Bahrain Medical Bulletin, Vol. 36, No. 3, September 2014

Hyperbaric Oxygen Therapy as an Adjunct in the Management of Diabetic Foot Complications

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ABSTRACT

Objective: To evaluate the use of hyperbaric oxygen therapy on the rate of lower limb amputation and total wound healing in the management of diabetic foot.

Setting: Hyperbaric Unit, King Hamad University Hospital.

Design: A Retrospective Study.

Method: All diabetic patients with a breach of the skin of the foot and who had received either wound care or combined with hyperbaric oxygen therapy from January 2012 to September 2013 were included in the study. Data documented were the following: lower limb amputation, minor amputation, surgical debridement, healing status achieved and the effect of hyperbaric oxygen therapy on any of these outcomes.

Result: Seventy-six patients had Diabetic Foot Ulcers of different stages. The Wagner grading system and University of Texas diabetic foot severity scale were both used to determine the most sensitive and specific tool for future use. Fifty-two (68%) patients were included for analysis, 25 (48%) were grade 3-4 Wagner Classification and 29 (56%) 2D-3D University of Texas Classification, 44 (85%) were male and 8 (15%) were female. The majority were in the age group of 45-64 years. Full healing was achieved in 42 (80.8%) patients. Four (8%) patients had major amputation procedure. All patients analyzed had received hyperbaric oxygen as adjunctive therapy.

Conclusion: In this study, only four (8%) patients had major amputation procedure. Hyperbaric oxygen therapy reduced overall major limb loss and helped in acceleration of wound healing achieved. An integrated team approach played a role in achieving good patient outcomes despite late presentation.

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INTRODUCTION

The absence of pain due to the presence of neuropathy in the feet of the majority of diabetic patients makes the foot prone to complications[1]. Peripheral neuropathy in diabetics is associated

with 15% to 25% risk of developing foot ulcer[2-3]. International Diabetes Federation (IDF) report 2012 on Epidemiology of people with Diabetes Mellitus in Bahrain has reached 185,330 cases with a high male preponderance[4].

Peripheral motor neuropathy and sensory neuropathy increase the risk for injury[2]. Non-healing diabetic foot ulcers are due to poor glycemic control, poor tissue oxygenation and impaired systemic immune response[2,5,6].

The incidence of lower extremity amputations in diabetic patients is high, 2.8%-4.4%. Older age and long duration of diabetes poses high risk for major lower limb amputation, repeat amputation procedure whether to the ipsilateral limb or contralateral limb ranges from 26.7%-53.3% in one year[7,8]. Diabetic foot complications conservative treatment or amputation is expensive and it adds a burden to the cost of health system[8-10].

Single therapeutic intervention in diabetic foot management is not sufficient. An integrated team approach (surgery, wound care, physicians, dieticians and podiatry) is needed to promote best clinical outcome for diabetic foot patients[11]. An important factor that influences patient outcomes is the adherence to the treatment plan.

Hyperbaric Oxygen Therapy (HBOT) has been well-known as an adjunctive therapy for diabetic foot ulcers. HBOT significantly reduce major amputation rates if used as an adjunct in the treatment of diabetic foot complications[12].

HBOT is defined as the application of 100% oxygen at more than 1 ATA of pressure in which the partial pressure of oxygen will be increased in proportion to the increase of pressure. This delivery of oxygen would involve the lungs and should not be confused with topical oxygen therapy[13]. HBOT has no significant effect on a wound that is already adequately vascularized and this status is determined by Transcutaneous Oxygen Measurement (TCOM) and vascular assessment.

Diabetic foot wounds are not separate category as criteria for HBO treatment. The Underwater and Hyperbaric Medical Society suggests HBO as an adjuvant treatment for refractory osteomyelitis and selected problem wounds in patients with arterial insufficiency[8].

Tissue repair and wound healing is impaired in hypoxic tissue and associated with increased susceptibility to infection due to necrotic tissue and mixed bacterial infection. HBOT have bactericidal effect on anaerobes. Increased oxygen tension improves oxygen dependent mechanisms (oxygen, peroxides, and superoxides) that are primarily used by leukocytes in their defense against microorganisms.

