The Problems and Cost-Effectiveness Analysis of Diabetic Foot Infections

Diyabetik Ayak Enfeksiyonlarındaki Problemler ve Maliyet Analizi

Mustafa Sait Gönen, Mehtap Çakır, Gülsüm Gönülalan, Mine Öztürk, Süleyman Hilmi İpekçi, Ali Köşker, Mustafa Nazım Karalezli*, İbrahim Erayman**, Kadir Durgut***, Mustafa Keskin****, Nevra Seyhan****

Selcuk University, Meram School of Medicine, Endocrinology and Metabolism, Konya, Turkey
*Selcuk University, Meram School of Medicine, Orthopedics and Traumatology, Konya, Turkey
**Selcuk University, Meram School of Medicine, Infectious Diseases, Konya, Turkey
***Selcuk University, Meram School of Medicine, Cardiovascular Surgery, Konya, Turkey
****Selcuk University, Meram School of Medicine, Plastic, Reconstructive and Aesthetic Surgery, Konya, Turkey

Abstract

Objective: Hospitalization in patients with diabetic foot infection usually increases costs due to required long-term medical treatments and surgical managements. We aimed to investigate the ethiological factors of diabetic foot infections, frequency of osteomyelitis and amputation and the cost of diabetic foot infection treatments.

Materials and Method: Patients with DM and diabetic foot infections that was admitted to our Endocrinology clinic between January 2009 and January 2010 was reviewed retrospectively. Demographic properties, phisical examinations, laboratuary tests, treatments, hospitalization time and cost informations of patients were investigated.

Results: The mean age of 80 patients with 59 males and 21 females was 62±11 years. All patients were diagnosed as Type 2 DM except four patients (5%) with Type 1 DM. The mean duration of DM in our study group was 15.6 years, the mean hospitalization time was 22.1 days and mean cost per patient was 2573 $.

Discussion: Diabetic foot infection is an important complication of DM due to impaired quality of life, loss of work, developement of psychosocial trauma, increased frequency and duration of hospitalization, increased cost of treatment recently. Daily foot care and examination by patients seem an important factor to reduce cost of diabetic foot infections. *Turk Jem 2012; 16: 10-3*

Key words: Diabetic foot infections, cost-effectiveness, diabetic nephropathy

Özet

Amaç: Diyabetik ayak efeksiyonu genellikle hastanede yatış, uzun süreli medikal ve cerrahi tedavi gerektirdiği için maliyeti arttırır. Bizim amacımız diyabetik ayak enfeksiyonlarındaki etyolojik faktörlerin, osteomiyelit ve amputasyon sıklığı ve diyabetik ayak enfeksiyon tedavilerinin maliyetini araştırmak.

Gereç ve Yöntemler: Ocak 2009- Ocak 2010 yılları arasında diyabetik ayak enfeksiyonu ile endokrinoloji kliniğimize başvuran hastalar geriye dönük tarandı. Hastaların demografik verileri, fizik bulguları, laboratuvar sonuçları, yapılan tedavileri, yatış süreleri ve maliyet bilgileri toplandı.

Bulgular: 59 erkek, 21 kadın toplam 80 hastanın yaş ortalaması 62±11 idi. Hastaların 4'ü tip 1 DM, diğerleri (%95) tip 2 DM idi. Tüm hasta grubumuzda diyabet yaşı ortalama 15,6±8,1 yıl, hastanede ortalama yatış süreleri 22,1±20,1 gün, hasta başı maliyet 3860,4±3683.9 TL idi.

