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Original Study

COVID-19 and Proximal Femur Fracture in Older Adults—A Lethal Combination? An Analysis of the Registry for Geriatric Trauma (ATR-DGU)

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A B S T R A C T

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Objectives: COVID-19 can be a life-threatening illness, especially for older patients. The COVID-19 outbreak created a dramatic organizational challenge in treating infected patients requiring surgical treatment, like those suffering a proximal femur fracture, in a pandemic setting. We investigate the impact of a COVID-19 infection in patients with a proximal femur fracture not only on mortality but also on quality of life (QoL), length of stay, and discharge target.

Design: Retrospective cohort analysis from July 1, 2020, to December 31, 2020. The Registry for Geriatric Trauma collected the data prospectively. Patient groups with and without COVID-19 infection were compared using linear and logistic regression models.

Setting and Participants: Retrospective multicenter registry study including patients aged ≥70 years with proximal femur fracture requiring surgery from 107 certified Centers for Geriatric Trauma in Germany, Austria, and Switzerland.

Measures: The occurrence and impact of COVID-19 infection in patients suffering a proximal femur fracture were measured regarding in-house mortality, length of stay, and discharge location. Moreover, QoL was measured by the validated EQ-5D-3L questionnaire.

Results: A total of 3733 patients were included in our study. Of them, 123 patients tested COVID-19 positive at admission. A COVID-19 infection resulted in a 5.95-fold higher mortality risk (odds ratio 5.95, $P < .001$], a length of stay prolonged by 4.21 days [regression coefficient (β) 4.21, $P < .001$], a reduced QoL (β −0.13, $P = .001$), and a change in discharge target, more likely to their home instead of another inpatient facility like a rehabilitation clinic ($P = .013$).

Conclusions and Implications: The impact of a COVID-19 infection in patients suffering a proximal femur fracture is tremendous. The infected patients presented a dramatic rise in mortality rate, were significantly less likely to be discharged to a rehabilitation facility, had a longer in-hospital stay, and a reduced QoL.

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The outbreak of the novel coronavirus (SARS-CoV-2) resulting in the disease COVID-19 in December 2019 led to a pandemic that has been life-threatening, especially for older and pre-diseased people.[1] Above all, the spread of COVID-19 poses a great risk in nursing homes, hospitals, and other institutions housing people with disabilities and immunodeficiencies. The treatment of older patients with

COVID-19 infection is prolonged and associated with a high mortality rate.[2] The virus is even more difficult to treat when another condition is present that led to hospitalization, like a fracture of the proximal femur. Several studies have shown a poor outcome for patients with a fracture of the proximal femur when they were diagnosed with COVID-19 at admission.[3−5] Moreover, a multicenter cohort study reported an increased 30-day mortality for patients with COVID-19 infection requiring surgery.[6]

Proximal femur fractures themselves are often life-changing events in older adults and are associated with a high mortality rate. To provide the best care for those patients, the German Trauma Society (DGU) has begun to establish orthogeriatric centers and provide a certification called Center for Geriatric Trauma DGU (ATZ-DGU). The participating centers are obliged to provide their data to the Registry for Geriatric Trauma (ATR-DGU).[7] To cope with the new virus threat, the ATR-DGU began collecting data on COVID-19 infection at admission in July 2020 and enabled the retrospective entry of COVID-19 status for all patients admitted to an ATZ-DGU at any time in 2020.

We hypothesized that COVID-19 infection would have a negative impact on length of stay in hospital, quality of life (QoL), rehabilitation, and mortality of patients undergoing hip surgery due to fracture. Therefore, we conducted a retrospective analysis of the data from the ATR-DGU.

Methods

Data Sources

Data were obtained from the ATR-DGU. This multicenter database provides pseudonymized and standardized data of patients with a proximal femur fracture, including periprosthetic and peri-implant fractures. Currently, 107 hospitals in Germany, Switzerland, and Austria participate in the ATR-DGU, with a total of about 35,000 cases entered between 2016 and 2020. The scientific management is carried out by the Working Committee on Geriatric Trauma Registry (AK ATR) of the DGU. Approval for scientific data analysis from the ATR-DGU is granted via a peer-review process in accordance with the publication guidelines laid out by the AK ATR. The present study is in accordance with the publication guidelines of the ATR-DGU and registered as ATR-DGU project ID 2021-002.

