DIABETES AND FOOT BURNS

DIABÈTE ET BRÛLURES DU PIED

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SUMMARY. The incidence of diabetes and diabetic foot burns is increasing worldwide. In the present study, we surveyed frequency, morbidity and mortality of diabetic foot burn patients in our centre. The study was a cross-sectional survey with one-year follow up of our adult diabetic patients with lower extremity burns. Data on demographics, cause of burn, time from injury to hospital, TBSA, presence of neuropathy and diabetic foot, treatment plan for controlling blood sugar, smoking, infection, morbidity, co-morbid diseases, amputation and mortality were gathered from patient files. Statistical analysis was done with SPSS 21 software. A p value less than 0.05 was considered significant. Of the 34,300 burn patients seen in a year, 2096 were admitted according to ABA criteria. 47 patients had diabetic foot burn. Half of them had diabetic neuropathy. 48.9% had type I diabetes and 51.1% had type II. 70.2% were male, 29.8% were female. Mean +/- SD age was 58 +/- 14 years; 14 patients were smokers and 40 had co-morbid diseases. Hypertension frequency was 44%, ischemic heart disease 25%, CVA 8.5% and renal failure 6.4%. Half of the patients had uncontrolled blood sugar. Mean +/- SD delay in admission was 2.5±1.5 (days). Mean +/- SD TBSA was 2.4 +/- 1.4%. Mean +/- SD length of stay was 11.4±6.1 (days). 8.5% underwent amputation and there were no deaths. Diabetic foot burn patients delay seeking medical attention, have a longer length of stay, more complications and more amputations than other burn patients (compared with our previous study on burn patients). Prevention and training programs are highly needed to prevent foot burns.

Keywords: burns, diabetes, foot burn, blood glucose, TBSA, amputation

RÉSUMÉ. *L'incidence du diabète et, concomitamment, des brûlures du pied chez ces patient, est en augmentation dans le monde. Nous rapportons la fréquence, la morbidité et la mortalité des brûlures du pied chez les diabétiques vues dans notre centre. Il s'agit d'une étude en cross-over avec suivi sur 1 an des adultes diabétiques avec une brûlure de l'extrémité distale des membres inférieurs. Nous avons relevé les données démographiques, les comorbidités, la cause et l'étendue de la brûlure, le délai entre brûlure et hospitalisation, le tabagisme, la présence de neuropathie et de pied diabétique, la stratégie d'équilibration glycémique, les infections, la nécessité d'amputation, la mortalité. Les analyses ont été réalisées avec SSPS 21, un p<0,05 étant considéré significatif. Deux mille quatre vingt seize des 34 300 patients vus ont été hospitalisés (en utilisant les critères de l'ABA). Quarante sept diabétiques (48,9% type 1 ; 51,1% type 2) avaient une brûlure de pied. Ils étaient âgés de 58 +/- 14 ans ; 70,2% étaient des hommes (29,8% des femmes). Quatorze étaient fumeurs, 40 avaient une pathologie associée (HTA 44%, coronaropathie 25%, insuffisance rénale 6,4%). La moitié d'entre eux avaient un diabète mal équilibré. Ils étaient admis après 2,5 +/- 1,5 jours et restaient 11,4 +/- 6,1 jours. La surface brûlée était évaluée à 2,4 +/- 1,4%. Une amputation a été nécessaire dans 8,5% des cas, aucun patient n'est mort. Les diabétiques avec un pied brûlé consultent plus tardivement, restent plus longtemps, ont plus de complications et sont amputés plus fréquemment que les autres brûlés (données d'une étude précédente). Des programmes d'éducation et de prévention sont réellement nécessaires vis-à-vis de ces patients.*

Mots-clés : *brûlure, diabète, pied, glycémie, surface brûlée, amputation*

Introduction

Diabetes is one of the most common diseases in our country. There were over 4.6 million cases in 2015. The prevalence of diabetes in adults in our country is 8.5%. Many middle- and low-income countries have more people under the age of 60 with diabetes compared to the world average (report from the International Diabetes Federation Middle East and North Africa, 2015). Burn injuries are also one of the most frequent traumas in our country.