Patients are usually assessed according to the Wound Bed Preparation total patient approach[14,15]. The local wound is classified to healable, maintenance and non-healable wound[14,15].

Sixty seconds foot screening test to identify the major cause of the foot problem is mandatory (lack of vascular supply, infection, neuropathy or constant pressure over a bony prominence[14-19]. Wagner Grading system and University of Texas Diabetic Foot Classification systems are a

guide to determine which is more sensitive and specific in identifying diabetic foot complications[20-21].

The aim of this study is to evaluate the use of hyperbaric oxygen therapy on the rate of lower limb amputation and total wound healing in the management of diabetic foot.

METHOD

Diabetic patients treated in the Hyperbaric Oxygen Treatment and Diving Unit from September 2012 to September 2013 were reviewed.

Included were diabetes mellitus Type 1 and Type 2 with any grade of skin breach on the foot regardless of any co-existing co-morbidities. Informed consent was obtained from all patients.

Patients were assessed according to the Wound Bed Preparation total patient approach. The local wound is classified to healable, maintenance and non-healable wound.

Patients were also subjected to the 60 seconds foot screening test to identify the major cause of the foot problem (lack of vascular supply, infection, neuropathy or constant pressure over a bony prominence). In patients with absent foot pulses, Doppler Ultrasound and Transcutaneous Oxygen Measurements were done. All skin breaches were classified on both the Wagner Grading system and University of Texas Diabetic Foot Classification systems to determine which one is more sensitive and specific in identifying diabetic foot complication, see tables 1 and 2.

Table 1: Wagner Classification System for Diabetic Foot Ulcer

0	No open lesions: may have deformity or cellulitis
1	Superficial ulcer
2	Deep ulcer to tendon or joint capsule
3	Deep ulcer with abscess, osteomyelitis or joint sepsis
4	Local gangrene - forefoot or heel
5	Gangrene of entire foot

Table 2: University of Texas Diabetic Wound Care Classification System

A0	Pre or post-ulcerative lesion completely epithelialized
A1	Superficial wound not involving tendon, capsule or bone
A2	Wound penetrating to tendon or capsule
A3	Wound penetrating to bone or joint
B0	Pre- or post-ulcerative lesion completely epithelialized with infection
B1	Superficial wound not involving tendon, capsule or bone with infection
B2	Wound penetrating to tendon or capsule with infection
B3	Wound penetrating to bone or joint with infection
C0	Pre- or post-ulcerative lesion completely epithelialized with ischemia
C1	Superficial wound not involving tendon, capsule or bone with ischemia
C2	Wound penetrating to tendon or capsule with ischemia

C3	Wound penetrating to bone or joint with ischemia
D0	Pre- or post-ulcerative lesion completely epithelialized with infection and ischemia
D1	Superficial wound not involving tendon, capsule, or bone with infection and ischemia
D2	Wound penetrating to tendon or capsule with infection and ischemia
D3	Wound penetrating to bone or joint with infection and ischemia

Size and photographic documentation of these ulcers were retrieved to determine improvement in wound healing; full healing was described as 100% re-epithelialization with or without any surgical procedures.

RESULT

Forty-four (85%) were males and 8 (15%) were females; the age range was 45-64 years. Nine (17%) patients were younger than 44 years, see figures 1 and 2.