Patients

The inclusion criteria of the ATR-DGU are patients with proximal femur fractures including periprosthetic and peri-implant fractures requiring surgery and who are aged ≥70 years. Since the novel coronavirus SARS-CoV-2 was first described in December 2019 and the query regarding COVID-19 infections in the ATR-DGU started in July 2020, we included all patients with a fracture of the proximal femur with positive or negative COVID-19 status at admission who were admitted between July 1 and December 31, 2020. Patients without any documentation of COVID-19 status and those with pathologic, peri-prosthetic, and peri-implant fractures were excluded.

Covariates

The following covariates were measured: age, gender, American Society of Anesthesiologist (ASA) grade (1-5), the Identification of Seniors At Risk score (ISAR) (score from 0 to 6; the need for geriatric treatment is thought to be necessary for a score of 2 and above),[8] the use of oral anticoagulants (acetylsalicylic acid was not considered as an anticoagulant), time to surgery, preinjury and current residential status, and the presence of injuries besides the hip fracture.

Outcomes

The primary outcome was mortality within in-hospital stay. Other outcome parameters were EQ-5D-3L questionnaire—a validated questionnaire to measure QoL—on the seventh day postoperatively. This questionnaire consists of 5 dimensions: mobility, self-care ability, usual activity, pain, and anxiety/depression. For every item, there are 3 levels to choose: no problem, some problem, and extreme problem. In addition, length of stay in hospital, and change in living situation after hospitalization were measured. Moreover, for the subgroup of COVID-19−positive patients, we analyzed the effect of preinjury residential situation (nursing facility vs living at home) on the outcome variables.

Statistical Analysis

All calculations were performed via statistics software R v. 4.0.2 (Foundation for Statistical Computing, Vienna, Austria). For descriptive analyses, categorical data were presented as counts and percentages and continuous variables as median with interquartile range. The results of the EQ-5D-3L questionnaires were transformed to a single value, using the Time Trade Off algorithm validated for Germany.[9] This value ranges from 0 for the worst to 1 for the best health status. Comparisons between groups (COVID-19 positive vs COVID-19 negative) were made using the χ^2 test for categorical variables and the Wilcoxon test for continuous variables. Linear models and logistic regression models were used to examine the impact of COVID-19 on outcomes after controlling for ASA grade, sex, age, and type of proximal femur fracture. Results are reported as regression coefficients (β) for linear regression and odds ratios for logistic regression, along with their 95% confidence interval. Differences were considered statistically significant when $P < .05$.

Ethics

Written patient consent was obtained by the participating hospitals. The data from the ATR-DGU have received full approval from the Ethics Committee of the medical faculty of the Philipps-University Marburg, Germany (AZ 46/16).

Results

A total of 4944 patients were admitted between July 1 and December 31, 2020. After exclusion of pathologic, peri-/inter-prosthetic, and peri-implant fractures (n = 372) and patients with a missing COVID-19 status (N = 839), 3733 patients remained. Among these patients, 123 tested COVID-19 positive at admission. No difference between the groups was seen in age, sex, anticoagulation, ASA grade, or the ISAR score. Time to surgery showed no delay in COVID-19−positive patients. Positive-tested patients were more likely to come from a nursing home (P = .021) and showed a restricted self-mobility (P = .001). The baseline data of the included patients are presented in Table 1.

Inpatient Outcomes

No difference was seen in the time-to-surgery period between the 2 groups. The postoperatively collected EQ-5D-3L data resulted in a lower QoL in the infected cohort (median 0.291 vs 0.701; P = .002). Comparing the length of stay for survivors, we saw a significant difference in the positive-tested group vs the negative-tested reference group (median 19.1 vs 15.1 days; P = .002).

