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The impact of COVID-19 prevention measures on epidemiology of orthopedic injuries: the outbreak ages fractures!

Giuseppe Gianluca Costa[1], Giuseppe Fanzone[1], Angelo Graceffa[1], Michele Lauria[1], Gianluca Zocco[1], Antonino Cassarà[2], Alberto Campailla[2], Alessia Saccà[3], Enrico Santanna[4], Gianclaudio Caputo[4], Arcangelo Russo[1].

[1]Orthopaedic and Traumatologic Unit, Umberto I Hospital, Azienda Sanitaria Provinciale di Enna, C.da Ferrante, 94100, Enna, Italy.
[2]Medical School Dunarea De Jos "Fondo Proserpina", 94100, Enna, Italy.
[3]University of Catania, 95124, Catania, Italy.
[4]Orthopaedic and Traumatologic Unit, Michele Chiello Hospital, Azienda Sanitaria Provinciale di Enna , C.da Biella,94015, Piazza Armerina (EN), Italy.

Summary. *Background:* The application of stringent prevention measures for contrasting COVID-19 spread generated changes not only in the outbreak course, but also in epidemiology of traumatic fractures. The aim of this study was to report the epidemiologic characteristics of surgically-treated fractures during the COVID-19 outbreak over a six-month period, and to describe the variation in volumes and types of injuries, by comparing them with fractures which occurred during the same period in 2019. *Methods:* We retrospectively analyzed all surgically-treated fractures which were admitted from the January 1st 2020 to June 30th 2020, and compared these data to those of the corresponding timeframe in 2019. The collected data of interest included demographics, such as age and gender, fracture location, time lapse between presentation at Emergency Department and admission in the ward, length of stay. *Results:* A total of 117 patients were admitted with a diagnosis of facture and surgically treated, with no cases of COVID-19 positive patients. In the corresponding period of 2019, the number of patients admitted for the same reasons was 129. This decrease was more significant in the period between March and April (-30.6%), during which time prevention measures were more stringent. The only statistically significant discrepancy between the two study groups was the mean age, which was significantly higher in 2020. The location of examined injuries were similar in the two study groups, with proximal femur fractures representing the most frequent injuries. *Conclusions:* This study demonstrated significant changes of epidemiologic patterns of fractures during COVID-19 outbreak. These data should provide support for clinicians and government to evaluate the management and prevention strategies of traumatic not only during outbreak but also in non-outbreak period. (www.actabiomedica.it)

Study design: Retrospective case-control study, Level of Evidence III.

Keywords: COVID-19, fractures, epidemiology, age.

Introduction

The current pandemic caused by COVID-19 is one of the biggest challenges that modern society has had to face, with more than 12 million of confirmed cases and more than 500,000 deaths worldwide. [1] Among the involved countries, Italy had one of the most serious COVID-19 outbreaks, that is still ongoing. In order to control the epidemic situation, a national prevention system has been developed to restrict the disease spread, according to the international guidelines. [2] This included social distancing, lockdown, curfews and self-isolation.

As could be expected, while most medical resources are allocated to treat COVID-19 patients, fractures did not quarantine. [3] The revolution of people's life style and related psychological state due to prevention measures generated changes not only in the outbreak course, but also in epidemiology of traumatic fractures. [4 - 6] Epidemiologic analysis is of utmost importance, because it is a fundamental indicator of disease distribution and health status, as well as an essential tool to avoid or reduce the occurrence of traumatic fractures. To ensure that, in the last few months several studies analyzed the epidemiologic patterns of fractures during COVID-19 outbreak [3 - 10], but all studies covered a short period of evaluation, and all focused on the outbreak pick. Therefore, the effect of the entire period of lockdown as well as the gradual resumption of daily activities is still not evaluated.

The aim of this study was to report the epidemiologic characteristics of surgically-treated fractures during the COVID-19 outbreak over a six-month period, and to describe the variation in volumes and types of injuries, by comparing them with fractures which occurred during the same period in 2019.

Materials and methods

A retrospective analysis of all patients admitted between January 1st and June 30th 2020 with a diagnosis of fracture was conducted. All the data were provided by 2 hospitals of the Province of Enna (Sicily), including the Umberto I Hospital of Enna (which is a secondary referral hospital) and the Michele Chiello Hospital of Piazza Armerina (tertiary referral hospital). These two hospitals were chosen for the present analysis because, during the pick of COVID-19 outbreak (between March and April), the Umberto I Hospital was defined as COVID Center and rescheduled to treat exclusively patients with established diagnosis of COVID-19 or emergencies (open trauma, fracture with vascular and nerve injury, partial unstable pelvic fracture, limb or life-saving surgery) in patients where COVID-19 infection could not be previously excluded due to time constraints, while the second hospital was dedicated to treat all COVID-19 negative patients.