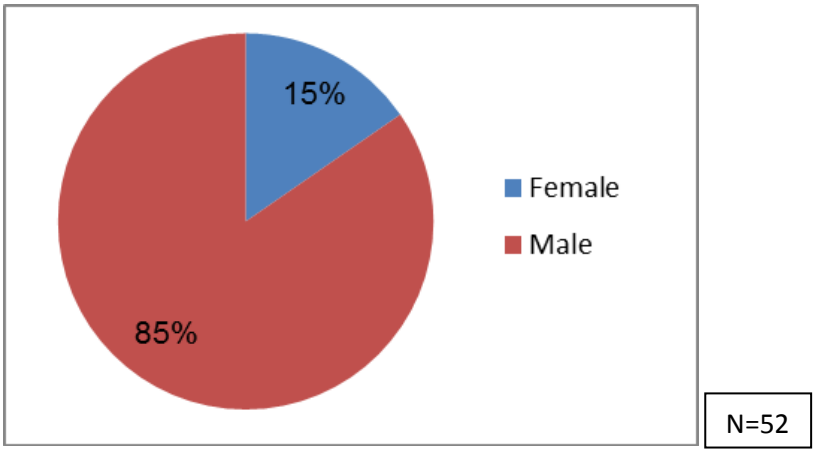

Figure 1: Gender Distribution

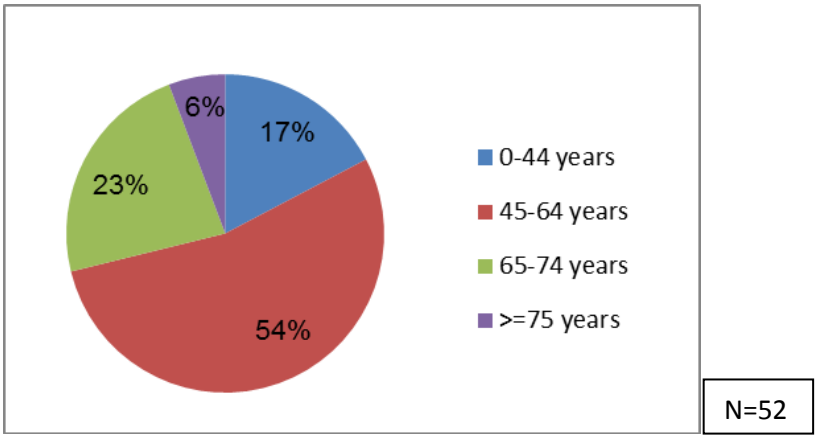

Figure 2: Age Distribution

Thirty-three (63%) were classified as maintenance wounds, see figure 3.

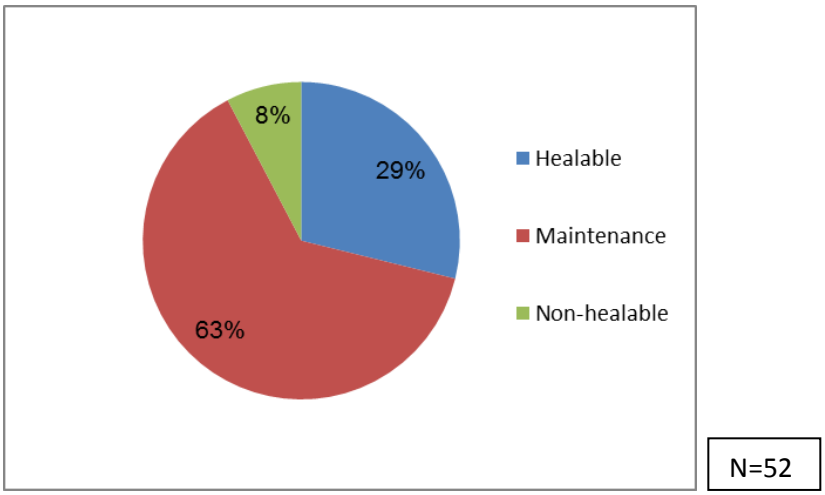

Figure 3: Wound Healability Potential

The majority of foot complications and ulcer depth were up to the tendon. Twenty-five (48%) were Grade 3-4 category. Comparing Wagner grading and University of Texas revealed that 75% patients had an already established complication which could result in lower limb loss, see figures 4 and 5.