A significant difference was also found in the mortality rate between COVID-19−positive and COVID-19−negative patients. In the infected cohort, 26% died during in-hospital stay, whereas in the negative cohort, only 5.9% died (P = .001). Additionally, patients with a

Table 1
Comparison of the Baseline Data Between the Patients With and Without COVID-19 Infection

	COVID-19–Negative Patients	COVID-19–Positive Patients	P Value
Patients, n	3610	123	
ASA grade			
n	3528	117	.13
Median (IQR)	3 (3-3)	3 (3-3)	
1	31 (0.9)	0 (0.0)	
2	746 (21.1)	16 (13.7)	
3	2474 (70.1)	91 (77.8)	
4	271 (7.7)	10 (8.5)	
5	6 (0.2)	0 (0.0)	
ISAR score			
n	2707	85	.18
Median (IQR)	3 (2-4)	3 (2-4)	
0	297 (11.0)	8 (9.4)	
1	325 (12.0)	6 (7.1)	
2	606 (22.4)	19 (22.4)	
3	644 (23.8)	20 (23.5)	
4	555 (20.5)	17 (20.0)	
5	226 (8.3)	10 (11.8)	
6	54 (2.0)	5 (5.9)	
Sex			
n	3608	123	.81
Male	1020 (28.3)	33 (26.8)	
Female	2588 (71.7)	90 (73.2)	
Anticoagulation			
n	3525	118	
Yes	1981 (56.2)	65 (55.1)	.88
No	1544 (43.8)	53 (44.9)	
Age, y			
n	3594	122	
Median (IQR)	85 (80-89)	86 (80-89)	.45
Living situation before fracture			.021*
n	3575	120	
At home	2731 (76.4)	78 (65.0)	
Nursing home	795 (22.2)	38 (31.7)	
Hospital	35 (1.0)	3 (2.5)	
Other	14 (0.4)	1 (0.8)	
Walking ability before injury			
n	3334	106	
Independent without walking frame	1171 (35.1)	32 (30.2)	.001*
Out-of-house walking with 1 crutch	333 (10.0)	14 (13.2)	
Out-of-house walking with 2 crutches or other walking frame	1152 (34.6)	34 (32.1)	
Walking ability within apartment, outside only with auxiliary person	558 (16.7)	23 (21.7)	
No functional walking ability	120 (3.6)	3 (2.8)	

IQR, interquartile range; ISAR, Identification of Seniors At Risk.
The number of patients with data is given separately for each parameter. Unless otherwise noted, the values within parentheses are percentages.
  *Significant difference.

positive result were significantly less likely to be discharged to another inpatient clinic like geriatric rehabilitation. The distribution of the discharge target for patients living in their own homes before injury is presented in Figure 1. Details of the inpatients' outcomes are presented in Table 2.

Multivariable Logistic and Linear Regression

The impact of COVID-19 infection on in-hospital complications and postoperative outcome parameters was tested using logistic and linear regression models adjusted for gender, age, ASA grade, and type of proximal femur fracture. The odds of dying were 5.95 higher for patients testing positive at admission. The length of hospital stay was prolonged by an additional 4.21 days in the COVID-19–positive cohort. The results of the regression models are presented in Table 2.

For the subgroup of COVID-19–positive patients, we found no differences for time to surgery, resurgery, or the quality of life on the seventh day postoperatively between patients admitted to the hospital from nursing facilities and those residing in their own homes (Table 3). However, COVID-19–positive patients had a significantly

shorter hospital stay when coming from a nursing home as compared to those living at home (Table 3).

Discussion

In this multicenter study, we identified 123 patients testing positive for COVID-19 who underwent hip surgery due to fracture of the proximal femur in the second half of 2020. To our knowledge, this is the largest cohort published so far. We showed that hip fracture surgery was associated with a 5-fold increased risk of mortality for the COVID-19–positive patients, and they were staying significantly longer in an acute care hospital and were more often discharged to nursing homes or their homes without any rehabilitation. No significant differences were seen in the baseline data between COVID-19 negative and positive patients. There were no significant differences in age, sex, ASA grade, or ISAR score between the cohorts, which underlines the impact of the infection on the outcome. COVID-19–positive patients were more likely to be admitted from a nursing home because of the dispersal characteristics of COVID-19.

