder (2022) [12] reported the Ct value < 30 was associated with higher risk of intensive care unit admission, and Ct value < 26 might predict higher mortality. However, the prognostic roles of Ct values when applying the COVID-19 hip fracture patients remains unknown. Our study is the first paper to report that Ct values cannot predict complications or mortality in COVID-19 hip fracture. When hip fracture patients are co-infected with COVID-19, there is higher mortality and complication rates regardless of Ct values. Therefore, Ct values have no prognostic role in COVID-19 with concomitant hip fracture. Nevertheless it is worth noting that Ct values indirectly reflect the infectiousness of COVID-19 patients, Ct values may still play an essential role for infection control measures including the arrangement of isolation theatres and wards.

D-dimer is often used as a predictor for COVID-19 outcomes, with D-dimer levels >2010 ng/ml are associated with higher mortality. The hypercoagulability has been described as a significant cause for increased thromboembolic risk in COVID-19 patients [37,38]. While D-dimer levels are commonly elevated in COVID-19 patients, their levels are even higher in COVID-19 patients with concomitant hip fracture [39]. Our results, however, showed that D-dimer levels were not associated with mortality or complications in COVID-19 hip fracture patients, despite having a mean level of 6260.2 ng/ml. A possible reason for that is the relatively low incidence of thromboembolic events in Asians when compared to Caucasians [30,40]. Chemoprophylaxis was also given to selected COVID-19 patients which further reduced the thromboembolic risks. Although D-dimer was not found to be a prognostic factor in our study, it may still play a role in Caucasian patients.

The mean timing to operation was 85.18 and 84.11 h in COVID-19 group and non-COVID-19 respectively. The waiting time was subject to lots of clinical and administrative factors, including admission screening, pre-operative optimisation, preparation of designated theatres, etc. Iyengar demonstrated a significantly lower proportion of hip fracture patients were operated within 36 h during the first lockdown of COVID-19 in the United Kingdom. Their mortality rate was also higher at 30 and 60 days when compared to pre-COVID-19 period, although not statistically significant [41]. Delay in operation time was also described in other studies during the COVID-19 pandemic [42,43]. While it is well recognised from meta-analyses that geriatric hip fracture should be managed with early operative treatment [11,44], there is limited data that clearly demonstrates the optimal timing to operation in hip fracture and concomitant COVID-19, and contradicting results have been reported. It is therefore common that concerns are raised among patients, their families and even surgeons, regarding whether operating early during active COVID-19 infection may pose additional risks to these frail patients. Dar et al. reported 2 mortality cases out of 24 patients who received delayed operations of 15–21 days, and suggested that COVID-19 hip fracture patients can safely undergo delayed surgical intervention after appropriate medical optimisation [9]. On the other hand, several studies suggested early operation despite active COVID-19 coinfection as surgeries improved oxygen saturation and assisted respiratory support [45–48]. A recent study by Jagadeesh et al. has also shown that delay in surgery of more than 36 h was an independent risk factor for mortality in COVID-19 hip fracture patients [49]. However, none of these studies have taken Ct values into account when reviewing the surgical outcomes. Our study demonstrated that regardless of the Ct values being >30 or <30, operation performed within or beyond 48 h showed no significant difference in mortality or complication rate, and conservative treatment was associated with much higher mortality with odds ratio of 16.00. Delaying operation showed no benefits in clinical outcomes. We therefore recommend early operative treatment for COVID-19 hip fracture patients as soon as they are medically fit for operation.

Our study was one of the largest cohorts for Asian population and our data was comprehensive with Ct-values and D-dimer levels. The limitations included this study was performed in a single Trauma Centre and there was a short follow-up period. We have included only 42 hip fracture patients with concomitant COVID-19 coinfection, which is a relatively small sample size.

In conclusion, our study demonstrated COVID-19 hip fracture patients in Chinese populations had higher mortality, complication rates and longer hospital stay compared to non-COVID-19 hip fracture patients. Extra attention and care should be made especially for those with advanced age, the use of systemic steroids, conservative treatment and ASA score ≥ 3 as they were risk factors for poor outcomes. Ct values and D-dimer levels had no prognostic role in predicting mortality and complications.

Ethics statement

This study was approved by The Joint Chinese University of Hong Kong—New Territories East Cluster Clinical Research Ethics Committee (CREC Ref. No. 2022.313).

Authorship

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Each author certifies that this material or part thereof has not been published in another journal, that it is not currently submitted elsewhere, and that it will not be submitted elsewhere until a final decision regarding publication of the manuscript in Journal of Orthopaedic Translation has been made.

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