Sonuç: Yaşam kalitesinde bozulma, iş kaybı, psikolojik travma gelişmesi, hastaneye yatış sıklığı ve süresinde artma gibi faktörler günümüzde tedavi maliyetini artırdığı için diyabetik ayak diyabetin önemli bir komplikasyonudur. Hastalar tarafından yapılan günlük ayak bakımı ve muayene diyabetik ayak enfeksiyonlarının maliyetini azaltmada önemli bir faktördür. *Türk Jem 2012; 16: 10-3*

Anahtar kelimeler: Diyabetik ayak enfeksiyonlar, maliyet, diyabetik nefropati

Address for Correspondence/Yazışma Adresi: Mustafa Sait Gönen MD, Selcuk University, Meram School of Medicine, Department of Endocrinology and Metabolism, Konya, Turkey
Phone: +90 332 223 60 00 Fax: +90 332 323 72 10 E-mail: m.saitgonen@hotmail.com **Recevied/Geliş Tarihi:** 03.07.2011 **Accepted/Kabul Tarihi:** 31.10.2011

Introduction

Diabetic foot infection is a common and important complication of diabetes mellitus (DM). The risk of diabetic foot ulcer is higher than 15% in lifetime of patients with DM (1). While 15-20% of diabetic foot infections require amputation, 85% of non-traumatic amputations are due to diabetic foot infections (2,3). Although there are several factors contribute to the development of diabetic foot infections, peripheral sensorial neuropathy and peripheral vascular disease are the most important ones (3).

Diabetic foot infections are an important risk factor for small limb amputations (3,4) and are associated with increased treatment costs (5). Hospitalization generally increases the costs due to requirements of long-term medical treatments and surgical managements.

In this study, we investigated the etiological factors of diabetic foot infections, frequency of osteomyelitis and amputation, and the costs associated with the treatment of diabetic foot infections.

Materials and Methods

Patients with diabetes mellitus (DM) and diabetic foot infections who were evaluated by The Multidisciplinary Diabetic Foot Study Group in Selcuk University Meram School of Medicine between January 2009 and January 2010 were included in the study. Demographic properties, physical examinations, laboratory tests, treatments, length of hospital stay and cost information were investigated. Creatinine clearance was calculated using the Modification of Diet in Renal Disease equation (MDRD). Foot lesions were classified according to Wagner's classification of diabetic foot ulcers; Grade 0: High risk foot and no ulceration. Grade 1: Superficial Ulcer. Grade 2: Deep Ulcer (cellulitis). Grade 3: Osteomyelitis with ulceration or abscess formation. Grade 4: Gangrenous patches or partial foot gangrene. Grade 5: Gangrene of entire foot. Affected bones were evaluated by X-ray. Arterial circulation was evaluated with palpation of peripheral pulses and ankle brachial pressure index was calculated using a hand-held Doppler ultrasound device.

Statistical analyses of data were performed using SPSS (Statistical Package for Social Science) version 15.0 for Windows within 95% confidence interval. The values were shown in terms of mean ± standard deviation (SD). Difference between the groups was evaluated by the Mann-Whitney U test. The degree of association between variables was assessed by Spearman's correlation coefficient. A p-value less than 0.05 was considered statistically significant.

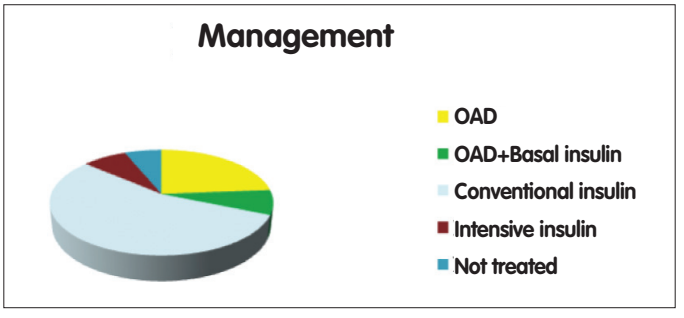

Figure 1. Treatments of patients for DM at the time of diagnosis with diabetic foot infections

Results

The mean age of 80 patients (59 males and 21 females) was 62 years. All patients were diagnosed as having Type 2 DM except four patients (5%) with Type 1 DM. Treatments of patients were oral antidiabetic drugs (OAD) alone in 19 patients (24%), OAD and basal insulin in 6 patients (7.5%), conventional insulin treatment in 44 patients (55%), and intensive insulin treatment in 6 patients (7.5%) initially. 5 patients (6%) were not treated (Figure 1). 2 patients were diagnosed as having DM when they had been admitted due to diabetic foot infection. The mean duration of DM in our study group was 15.6 years, the mean length of hospital stay was 22.1 days and the mean cost per patient was 2573$ (Table 1 and 2).