Several smaller studies have monitored the outcome of COVID-19 patients with fracture of the proximal femur over a shorter period of
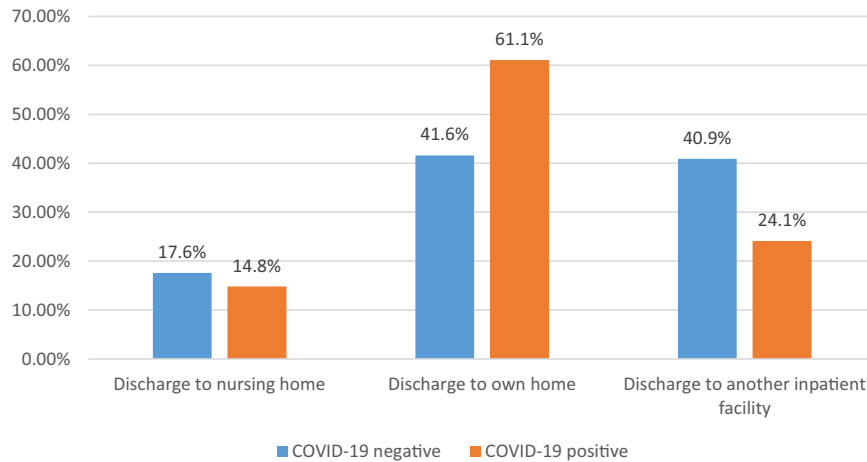
Fig. 1. Distribution of the discharge target for patients living in their own home before injury. The overall distribution was significantly different ($P = .013$).

time, and most of the data were examined at the beginning of the pandemic.[10−12] Kayani et al[11] reported a perioperative mortality rate of 30.5% (25/82 patients) in positive-tested patients in Greater London with hip fracture. A retrospective national database review from the United States showed not only a significant decrease in patients with hip fractures compared with 2019 but also a 14-fold increase in in-hospital mortality for COVID-19−positive patients.[5] A recently published meta-analysis on this topic found 35 relevant studies, of which 20 were included. No single study reached our number of positive-tested patients. The overall mortality rate was 36.61% for COVID-19−positive patients vs 8.6% death among nonpositive patients.[4]

Our data were collected at times with low incidence and high incidence over a 6-month period, which underlines the validity of this study. Parallel to the pandemic, most patients in our study tested positive from October to December 2020. The number of tests done for COVID-19 was rising through the end of the year, which paralleled the nationwide German test strategy.

An observational study with data from German health care funds showed an overall in-hospital mortality of 14.6% for COVID-19−positive patients aged 70-79 years without ventilation and 33.8% for patients older than 80 years. Once patients were ventilated, mortality rose markedly, to 62.6% and 72.2%, respectively.[2] Our analysis

found a mortality rate of 26% for COVID-19−positive patients with a fracture of the proximal femur.

Older patients do regularly present with comorbidities, which must be considered when planning surgery. It is commonly agreed that fractures of the proximal femur should be treated within 24 hours. In the context of COVID-19, the logistical challenges for hospitals in guaranteeing immediate surgery are considerable,[13,14] and as a matter of current debate, the influence of the best time to surgery remains unknown.[15−18] Our data showed no difference in time to surgery, and hospitals were able to provide surgery within 24 hours for most patients (77.9% and 74%), independently of whether they had tested positive or negative ($P = .436$). However, it must be emphasized that our data cover only specialized geriatric trauma centers, which may not be representative of the broad mass of hospitals providing care in terms of treatment quality.

In contrast to the time-focused preoperative procedure, postoperative treatment showed some differences and may indicate a deficit in care for COVID-19−positive patients. COVID-19−positive patients stayed significantly longer in acute care hospitals and were significantly less likely to be discharged to a rehabilitation unit. Even though the COVID-19−positive patients were more likely to be living in a nursing facility preinjury, they did not differ significantly in other

Table 2
Differences in Inpatients' Outcome Between Patients With and Without COVID-19 Infection and Analysis of the Impact of an Infection Using Linear and Logistic Regression

	Univariate Analysis					Linear and Logistic Regression Analysis		
	COVID-19−Negative Patients		COVID-19−Positive Patients		P Value	n	β (95% CI)	P Value
	n	Median (IQR)	n	Median (IQR)				
Time to surgery, h	3529	16.4 (6.8-23.0)	123	17.6 (7.2-24.6)	.38	3692	0.47 (−3.80, 4.74)	.83
Length of hospital stay for surviving patients, d	3387	15.1 (10.0-21.0)	88	19.1 (10.5-30.1)	.002*	3452	4.21 (2.40, 6.02)	<.001*
EQ5D score 7 d after surgery	2465	0.701 (0.262-0.701)	69	0.291 (0.063-0.701)	.001*	2508	−0.13 (−0.20, −0.05)	<.001*
		n (%)		n (%)			OR (95% CI)	
Died during hospital stay	3609	214 (5.9)	123	32 (26)	<.001*	3620	5.95 (3.71, 9.33)	<.001*
Resurgery during inpatient stay	3609	136 (3.8)	123	8 (6.5)	.19	3620	1.65 (0.68, 3.38)	.21
Discharge target for patients living in their own home before injury	2205		54		.013*		Not applicable	
Own house		917 (41.6)		33 (61.1)				
Nursing home		387 (17.6)		8 (14.8)				
Inpatient facility		901 (40.9)		13 (24.1)				