Diabetic patients have neuropathy in the lower extremities and lower sensation in the foot than non-diabetic patients.[1,2,3,4,5]

With reduced sensation, burn injury (and also other injuries) may and can happen while warming the foot with warm water or other kinds of heaters.[4,6] Contact of a reduced sensate foot with hot objects or walking on a hot surface may also lead to burns.[4]

It has also been reported that frost bite can happen in the insensate foot.[4,6]

These patients have reduced sensation, so they may realize they have a burn injury very late, leading to a delay in seeking

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medical treatment. Moreover, neurovascular disease in the foot and lower extremities can delay the healing process. Therefore, the healing process in diabetic patients is slow. All of the above factors can lead to delayed healing, infection, higher rates of complications, amputations and even mortality.[1,7,2,6,3]

Aware of the paucity of reports and research on this topic, in this study we surveyed our diabetic burn patients' data for complications, morbidity and mortality.

Materials and methods

This was a cross-sectional study conducted in 2014. For one year we retrospectively surveyed our burn patients and those with lower extremity burns and diabetes. Inclusion criteria were burns, diabetes, lower extremity burn, age > 18 years and admission to hospital. Those given outpatient treatment were excluded. All the patients were admitted according to ABA (American Burn Association) criteria.

We examined the files of all burn patients admitted to our hospital, and the files of those with lower extremity burns were extracted. Subsequently, those with diabetes and age > 18 were selected.

The following variables were collected retrospectively: demographic data, cause of burn, diabetes (known or newly detected), type of diabetes, grade of burn, TBSA, the time from injury to hospital (delay in admission), treatment plan for blood sugar, length of stay, smoking habit, surgical treatments, amputation, complications, mortality, type of treatment for diabetes, presence of neuropathy and diabetic foot. Mean follow up period was one year (10-18 months).

All data were gathered in a pre-designed questionnaire and data analysis was performed using SPSS 21 software. A *p* value less than 0.05 was considered significant.

Results

In one year we saw around 34,300 burn patients in the emergency clinic of our hospital. 2096 adult burn patients were admitted to the hospital. The patients were admitted according to ABA criteria for the admission of burn patients.

104 patients (5%) had diabetes and 47 patients (49.2% of diabetic patients) had lower extremity burns. 23 patients (48.9%) were insulin dependent and 24 (51.1%) were treated with oral anti-hyperglycaemic medicine, glybenclamide and metformin.

Half of the patients had diabetic foot and diabetic neuropathy. The blood glucose of patients was kept between 130-190 mg/dl. All of them were given only insulin (crystal and NPH) during their stay in hospital. For most of them, insulin twice a day was sufficient. Blood glucose was tested twice a day. In addition, urine was examined for glucose every other day. A urine glucose of zero or one plus (+) was considered sufficient. A total of 14 patients (29.8%) were female and 33 patients (70.2%) were male (male to female ratio = 2.35: 1).

The mean age was 58+/-14 (26 - 86) years. The mean duration (+/- SD) of diabetes in our patients was 11 (+/- 5.6) years. *Table I* shows the characteristics of the diabetic foot patients' burns.

Forty patients had co-morbid diseases. *Table II* shows a summary of the treatments the patients underwent. Fourteen patients were smokers. Ten patients had type I diabetes and 37 had type II.

Table I - Characteristics of burning in the diabetic foot patients

Variable	Results
TBSA	2.4±1.4 (%)
Grade	
II	14 (29.8%)
III	28 (59.6%)
IV	5 (10.6%)
Cause of burning	
Hot fluid	19 (40.4%)
Hot solid	28 (59.6%)
Delay in admission	2.5±1.5 (days)
Co morbid disease	
HTN	21 (44.7%)
IHD	12 (25.5%)
CVA	4(8.5%)
RF	3 (6.4%)

HTN = hypertension; IHD = ischemic heart disease; CVA = cerebrovascular accident; RF = renal failure

Table II - Clinical and treatment characteristics of burning in the diabetic foot patients

Variable	Results
Hospital stay	11.4±6.1 (days)
Number of surgery	2.5±1
ICU admission	11 (23.4%)
Positive wound culture	27 (57.4%)
Cellulitis and AB	30 (63.8%)
Type of surgery	
Debridement	6 (12.8%)
Amputation	4 (8.5%)
Debridement & graft	28 (59.6%)
Amputation & Debridement	2 (4.3%)
Debridement & Flap	3 (6.4%)
Amputation & Debridement & Graft	4 (8.5%)

