State of the art paper

Diabetic foot disease during the COVID-19 pandemic: lessons learned for our future

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Abstract

The COVID-19 pandemic has had a strong impact on the treatment of all diseases, especially chronic ones, and diabetic foot is no exception. The COVID-19 pandemic has favored the adoption of a new model of assistance delivery to facilitate the delivery of remote assistance to patients. The standard model based on face-to-face visits has been integrated by a hybrid model of telemedicine, home care and face-to-face visits to keep patients at home to minimize the number of in-person visits to clinics and admissions except for complicated DFUs. However, telemedicine is not always possible or suitable for various reasons (patients not digital, need for practical treatment of the foot etc.). In this review, we looked at the different approaches to diabetic foot ulcer management and the indirect impact of the COVID-19 pandemic on diabetes-related lower extremity complications and the lessons we have learned for the future.

Key words: telemedicine, amputation, COVID-19 pandemic, diabetic foot ulcer, foot ulceration.

Introduction

The COVID 19 pandemic

In December 2019, a new coronavirus (CoV) strain causing severe acute respiratory syndrome was first isolated in Wuhan (China) and quickly spread worldwide [1]. Almost 525 million subjects have been infected and more than 6 million subjects have died worldwide, so far [2]. In Italy almost 17 million subjects have been infected and more than 165 000 subjects have died [2]. Despite important advances in understanding the pathophysiology of COVID-19, the rapid development of vaccines and drugs against the disease, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is still a global nightmare. Diabetes mellitus (DM) has been identified as one of the most frequent diseases associated with COVID-19: people with DM, particularly type 2 diabetes, infected with SARS-CoV-2 are susceptible to clinical worsening (higher hospitalization and mortality rate) [3].

Diabetic foot disease

People with diabetes are at high risk of developing a range of lower-extremity complications [4, 5]. According to the Global Burden of Disease (GBD) study [6], an estimated 131.0 million (1.77%) people worldwide had diabetes related lower-extremity complications (DRLECs) in 2016, equaling 34% of the diabetic population, including 105.6 million with neuropathy only, 18.6 million with foot ulcers, and 6.8 million with amputations (with or without a prosthesis). This resulted in 16.8 million years lived with disability (YLDs) (2.07% of all YLDs), including 12.9 million from neuropathy only, 2.5 million from foot ulcers, and 1.6 million from amputations [6].

In people with diabetes mellitus, the risk factors for developing ulcers are distal peripheral neuropathy, peripheral arterial disease, repeated trauma, previous ulcers, and/or amputation. The most affected are male subjects, with a longer duration of illness and low socio-economic level [7–9].

Neuropathy and PAD often co-exist and may lead to neuroischemic ulceration, and symptoms may be absent, despite severe peripheral ischemia. The combination of two or more of the above risk factors commonly results in ulceration [10].

The majority of injuries to the diabetic foot are caused by trauma in the presence of neuropathy and/or PAD: repetitive stress [11] thermal trauma (hot water bags, high-temperature footbaths), chemical trauma (inappropriate use of over-the-counter corn treatments) [12].

In Italy every year 7,000 people with diabetes are subjected to amputation (40% of these undergo a major amputation of the lower limb [13], but a recent study showed a clinically significant reduction in major amputations among people with diabetes [14].

It is important to note that 84% of lower-extremity amputations are preceded by a foot ulcer [15] but still ulcer prevention is a neglected opportunity [16]. Amputations can be avoided if diabetic foot ulcers (DFUs) are effectively detected, assessed, referred and rapidly treated, in order to optimize healing [17, 18]. The risk for ulcer recurrence is high, with recurrence rates of 40% in the first year and 65% in the first 3 years after healing [11].

A recent systematic review showed that specific organizational arrangements including multidisciplinary teams and care pathways can prevent half of the amputations in people with diabetes and foot ulcers [19].

Diabetic foot disease management during the COVID-19 pandemic

The COVID-19 pandemic has disrupted the provision of diabetic foot care for various reasons: first, social isolation measures have reduced access to appointments, education and routine screening for diabetic foot; secondly, many diabetes professions have been reassigned to acute medical services to help with the high volume of acute patients; and last but not least, many people with diabetes have been really afraid to attend hospitals as they rightly perceive that it is likely that the hospital is occupied by many patients with active COVID-19 disease [20, 21].