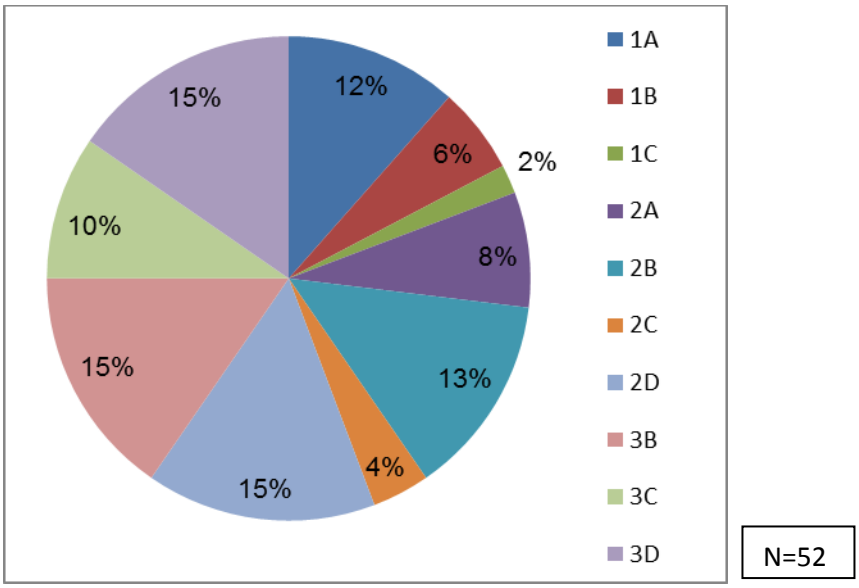

Figure 4: Diabetic Foot Complication classification according to University of Texas Diabetic Wound Care Classification System

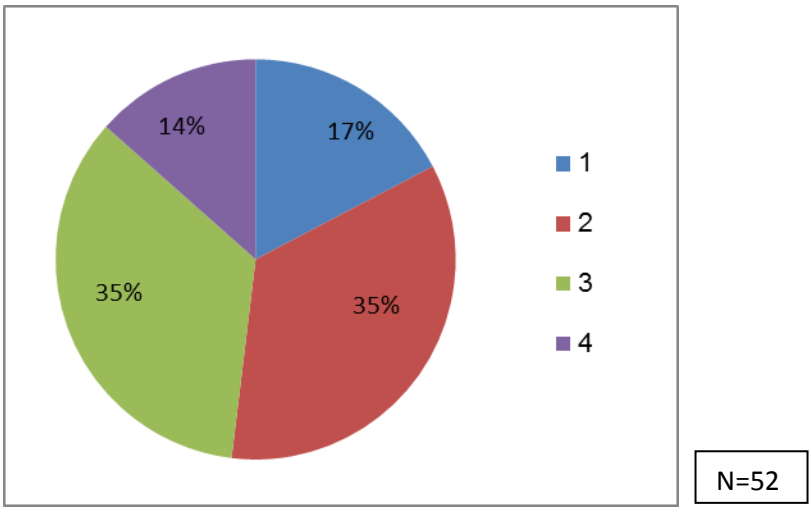

Figure 5: Diabetic Foot Complication classification according to the Wagner Diabetic foot grading system

Full healing was achieved in 42 (80.8%) patients. Four (5.3%) patients died of other co-morbidities coinciding with their foot complication. In this group, 11 patients remain where the causes could not be treated (equal pressure redistribution and other patient adherence issues); they were put on the sustained maintenance wound care program. In these cases, the aim is to prevent infection, deterioration and limb loss, see figure 6.

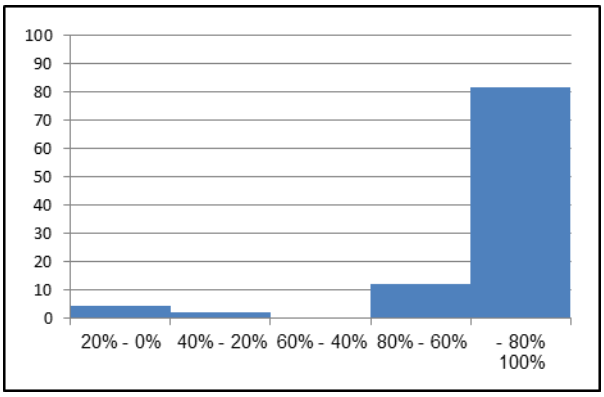

Figure 6: Percentage Wound Healing Achieved

Figure 7 and 8 show the improvement and the healing in diabetic foot ulcer after hyperbaric therapy and wound care.