Exclusion criteria were: (1) patients admitted for other reasons than fractures, (2) patients requiring elective surgery (arthroscopic procedures or joint replacements), (3) patients with fractures who were managed conservatively, (4) patients who were admitted outside the evaluation period (before January 1st or after June 30th 2020).

This cohort group was defined as epidemic group; as a control group, all patients admitted in the same period of 2019 were reviewed, following the same exclusion process.

The collected data of interest included demographics, such as age and gender, fracture location, time lapse between presentation at Emergency Department and admission in the ward, length of stay. According to the progress of COVID-19 outbreak, patients were divided into three clusters: pre-lockdown group (patients admitted before March 2020), lockdown group (patients admitted between March 01st and April 31th 2020) and post-lockdown group (patients admitted on May 01st or later). Based on age, patients were divided into 3 clusters: children (≤18 years), adults (19–64 years) and elderly patients (65 years and over). The fracture sites were recorded as proximal, shaft and distal fracture for each limb long-bone (humerus, ulnar and radius, femur, tibia and fibula), pelvic and acetabular fracture, scapula, clavicle, patella, cervical vertebra, thoracolumbar fracture, hand and wrist fracture, foot and ankle fractures.

Therapeutic algorithm for traumatic fractures during COVID-19 outbreak

During the epidemic period, the orthopedics and traumatology units suspended all elective surgeries.

When patients with history of injury and signs of fracture came to the Emergency Department, body temperature was screened and any suspicious symptom (fever, cough, respiratory symptoms, etc) was collected before evaluation. If the patient during the previous 14 days had a direct or indirect contact history with a COVID-19 positive person, or had symptoms consistent with COVID-19, isolation measures were taken immediately. If history or clinical signs were not consistent with COVID-19, a detailed history in relation to the trauma sustained was asked from each patient, as well as necessary imaging examinations were carried out. If the suspicion of fracture was confirmed, and hospital admission for surgical treatment was needed, additional imaging examinations (chest X-ray or chest computed tomography) and laboratory tests were carried out, including blood routine test, liver and kidney function, inflammation index and coagulation markers. Furthermore, an oropharyngeal swab was performed in order to determine the diagnosis of COVID-19 by a polymerase chain reaction (PCR) test. Until the completion of these tests, the suspected patient was lodged in an isolation ward alone.

Patients were classified in two different categories corresponding to dedicated management pathways for trauma cases: one pathway for those with confirmed COVID-19, one pathway for those with negative test, which were then admitted to the usual ward, choosing single rooms when available. Two different operating rooms were enabled during the outbreak pick: the first one was dedicated only for negative patients, while the second one exclusively for positive patients. The medical staff and the heath care professional were divided in two groups, which periodically alternated in both pathways, thus minimizing risk of mixture.

In cases of emergencies (open fractures, instable pelvic injuries, concomitant neurovascular injuries etc.) in patients which could not be properly categorized because of time, consultation was conducted by a multidisciplinary team consisted of orthopedics, infectious diseases physicians, anesthetists and intensive care unit physicians. Patients were treated as positive until proven otherwise, and any surgical procedure was performed in the dedicated COVID-19 operative room, respecting the specific protocol for reducing risk of contamination and spread of infection. At the end of the surgical procedure, patients were moved in a single room of a dedicated "gray" ward, waiting for the result of the PCR swab test. If the result was negative, the patients were directed to the usual ward. When the result was positive, the patient was moved to the dedicated COVID-19 ward.

Statistical analysis

Statistical analysis was performed using SPSS® Version 25 (SPSS Inc, Chicago, IL, USA).

All categorical variables were expressed as percentage or frequencies, and the continuous variables were expressed as arithmetic mean ± standard deviation (SD). The Pearson Chi Square test or the Fisher's exact test, where appropriated, was used for comparing the categorical variables, and the Mann-Whitney test was used for the continuous variables.

The statistical test level was set as $p < 0.05$.

Results

During the study timeframe in 2020, a total of 117 patients were admitted with a diagnosis of facture and surgically treated, with no cases of COVID-19 positive patients. In the corresponding period of 2019, the number of patients admitted for the same reasons was 129; therefore, a decrease of -9.7% was reported in the epidemic group. This decrease was greater in the "lockdown" period between March and April (-30.6%), during which time prevention measures were more stringent. During the remaining four months under examination, the number of fractures did not disclose significantly between the two groups (Figure 1). However, all differences between the two study groups did not reach the statistical significance (Table 1).