In this perspective, we summarize the evidence identified through rapid reviews and lessons learned for our future. During the lockdown, the first published reports reported significant reductions in the number of visits.

In Slovenia, Urbančič-Rovan [22] reported that the total number of clinic visits decreased by 58%, mainly due to a significant reduction in foot screening, but foot ulcer visits and emergency visits also decreased by 42% and 34%, due to serious logistical problems in the care of patients with DFUs such as the lack of public transport and, again, the fear of contagion from COVID-19. It was possible to partially compensate for this lack of presence by resorting to telephone and e-mail consultations.

Also Shin *et al.* [23] in their study "A Tale of Two Cities" reported a nearly 50% drop in foot clinic visits in Manchester (U.K.) and nearly a 70% drop in Los Angeles (U.S.) after lockdown.

In Argentina, Carro *et al.* [24] reported a 29% reduction in visits. To stay in touch with our patients during the pandemic we have used new ways of patient consultation, including the use of telephone consultations and telemedicine [21]. However, clinical examination and diabetic foot screening need a complete physical examination of the lower limbs [25].

Fearing that people with diabetic foot could have a lack of or delayed access to care, the American Podiatric Medical Association issued a special communication in 2020 emphasizing the importance of appropriate management of DFUs and other complications [26].

Delayed patient referrals to specialized diabetic foot clinics increase the risk of amputation and mortality, mainly in the case of complicated DFUs. Such delayed referrals are often a result of healthcare professionals' and patients' lack of education and knowledge about foot ulcers [27].

Before the COVID-19 pandemic, a survey designed by the Italian Diabetic Foot Study Group to investigate barriers and gaps in the management of diabetic foot disease in Italy identified late referral and urgent surgical treatment as the main barriers among Italian diabetic foot centers [28].

The International Working Group on Diabetic Foot (IWGDF) and D-Foot International developed an adapted Covid-19 'fast-track pathway' for

non-specialist health care professionals who work in primary care, aiming to reduce the risk of late referral of DFUs and avoid unnecessary diabetic foot ulcer-related hospital admissions [29].

Uncomplicated DFUs, defined as superficial, not infected and not ischemic ulcers, can be monitored by primary care and supported with tele-medicine with respect to standard of care.

In the case of unstable uncomplicated DFU during the follow-up, patients should be referred within 48–72 h to a specialized Diabetic Foot Service, while complicated DFUs defined as suspected ischemic ulcers or infected or deep ulcers and/or any kind of ulcers in patients with active heart failure or end stage renal disease should be referred to a specialized DFS within 4 days from the first assessment.

Severely complicated DFUs defined as wet gangrene, abscess, phlegmons or foot ulceration in persons with fever or signs of sepsis require urgent hospitalization in a specialized DFS within 24 h from the diagnosis (Table I).

Telemedicine has assumed a crucial and indispensable role in the management of diabetic foot. A meta-analysis of four controlled trials [30] demonstrated that treating DFU via telemedicine is an effective method when face-to-face attendance is reduced or not possible such as during this COVID-19 pandemic and the likely future outbreaks.

People with diabetic foot appear to enjoy telemedicine very much [31]. A survey conducted in Tuscany, Italy, showed that subjects with diabetic foot reported on a scale of 0 to 5 that telephone monitoring was useful (mean: 4.35), and also would be useful for the future (mean: 4.34) [32].

However, there are several potential general obstacles to providing a diabetic foot telemedicine service: many healthcare facilities are not adequately equipped to provide this service; and many persons may not be able to use the technology due to age or socioeconomic status [31–33].

Several low-to-middle income countries, such as Iran, China, and Brazil, found that the widespread use of smartphones facilitated remote care via social media apps such as WhatsApp, Facetime, and Skype to communicate with their patients [34–38].