Figure 7: Beginning of Treatment Patient A

Figure 8: After 4 Months of Treatment Patient A

Fifty-two patients received HBOT; only 4 (8%) patients had below knee amputation. Minor amputations that did not extend beyond the ankle were necessary in 28% of the group giving an overall amputation salvage rate of more than 75%. No post-surgical complications were documented nor were any re-amputation was performed, see figure 9.

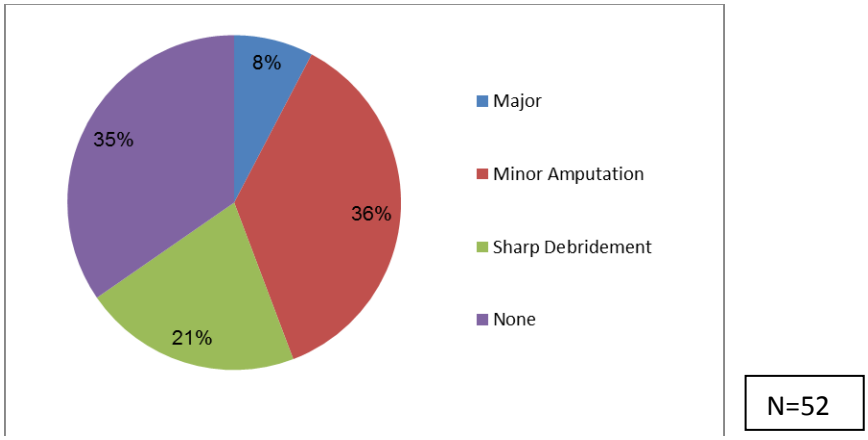

Figure 9: Amputation Rate in patients after HBOT

DISCUSSION

Uncontrolled diabetes mellitus leads to vascular changes and neuropathies, which causes delay in seeking medical advice. As supported by the IDF Bahrain Data, there is a higher preponderance of males in our report 85% males and 15% females compared to 65% and 35%[2]. In this study, 4 (8%) patients were non-healable.

Hyperbaric oxygen mechanism of action provides hyperoxygenation and vasoconstriction which controls and activates neovascularization due to a steep oxygen pressure gradient between viable and non-viable tissue.

In this study, we achieved full healing in 80.8% of patients, which demonstrates the efficacy of Hyperbaric Oxygen Treatment in the management of the diabetic foot ulcer in saving the lower limb. This outcome was achieved despite the worst initial clinical presentations on both the Wagner and Texas classification systems.

Only 4 (8%) required major amputation (below knee amputation), 19 (36.5%) required minor amputation procedures due to localized osteomyelitis.

Current patients in this audit will need further follow-up in the next 5 years and will require preventive maintenance for their diabetic foot problems with active podiatric intervention.

HBO can re-perfuse and revitalize; patients treated with HBO further saves overall treatment logistics. The development of a neat demarcation line that usually happens after 5-7 sessions of HBO adds surgical precision in the clear separation between viable and non-viable tissue limiting additional tissue loss by providing an exact debridement parameter.

Further studies are recommended on the effects of Hyperbaric Oxygen Treatment on Diabetic osteoarthrosis (Charcot Foot).

CONCLUSION

This retrospective audit illustrates the use of HBOT in the diabetic foot ulcers to increase the likelihood of achieving full wound healing in different stages of severity with rare complications encountered. This in conjunction with a multi-professional wound care approach improves overall welfare and decreases the risk of major amputations resulting in lower limb loss.

Podiatric Medicine would be a valuable addition to the management and prevention of Diabetic Foot Ulcers as equal pressure redistribution and effective downloading of the foot remains one of the major challenges to be bridged in Bahrain.

Author Contribution: All authors share equal effort contribution towards (1) substantial contribution to conception and design, acquisition, analysis and interpretation of data; (2) drafting the article and revising it critically for important intellectual content; and (3) final approval of manuscript version to be published. Yes.

Potential Conflicts of Interest: None.

Competing Interest: None. **Sponsorship:** None.

Submission Date: 26 December 2013. **Acceptance Date:** 30 June 2014.

Ethical Approval: Approved by the Research and Ethics Committee, King Hamad University Hospital.

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