Discussion

Diabetes is one the most common diseases, and affects around 10% of the adult general population worldwide. Frequent neuropathy and reduced sensation in the foot of these patients can lead to unwanted or accidental burns.[1,2,3,4,5]

Frequently, the patients have reduced circulation in their lower extremities and a cold feeling. Therefore, they try to warm their feet with hot water or hot objects, such as heaters. The insensate condition can lead to burning of the skin and as the patient cannot feel pain, the burn may be deep, mostly a deep 2nd degree or even 3rd degree burn.[4] Another scenario is people who walk barefoot over a hot or cold surface, which could cause injury to their feet with a burn or frostbite.[4,6] These patients may feel less pain compared to non-diabetic patients, therefore they might presume the burn wound is not a deep or critical one and thus delay seeking medical attention.[8,6,3,4]

During this delay, they may use non-medical, traditional or harmful ointments and/or harmful treatments that can aggravate their problem.[4] It is not uncommon for them to get community-acquired infection in their burn wounds. Obviously infection in these burn wounds aggravates the problem and prolongs the heeling process.[6]

Infection can deteriorate the brittle stable condition in some diabetic patients, so they may have uncontrolled blood sugar, renal failure and heart and circulation problems.[4,6]

Therefore, the surgeon usually encounters a necrotic, badly treated and infected wound. Infection in such a burn wound further delays healing time. Diabetes itself has some adverse effects on the healing process. Delay in receiving proper treatment and wound infection can worsen this process too. Diabetes can have

adverse effects on the healing process in many ways.

First: patients have a vascular problem, so macro-vascular and micro-vascular problems have adverse effects on wound healing.

Second: they may have renal function impairment, and uraemia will delay the healing process.

Third: they have neuropathy, and lack of neuro-feedback can flatten the arch of the foot. The result is increased pressure over metatarsal heads, especially the first two, and uneven distribution of body weight over the foot. Excess pressure in one area can delay the healing process.

Fourth: lack of sympathetic nerves can impair sweating and results in dryness and cracking of the skin. These cracks are the site of entry for bacteria.

Fifth: neuropathy and hyperglycaemia can lead to impaired local immune system function.

Sixth: hyperglycaemia leads to glycosylation of some molecules in the tissue and induces the production and release of cytokines.

These cytokines impair the inflammatory response in the tissue and thus impair healing.[3,4,6,8]

Seventh: infection by itself can increase resistance to insulin, increasing the patient's need for insulin, and the result is hyperglycaemia.

Eighth: nerve function impairment reduces the level of neuropeptides in the tissue, and decreases cell proliferation around the wound, impairing wound healing.[3,4,6,8,9,10,11,12]

Ninth: micro-vascular impairment leads to a decrease in the level of VEGF and FGF. And this in turn impairs the healing process.[13]

So neuropathy, neurovascular disease, uncontrolled blood glucose and infection are factors that can lead to severe complications, morbidity, amputation and mortality.[2,4,7]

There are reports that the number of diabetic patients is increasing worldwide: for example, in the USA it is estimated that this number will double by 2050.[8,9,10] Also the number of insulin dependent patients is increasing, so the incidence of neuropathy, angiopathy and micro-angiopathy is increasing too.[2]

In our study, we had 10 patients with type I diabetes and 37 patients with type II diabetes.

There are reports from Germany, the USA, the Netherlands, Australia and other countries that only a small percentage of their burn patients have foot burns, but that healing time and length of stay, rate of re-operation, re-grafting and amputations are high among these patients. Even morbidity and mortality are higher.[1,2,3,4,6,7,8,9,11,12,14]

In a report from the USA, 18% of their burn patients had diabetes and 27% had foot burns.[9] In our study it was shown that around 2.55% of our patients had diabetic foot burn.

In another report from the USA over 10 years, they stated that 68 diabetic patients and 37 patients were insensate. The rate of re-grafting was 20% and amputation 33%.[7]

In a report from the Netherlands, they stated that the number of diabetic foot burns is low, but the rate of morbidity is high. In our present study, compared with our previous study on burn patients, it was shown that these patients had higher morbidity compared to our other burn patients.[15]

Generally, the causes of diabetic foot burns in other reports were scalds and contact burns, contrary to reports on other burn patients (including our own report on the epidemiology of burn patients) where the most frequent causes of burns were flame and scalds. In our study, the causes of foot burn were scalds and contact burn.[4,8,10,15]

Most of the diabetic burn patients in other reports had uncontrolled blood glucose.[4,6,7] In our study, about 50% of patients had high blood glucose at admission. Uncontrolled blood glucose is related to a lack of sensation in the feet and this may explain the mechanism of injury.