In Salvador, Bahia (Brazil), the *Centro de Referência Estadual para a Assistência ao Diabetes e Endocrinologia* (CEDEBA) has created a structured screening system for patients who need care for diabetic foot [38]. In this way 120 subjects (36.4%) with neuroischemic diabetic foot ulcers were evaluated, followed and educated using images that were forwarded by them using mobile communication apps. Of them, 17 were referred for an in-person consultation because of unstable injuries with a risk of amputation. Only three individuals required a highly complex intervention and were referred directly to the specialist without the need to first be admitted to the emergency room.

The indirect impact of the COVID-19 pandemic on diabetes-related lower extremity complications: global reports

In this section of this article, we will look at specific reports from countries around the world on the indirect impact of the COVID-19 pandemic on diabetes-related lower extremity complications.

Table II shows the principal characteristics of the included studies.

European Union

In Italy during the lockdown, Caruso *et al.* [39] reported that diabetic patients with DFU had a 3 times greater risk of amputation than the 2019 data and a higher proportion of patients admitted for emergency. By contrast, Meloni *et al.* [40] reported that after the fast-track pathway implementation, fewer cases of late referral were reported in comparison to early referral during the pandemic.

In Friuli Venezia Giulia (Northern Italy) a population cohort study (unpublished data) found

Table I. Fast-track pathway for diabetic foot ulceration during COVID-19 crisis (adapted from Meloni *et al.* [29])

Type of lesion	Characteristics	Referral
Stable uncomplicated	Superficial No infection No ischemia	Telemedicine
Unstable Uncomplicated	Lesion in progression for ischemia, or infection, or impairment in size and depth	48–72 h
Complicated	Ischemia or Infection or Deep	48–72 h
Severely complicated	Gangrene Abscess Phlegmons Foot ulcerations in patients with sepsis	Within 24 h

Table II. The indirect impact of the COVID-19 pandemic on diabetes-related lower extremity amputations: global reports

References/ country	Research type	Pandemic period evaluated	Aim of study	Main results
Caruso *et al.* 2020/Italy	Retrospective study	9 March to 18 May 2020	To evaluate clinical features and amputation risk of individuals with diabetes and DFU during the COVID-19 lockdown	There was a 3-fold increase in minor amputation
Meloni *et al.* 2020/Italy	Retrospective study	January 2019 to May 2020	To investigate the effectiveness of fast-track pathway (FTP) in the management of diabetic foot ulceration (DFU) after 2 years of implementation	After the FTP implementation, fewer cases of late referral were reported in comparison to early referral
Mariet *et al.* 2021/France	Nationwide retrospective cohort study	January to December 2020	To examine the impact of the COVID-19 epidemic on the hospitalization rates for diabetic foot ulcer, osteomyelitis and lower limb revascularization procedure in people with DFU	Marked drop in hospitalization rates for DFU, osteomyelitis and lower limb revascularization procedures
Lipscomb *et al.* 2020/ UK	Retrospective study	January to April 2020	To assess the impact of COVID-19 on new diabetic foot ulcer events	There was a 52% reduction in new diabetic foot ulcer events in April 2020 compared with April 2019
Valabhji *et al.* 2021/UK	Retrospective national cohort study	March to June 2020	To carry out a population-based assessment of lower-limb major amputation, minor amputation, and revascularization procedure numbers and incidences during the first wave of the COVID-19 pandemic in England	Significant reductions in rates of lower-limb major and minor amputation and revascularization procedures during the first wave of the COVID-19 pandemic
Kleibert *et al.* 2022/Poland	Retrospective national cohort study	January to December 2020	To assess the impact of the COVID-19 pandemic on mortality and the number of procedures (amputation and limb-salvage procedures) related to DFU in 2020 in Poland	An increase in urgent hospitalization due to DFU with a simultaneous increase in minor amputations and a decrease in major amputations
Mayoral *et al.* 2022/Spain	Population-based cohort study	January to December 2020	To analyze whether the hospital admission pattern related to main DM complications in Andalusia has changed during the COVID-19 pandemic	Significant reductions in lower limb amputation rates in people with diabetes mellitus
Liu *et al.* 2020/China	Retrospective study	First trimester of 2020	To determine the impact of the COVID-19 outbreak on patients with DFUs at a multidisciplinary center	Significant reductions in hospitalizations for diabetic foot problems and increase of major amputations were reported during the first three months of 2020
Viswanathan *et al.* 2021/ India	Retrospective cohort study	25 March to 31 December 2020	To find out the alterations in the amputation rates among people with diabetes during the COVID-19 pandemic in India	There was a 54.1% increase in major amputations noted in the pandemic period compared to the pre-pandemic period

Table II. Cont.