The epidemic group included 42 males and 75 females (ratio 1:1.8), with a mean age of 71.5 ± 17.7 years at admission. Specifically, there were 1 child, 26 adults and 90 elderly patients. In the control group, there were 41 males and 88 females (ratio 1:2.1), with a statistically significant lower mean age of 65.9 ± 24.7 years. In particular, the number of children treated in 2019 was significantly higher when compared to fractures in 2020 (11 in control group vs 1 in epidemic

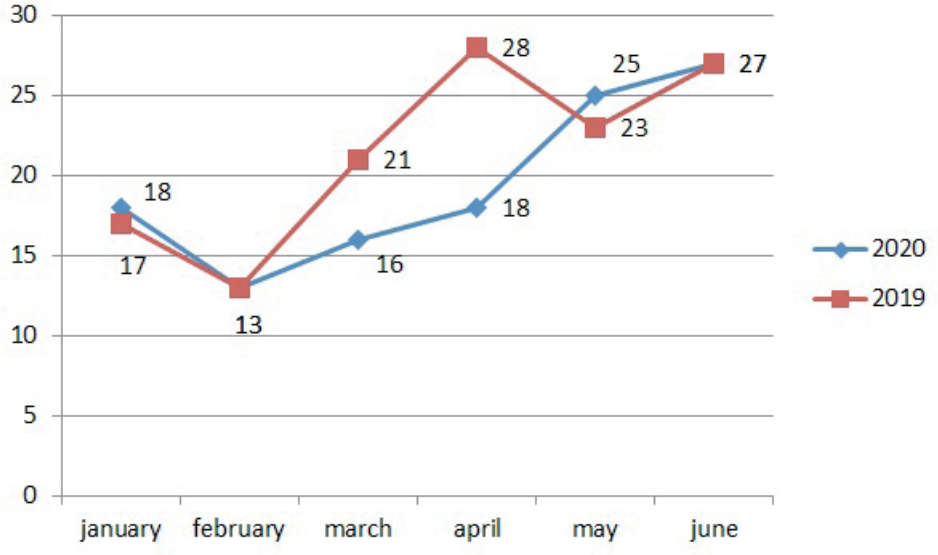

Figure 1. The number of fractures admitted in each month of the study evaluation period.

Table 1. The number of fractures for each cluster of the evaluation period, and relative differences between the two study groups. A p value < 0.05 was considered statistically significant. n.s: not significant.

	Epidemic group (2020)	Control group (2019)	Difference	P values
Pre lockdown	31	30	+3.2%	n.s.
Lockdown	34	49	-30.7%	n.s.
Post lockdown	52	50	+3.8%	n.s.
Total	117	129	-9.7%	

group, p=0.0053); a greater percentage of adult and mostly elderly patients was recorded in 2020, although this trend was not statistically significant (Figure 2). The time lapse between presentation at Emergency Department and admission in the ward (0.8 ± 0.6 days in the epidemic group, vs 0.7 ± 0.5 in the control group) was statistically comparable in the two study groups. In the same way, length of stay in the two years under examination (10.6 ± 7.0 days in the epidemic group vs 9.9 ± 6.4 days in the control group) did not statistically disclose.

The patterns of examined injuries were similar in the two study groups. Proximal femur fractures represented the most frequent injuries (47.8% in epidemic group vs 48.0% in the control group, p>0.05), followed by proximal humerus fractures (24.0% in epidemic group and 23.2% in control group, p>0.05) and ankle fractures (24.0% in epidemic group and 23.2% in control group, p>0.05).

The prevalence of femur fractures did not disclose significantly between the two years of evaluation (Figure 3). Demographic characteristics as well as fractures patterns, with relative statistical comparison, are detailed in Table 2.

Discussion

While most of the literature about COVID-19 understandably concentrates on the disease itself, there have been few papers about the epidemiological changes during the pandemic. Fractures constitute an

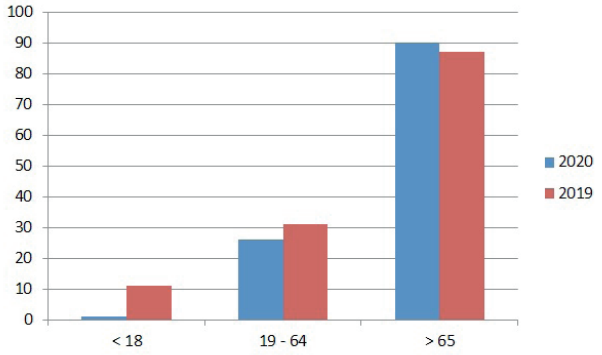

Figure 2. The number of fractures clustered according to the patients' age.