The number of patients with data is given separately for each parameter. All regression models were adjusted for ASA grade, sex, age, and type of proximal femur fracture.
β, regression coefficient; CI, confidence interval; IQR, interquartile range; OR, odds ratio.
  *Significant difference.

Table 3
Results of the Logistic and Linear Regression Analysis on COVID-19−Positive Patients and the Impact of Preinjury Living Situation

Impact of Living Situation in COVID-19−Positive Patients on:	n	OR (95% CI)	P Value
In-house mortality	106	1.37 (0.49, 3.75)	.54
Resurgery during inpatient stay	106	2.35 (0.26, 21.57)	.45
		β (95% CI)	
Time to surgery	114	−2.56 (−10.06, 4.94)	.50
Length of hospital stay for survivors, d	83	−9.43 (−15.09, −3.78)	.001*
EQ5D score 7 d after surgery	64	−0.16 (−0.33, 0.01)	.07

β, regression coefficient; CI, confidence interval; OR, odds ratio.
All regression models were adjusted for ASA grade, sex, age, and type of proximal femur fracture. Reference group were patients living in their own home prior to fracture.
  *Significant difference.

baseline characteristics compared with the COVID-19−negative patients, thus indicating that being COVID-19−positive on its own decreased the likelihood of receiving rehabilitation in a skilled facility. One explanation could be that the rehabilitation units were overloaded or could not provide rehabilitation to patients in quarantine. Another explanation could be that acute hospitals pushed COVID-19−positive patients to discharge as soon as possible, as care in quarantine could be provided in nursing homes or patients' own homes. Indeed, COVID-19−positive patients residing in nursing homes preinjury were released from acute care and returned to those facilities much more quickly than patients living at home (9 days sooner; Table 3). Hospitals might have used these skilled nursing facilities for quarantine instead of keeping patients in hospital. A prolonged stay for positive-tested patients has been reported before.[19,20] The lack of rehabilitation and/or physiotherapy due to quarantining in the acute hospitals might be represented in the EQ-5D score on the seventh day postoperatively, which showed a significant difference in mobility and self-care. In this questionnaire, patients with COVID-19 do present with a significant difference in the depression item, which could be caused by isolation.

Limitations

First of all, this was a retrospective study with all known potential biases, such as selection bias and confounding. Nevertheless, data for the ATR-DGU were collected prospectively. It is common sense that all registers are dependent on the exact collection and entry of the data. Quality protection is ensured by the certifications process and the audits for all hospitals participating in the ATR-DGU. Accordingly, it must be emphasized, as mentioned above, that our data are treatment data from specialized geriatric trauma centers, whose treatment quality may not be representative of the broad mass of hospitals providing care.

All patients' data were collected over a short period and at a time when the treatment of COVID-19−positive patients was not consistent because of lack of experience. Furthermore, the ATR-DGU does not collect data on the cause of mortality, therapy on intensive care units, patients' will toward treatment limitations, or relevant complications other than surgical complications, for example, cardiovascular or pulmonary issues. Moreover, the ATR-DGU does not distinguish between "symptomatic" and "asymptomatic" COVID-19−positive patients and does not include any vital signs, like respiratory rate or temperature on admission. Nevertheless, we could present a large data set from 3733 patients. Moreover, our study contributes new information regarding the impact of COVID-19 infection on QoL and

on discharge after in-hospital treatment, in addition to data on mortality and length of stay.

Conclusions and Implications

COVID-19 infection has a tremendous influence on the outcome of patients with hip fractures. Positive-tested patients were significantly less frequently discharged to a rehabilitation unit, had a longer in-hospital stay, a reduced QoL, and especially, a dramatic rise in mortality rate.

Our results suggest that patients and their families should be informed about the life-threatening combination of proximal femur fracture and a COVID-19 infection. Further, the likelihood for a prolonged hospital stay and delayed rehabilitation should also be addressed.

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