References/ country	Research type	Pandemic period evaluated	Aim of study	Main results
Yunir *et al.* 2022/ Indonesia	Retrospective cohort study	March 2020 to February 2021	To compare the characteristics of patients with DFU before and during the COVID-19 pandemic period	During the COVID-19 pandemic, patients with DFU had more severe infection, a higher proportion of osteomyelitis, longer waiting time for receiving surgical intervention, and higher incidence of major amputation
Ahmed *et al.* 2022/ Bangladesh	Retrospective study	March 2020 to August 2021	To assess the prevalence of major amputation in the COVID-19 era compared to the non-COVID-19 era	During the COVID-19 pandemic, there was an increase in major and minor amputations
Ergisi *et al.* 2022/Turkey	Retrospective study	August 2020 to February 2021	To evaluate the indirect impact of the novel coronavirus disease 2019 (COVID-19) pandemic on diabetes-related lower extremity amputations	There was no statistically significant difference in the amputation rates before and during the pandemic
Rubin *et al.* 2022/Israel	Retrospective study	March 2020 to December 2020	To examine the consequences of the COVID-19 pandemic for diabetic foot ulcer care, outcome, and mortality	There was no statistically significant difference in the mortality and major amputation rates before and during the pandemic
Schmidt *et al.* 2020/ USA	Longitudinal study	1 March to 31 May 2020	To develop a triage algorithm to effectively risk-stratify all DFUs for potential complications, complying with social distancing regulations, preserving personal protective equipment, and to assess feasibility of virtual care for DFU	There was no difference in rates of DFU-related hospitalization and minor amputation rates during and prior the pandemic
Casciato *et al.* 2020/ USA	Retrospective study	18 March to 31 August 2020	To perform a descriptive, secondary analysis, of an inpatient population requiring foot and ankle services in a level-one trauma center in the US Midwest during the COVID-19 pandemic through September 2020. To illustrate changes in this inpatient population in terms of both volume and infection severity in relation to identified time points during the pandemic, specifically in those with diabetes	There was a higher proportion of patients with mild and severe infections and an increased rate of major or minor amputations during the pandemic compared to the pre-pandemic period
Rastogi *et al.* 2021/USA	Prospective study	April 2020 to September 2020	To determine the clinical characteristics and outcomes of limb and lives in people with diabetic foot complications who underwent virtual triage and supervised teleconsultations for foot complications during the COVID-19 pandemic	Targeted foot-care service through virtual triage and teleconsultations during COVID-19 pandemic for people with foot complications have similar ulcer and limb outcomes compared to face-to-face foot care delivery

Table II. Cont.

References/ country	Research type	Pandemic period evaluated	Aim of study	Main results
De Mestral *et al.* 2022/ Canada	Population-based cohort study	1 January 2020, to 23 February 2021	To evaluate the association of the COVID-19 pandemic with diabetes-related care measures, foot complications, and amputation	During the COVID-19 pandemic there were no excess leg amputations among people living with diabetes
Pintado *et al.* 2020/Perù	Observational study	January to April 2020	To examine the impact of the current COVID-19 outbreak on the number of non-COVID-related patient presentations to a major national emergency traumatology/orthopedics referral center in Latin America	There was a significant increase in the number of hospitalizations for DFUs
Carro *et al.* 2020/ Argentina	Cross sectional study	June 2020	To compare the number of medical visits and the severity of new lesions at presentation at the Diabetic Foot Unit	There was a 29% reduction in the number of visits, an increase in the number of patients presenting with new lesions and an increase of major amputations

significant reductions in major rates of amputations during the COVID-19 pandemic compared to those of the previous year (–14.7% in 2020, 21.6% in 2021), while data relating to minor amputations could be underestimated in 2020, because during the first wave of the pandemic many minor amputations were performed in the outpatient clinic due to the unavailability of operating rooms [41].