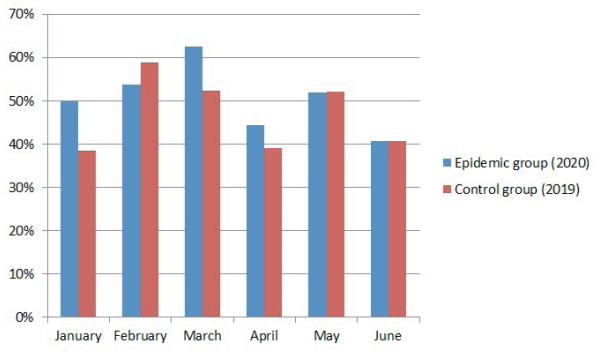

Figure 3. The month-by-month analysis of the prevalence of proximal femoral fractures.

Table 2. Demographic details and patterns of fractures, with relative statistical comparison between the two study groups. n.s: not statistically significant.

	Epidemic group (2020)	Control group (2019)	P values
GENDER			
Female	75 (64.1%)	88 (68.2%)	n.s.
Male	42 (35.9%)	41 (31.8%)	
MEAN AGE	71.5 ± 17.7	65.9 ± 24.7	0.0439
EMERGENCY DEPARTMENT-ADMISSION TIME LAPSE	0.8 ± 0.6	0.7 ± 0.5	n.s.
LENGHT OF STAY	10.6 ± 7.0	9.9 ± 6.4	n.s.
FRACTURES LOCATION			
Clavicle	0	2 (1.6%)	n.s.
Scapula	1 (0.9%)	0	
proximal humerus	14 (12.0%)	15 (11.6%)	
humerus shaft	1 (0.9%)	4 (3.1%)	
Elbow	4 (3.4%)	3 (2.3%)	
radius and/or ulna shaft	1 (0.9%)	3 (2.3%)	
Wrist	1 (0.9%)	4 (3.1%)	
Hand	1 (0.9%)	0	
pelvis/acetabulum	5 (4.3%)	1 (0.8%)	
proximal femur	56 (47.8%)	62 (48.0%)	
femur shaft	5 (4.3%)	5 (3.9%)	
distal femur	0	1 (0.8%)	
Patella	2 (1.7%)	3 (2.3%)	
proximal tibia	4 (3.4%)	2 (1.6%)	
tibia shaft	4 (3.4%)	5 (3.9%)	
Ankle	14 (12.0%)	15 (11.6%)	
Foot	5 (4.3%)	3 (2.3%)	

issue that deserves particular consideration, because they represent an important burden for the health care system and society. [11]

The main finding of the present study was that COVID-19 outbreak changed the epidemiological patterns of fractures. Specifically, the present study found that the average age in 2020 group was significantly older than that in the control group in the previous year. COVID-19 has spread rapidly in Italy since the first Italian case in the country, which was isolated on February 20th 2020. In order to reduce the flow of people, and consequently the spread of the virus, a series of measures were taken by Italian government from the 11th of March, followed by a gradual resumption of daily activities from the 3rd of May 2020. These measures included stop of most industries productions, dramatic reduction of outdoor activities and cancelation of unnecessary travels. The young and middle-aged adults were the mainstay of these activities. This may represent an exhaustive explanation of the decrease of fractures reported in this cluster of patients in the current analysis. On the other hand, the elderly people who ordinarily stay at home were more likely to have low-energy fractures due to the decrease of exercise and the change of sedentary lifestyle during the epidemic period. Also a previous multicenter prospective study [10] reported an increased age among patients admitted for fracture during COVID-19 outbreak. Specifically, the authors found that the most commonly involving age group was elderly patients in the epidemic period, while it was middle-aged adults in non-epidemic period.

A further aspect that deserves particular consideration is the lower number of fractures recorded in 2020, when compared to the same timeframe of the previous year. Although the difference did not reach the statistical significance even in the lockdown period, this trend should not be overlooked. As a confirm of the significance of this finding, time to admission in the ward and length of stay did not significantly disclose between 2020 and 2019, despite the increased pressure on the health care system. The lower number of fractures, together with our protocol of diagnosis, which has made use of diagnostic tools that ensured proper diagnosis in a short time, cancelled the inherent logistical problems related to COVID-19 diagnosis.