Length of stay in other reports was twice that for other non-diabetic patients and our results were the same (compared with our previous reports on burn patients).[4,7,8,15]

There is a report that senior (>55 years old) diabetic patients with burns had more urinary tract infections.[6] This issue was not evaluated in our study.

TBSA in other reports ranged from 0.5 to 4.2%[3,4,6,7,8] and in our study it ranged from 1 to 3.8%. Half of them were third degree burns (full thickness burns).

In a report from the Netherlands, 82% of patients had presented after a delay of more than 2 days.[8] In our study, the delay ranged from 1 to 4.5 days. It seems that insensate foot meant patients and their family did not seek prompt medical care. In the same report it was mentioned that diabetic patients had a longer hospital stay, more frequent complications and more residual defects.[2,4,6,7,8] Fortunately, our residual defects were minimal and occurred only in about 10% of the patients.

In 2004 in a report from the USA, it was shown that the rate of infection is higher in diabetic patients, and 42% occurred in the winter, most of them caused by streptococcus species.[4] In another report from the USA, infection was caused by multiple organisms and the most frequent one was Staff. aureus.[6] In our study, most of the infections were caused by one organism, and the most frequent were coagulase-negative staff. and pseudomonas species. The rate of infection in our patients was 57%.

The most frequent co-morbid diseases in our study were hypertension 44%, ischemic heart disease 25%, CVA 8.5% and renal failure 6.4%. We could not find any detailed description of co-morbid diseases in diabetic foot burns in the literature, but some reports mentioned cardiovascular disease as the most frequent one.[4]

ICU admission in our study was 23%. In a report from Granada, it was stated that the rate of ICU admission was twice that of other burn patients.[10] We could not find any other reports on ICU admissions for these patients. The paucity of reports on this specific topic is clear.

Four of our patients underwent amputation (8.5%). In a report from Australia, the rate of amputation was 33%.[7] In 2015, a report from Germany stated that the rate of amputation was higher than for other burn patients, without any mention of percentages.[2] In 2013, there was a report from the USA which stated that, over 10 years, the rate of amputation was 11 out of 68 patients (16.1%).[4] A few other reports have mentioned amputation for their patients but without any specification.

The mean hospital stay in our study was 11.4 days. In other reports it was between 5 to 21 days, and all of them mentioned that length of stay was at least twice as long as that for non-diabetic patients.[4,7,10,11] Longer stay in hospital and the need for more surgeries involves higher costs for the patients, society and the government. The same issue was reported in our previous studies on the economic burden of burn patients.[3,16,17]

Twenty-seven of our patients were smokers. In one report from the USA in 2014, 4 out of 33 patients were smokers, although the relationship between smoking and rate of wound healing was not evaluated.[3]

In our study, the mean number of surgeries was 2.5 and most of them involved debridement, skin graft or amputation.

Fortunately we had no mortalities, but in a report from

the USA, 3 out of 68 patients died (4.4%).[4] It seems that for foot burns only, without burns on other parts of the body, mortality rate is low, although morbidity, the possibility that the graft doesn't take and that re-grafting, re-operation, amputation and many repeat admissions are required, is still high.[4]

We found a few reports on diabetic foot burns in the literature, but all of them advise informing the patients and recommending measures for the prevention of foot burns. These include: controlling blood sugar, keeping the foot dry, wearing proper shoes, avoiding hot and very cold surfaces, not using hot water to warm the feet or hot objects (heaters), avoiding smoking, avoiding walking barefoot, frequent examination of the foot by the patients, moisturizing foot skin, and taking good care of the feet.[1,3,4,5,8,17,18,19,20]

Conclusions

Diabetic patients generally seek medical attention for foot burns after a delay of 1-3 days. They are deep burns. Compared with our previous report on burn patients, length of stay, rate of complications and morbidity are higher in these patients.

Their treatment has a high cost for the patients and for society.

Prevention and training programs for these patients are highly needed.

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