In France [42], a nationwide retrospective cohort study found a marked drop in hospitalization rates for DFU, osteomyelitis and lower limb revascularization procedures.

In the UK, a report from Brighton [43] described a 52% reduction in new diabetic foot ulcer events in April 2020 compared with April 2019, while a full population study [44] described significant reductions in major and minor lower limb amputation rates and revascularization procedures in persons with diabetes during the first wave of the COVID-19 pandemic compared to those of the same periods of the previous 3 years. The reduction in the incidence of major amputations was predominantly limited to those over the age of 65, so the competing endpoint of COVID-19 related mortality may have contributed. A lower incidence of minor amputations could be the result of a minor incidence of ulcers due to impaired walking in the context of home confinement, although there are no reliable data on the incidence of ulcers for the whole of England.

In Poland, Kleibert *et al.* [45] reported an increase in the total number of DFU amputations compared to the pre-COVID era. In particular, the authors did not observe a decrease in the number of majors amputations (above the knee) and simultaneously an increase in minor amputations (below the ankle).

In Andalusia (Southern Spain), a population-based study of all hospital discharges showed significant reductions in lower limb amputation rates in people with diabetes mellitus [46].

Asia

In China, significant reductions in hospitalizations for diabetic foot problems and an increase of major amputations were reported during the first three months of 2020 [47] as well as throughout 2020, due to the COVID-19 epidemic.

In South India, a retrospective, single-centered study [48] showed a 54.1% increase in major amputations noted in the pandemic period compared to the pre-pandemic period. In Indonesia, in a retrospective study [49] conducted in a tertiary referral hospital, the authors found that the proportion of amputation was higher during the pandemic (39.3% vs. 56.3%) and the proportion of major amputation was almost twice as high during the pandemic than the pre-pandemic (20.2% vs. 39.4%). In Bangladesh, a retrospective single-center study [50] reported increased prevalence of total amputations as well as major and minor amputations during the pandemic period. In Turkey, a single single-center, retrospective study [51] reported that there was no change in the amputation incidence and levels during the pandemic period. In Israel, a retrospective study conducted at a level 2 medical center reported that there was no statistically significant difference in the mortality and major amputation rates in persons with diabetic ulcer before and during the pandemic [52].

North America

Two retro-prospective observational cohort studies, conducted in the US, observed a similar number of amputations following foot ulcers during the pandemic compared to the pre-pandemic period [53, 54], while Casciato *et al.* [55] reported a higher proportion of patients with mild and severe infections and an increased rate of major or minor amputations during the pandemic compared to the pre-pandemic period.

In Ontario, Canada de Mestral *et al.* [56] conducted a population-based cohort study of adults with diabetes and compared the rates of selected outcomes from January 1, 2020, to February 23, 2021, vs. January 1, 2019, to February 23, 2020. The authors found that adults living with diabetes in Ontario did not undergo more amputations during the first 2 waves of the COVID-19 pandemic compared with historical data, despite limited ambulatory in-person assessment by physicians, hospital avoidance, and restrictions to scheduled hospital-based procedures.

South America

In Peru, compared to a general decline in hospitalizations during the lockdown, there was a significant increase in the number of hospitalizations for DFUs [57]. In Argentina, Carro *et al.* [24] reported a higher rate of major amputation and small changes in the consultation for new injuries in June 2020 compared to June 2019.

Conclusion and lessons learned for our future

In this review, we looked at the different approaches to diabetic foot ulcer management and the indirect impact of the COVID-19 pandemic on diabetes-related lower extremity complications in countries around the world. COVID-19 took us all by surprise. None of us could have imagined the impact of this pandemic on health systems and on society at large.

The first reports during the lockdown were limited to small cohorts of single specialized centers which showed different results [24, 39, 40, 43, 47–52], while subsequently several complete population studies have been published [42, 44–46, 56].