It has been already reported an unexpected decrease of other acute life-threatening conditions during COVID-19 outbreak, such as heart attack, stroke, hyperglycemic crisis. [12] Furthermore, previous papers reported a decrease in traumatic fractures [10], even for hip fractures. [9]. However all previous papers focused on a short period of evaluation, corresponding to the pick of the outbreak; therefore certain issues remain unclear. The pandemic state has been a dynamic process, and, thus, it is more appropriate to compare trends in a defined period of time than to compare data at specific time point. By adopting this methodological strategy, the present analysis allowed to describe epidemiologic changes during the different phases of the outbreak. Specifically, it was possible to identify the period when the epidemiologic discrepancy was more significant, that is during the third and fourth month of the year, in conjunction with application of stricter measures to protect public health. In the remaining months, the number of fractures requiring surgical management was comparable to the previous year. Therefore, it can be supposed that the lower number of fractures can be related to the prevention measures, rather than the course of the epidemic.

Conversely, the aforementioned prevention measures poorly affected the prevalence of proximal femur fractures, as well as all other patterns of fractures, which did not significantly disclose in the two periods of evaluation. This injury is typically the result of low-energy trauma, that should be expected increased according to the mean age of patients admitted in 2020 and the predominance of fractures occurring at home or nearby. [4, 10] Probably, lockdown and other prevention measures impacted family relationships in this area, ensuring greater surveillance of the most vulnerable groups of the society. Moreover, it should be recalled that this figure is relative to a small metropolitan area, and it can be secondary to the rescheduling of the local health care system, which relocated such minor traumas to peripheral hospitals, avoiding overload of the primary center. However, these data are not as unusual as expected. Maniscalco et al. [9] reported a significant reduction of hip fractures during

CoVID-19 spread, estimated in about -25% over previous year. On the other hand, Zhu et al. [4] found a disproportionately high prevalence of hip fractures in their cohort of study, which constituted approximately three-fifths of the overall fractures. This figure was about two-to-three times as that reported in the elderly patients in the literature. [13]

Another interesting finding was that no COVID-19 positive cases with fractures was reported in the current series. Although surprising, it is not as unusual as many think, since a recent multicenter analysis of 2,590 fractures [10] reported no positive cases with COVID-19. Catellani et al. [8] reported only 16 proximal femur fractures in a metropolitan area which counted more than 9,000 cases of COVID-19. Thus, our data are consistent with what previously reported in the literature, since to date the Province of Enna counted slightly more than 400 cases and about 120 admissions for COVID-19 disease, although with an incidence higher than the average in the rest of the Country. [14] The choice to delineate some "red zones" where lockdown was more stringent helps to properly estimate the size of the outbreak in this area. Dealing with fractures during international emergency like COVID-19 pandemic represents a further challenge for an already overburden health care system. Therefore, reducing the impact of these injuries is of utmost importance, now more than ever. Targeted measures for effective prevention remain essential. On the other hand, a successful choice may be to simplify treatments in order to reduce number of visits to the hospital and exposure to densely packed waiting rooms. Lv et al. [10] supported minimally invasive surgery as much as possible, for fracture fixation in a fast fashion, such as closed reduction and external fixation or traction fixation. This trend was reported in their multicenter analysis, where the authors found that the proportion of minimally invasive surgery in the epidemic period (45.0%) increased significantly as compared with the previous year (34.8%). A further matter for discussion is to accept a suboptimal outcome but with the aim to reduce hospital inpatient stays. In this context, some authors suggested reconsidering conservative, non-operative therapeutic approach as an alternative where surgical management is not mandatory. [15]

Limitations

The limitations related to this study need to be mentioned. Firstly, the inherent shortcoming of the retrospective design might compromise the accuracy in data collection. However, the variables in this study were relatively few. Thus, recall bias for patients is likely to be small. Secondly, this is a mono-geographic, observational study. The present results do not reflect the real epidemiology of the entire population in the country, therefore limiting the generalizability of our findings. However, this goes beyond our purposes. At last, only surgically-treated fractures were collected, and data regarding fractures which were managed conservatively are missing. This lack should be considered when interpreting the current findings.

Conclusion

In conclusion, this study demonstrated significant changes of epidemiologic patterns of fractures during COVID-19 outbreak. These data should provide support for clinicians and government to evaluate the management and prevention strategies of traumatic fractures more accurately, not only during outbreak but also in non-outbreak period.

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Ethical approval and consent to participate: All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Due to the retrospective nature of the present manuscript, without experimental procedures or drugs, the approval of Institutional Ethics Committee was not required, as per regulation.

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Competing interests: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article. All authors declare that they have no competing interests.

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Correspondence:
Giuseppe Gianluca Costa, MD
Orthopaedic and Traumatologic Unit,
Umberto I Hospital, Azienda Sanitaria Provinciale di Enna
C.da Ferrante
94100, Enna, Italy.
E-mail: gianlucacosta@hotmail.it