In many studies, the increase of amputations has been attributed to the severity of the infection and delayed referral [24, 39, 47, 48, 50, 55] while in several studies the lower rate of major amputations may be due to a lower incidence of ulcers [42–45, 56] due to reduced mobility in the context of home confinement, although reliable data on the incidence of ulcers are not available. In addition, data relating to minor amputations could be underestimated because during the first wave of the pandemic many minor amputations were performed in the outpatient clinic due to the unavailability of operating rooms [41].

During the COVID-19 pandemic, people with diabetes, particularly those with diabetic foot, appear to have suffered the brunt of the disease, but we have learned some lessons that we will need in the future.

The first lesson we learned during the pandemic was the need for a diabetic foot care model that was flexible, fluid and able to adapt to change. To stay connected with our patients during the pandemic, we have used new modes of consulting patients, including the use of telephone consultations and telemedicine [21].

The COVID-19 pandemic has favored the adoption of a new model of assistance delivery to facilitate the delivery of remote assistance to patients [58].

The standard model based on face-to-face visits has been integrated by a hybrid model of telemedicine, home care and face-to-face visits to keep patients at home to minimize the number of in-person visits to clinics and admissions except for complicated DFUs [31].

We have moved on to the quick "can do" approach, as opposed to the bureaucratic and very slow approach so often seen in the NHS, and we really hope that this approach will persist in the future.

The second lesson learned during the pandemic is that we need a personalized medicine that ensures the right treatment for the right patient at the right time. The current guidelines do not distinguish or at least take little account of important aspects of the people with diabetic foot, such as age, other complications of diabetes, comorbidities, frailty class, care network, or community resources.

We believe that the solution can be a personalized medicine, person-centered, risk-based model of population health based on early and appropriate interventions through a multidisciplinary and interprofessional team.

The goal of this approach is to reduce the risk of foot amputations and related deaths.

Recommendations for managing diabetic foot disease during the pandemic include patient education and the use of online resources that provide reminders to maintain glycemic control through appropriate diet, exercise, and medication. Encouraging self-examination of the feet and regular foot care prevents the development of pressure points around the foot and calluses.

Finally, telemedicine consultations allow for patient triage, new referral assessments, and visualization and assessment of new or recently healed ulcers and of the 'at risk' foot [59].

Our literature search tells us that there are several tools we can use to mitigate the risks to

the population with DFUs while the pandemic is underway, including better education of patients, health professionals in the area and telemedicine to keep in touch with persons with diabetic foot.

People with diabetes should know how to prevent potential foot problems and recognize early presentation without losing time before referral to doctors [60].

Many people with DFUs can be managed remotely and/or at home, but it should be emphasized that people whose lesions have increased in size, or who have ischemia and/or moderate to severe infection, should be looked after in person by a diabetic foot specialist.

Limb- or life-threatening infection must be drained or debrided urgently, regardless of circulation, but vascular evaluation begins immediately once sepsis is controlled [31].

The third lesson learned is that telemedicine, to be successful, needs to: overcome physician unwillingness to adopt telemedicine [31], simplify procedures, have an electronic medical record (EMR), adapt technological development, reduce costs and guarantee the protection of patient data.

The fourth and last lesson learned, but not the least, is that to ensure fairness, continuity and homogeneity of access to healthcare services and quality services for all citizens with diabetic foot, global patient care (disease management) with strong integration between hospital and territorial resources is essential: limited hospital admissions to the initial diagnostic and therapeutic phases and to severe instability, development of low care facilities, dedicated outpatient clinics for follow-up, integrated home care, development of primary care and socio-health integration at the district level. This requires financial investments, training processes and a new and more qualified way of operating on the part of general practitioners.

In the unitary conception of the network of health services, hospitalization represents only one of the moments of the diagnostic and curative path. The activities of prevention, diagnosis, follow-up and therapies that do not require hospitalization must be carried out in the territory and in direct proximity to the residential areas, exploiting the irreplaceable professionalism expressed by the hospital world in an integration process. Therefore, the most attention must be paid to building effective integration and continuity of the entire process, the implementation of which is also a primary objective for the hospital.

All this will be impossible without facilitating as much as possible the dialogue with the territory, in particular with general practitioners, and the exchange of skills and information between all the players in the system.

Conflict of interest

The authors declare no conflict of interest.

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