Nephropathy was detected in 86%, retinopathy in 78%, neuropathy in 95%, hypertension in 68%, coronary artery disease in 39% and peripheral artery disease in 48% of patients at admission. The mean serum level of HbA1c was 9.2% and serum level of HbA1c was 7% and over in 87% of patients. Serum hemoglobin level was under 12 g/dl in 66% of patients.

Osteomyelitis was detected in 37 patients (46.25%) by X-ray, Magnetic Resonance Imaging (MRI) or scintigraphy. Osteomyelitis was detected in 35 of 65 patients with over 20 mm/h sedimentation rate and 14 of 17 patients with over 70 mm/h sedimentation rate. Increased sedimentation rate was significantly related with osteomyelitis (p=0.007). CRP level was not significantly related with the development of osteomyelitis. On the other hand, increased levels of CRP were significantly associated with amputation in patients with diabetic foot infections (p=0.04). While no microorganism was isolated in 27% of patients' wound cultures,

Table 1. Patients' data

Sex: F/M	21/59
Type of DM: Type 1 DM / Type 2 DM	4/76
Duration of DM (Mean, years)	15.6±8.1
Time of hospitalization (Mean, days)	22.1±20.1
Cost per patient (Mean, $)	2573±2455
Body mass index (Mean, kg/m^2)	28±4.83
Serum level of HbA1c (Mean, mg/dl)	9.2±2.2

Table 2. Median, minimum and maximum values of patients

	Median	Min-max values
Duration of DM (years)	15	1-42
Time of hospitalization (days)	15.5	0-108
Cost per patient ($)	1732	10-9512
Serum level of HbA1c (%)	9.1	5.6-16.0
Serum level of hemoglobin (g/dl)	11.0	7.3-15.0
Erythrocyte sedimentation rate (mm/h)	50	11-120
C-reactive protein	52.5	3-135

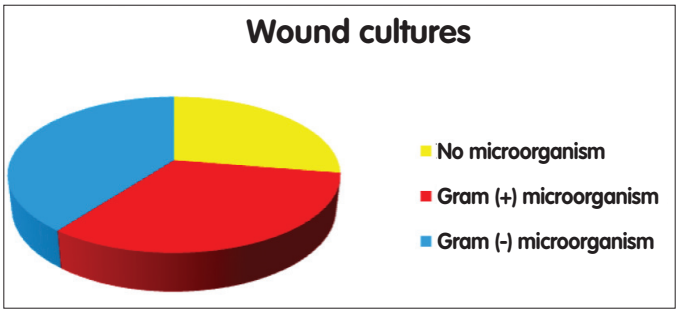

Figure 2. Evaluation of wound cultures

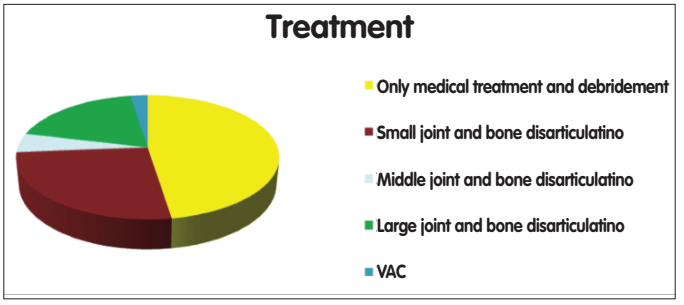

Figure 3. Treatments of diabetic foot infections

gram-negative microorganisms were isolated in 40% of patients (E. Coli in 6, Pseudomonas aeroginosa in 4, klebsiella in 4, enterococcus in 4, Morganella morgagni in 2, proteus spp in 2, acinetobacter spp in 2, Serratia marcences in 1, Citrobacter frendi in 1 ESBL in 1, and spirocet in 1 patient) and gram positive microorganisms were isolated in 33% of patients (Staf. Aureus in 8, coagulase negative Staf. in 7, enterococ in 4, streptococcus in 2 patients) (Figure 2). Multiple microorganisms were isolated in wound cultures of some patients.

All patients with diabetic foot infections have undergone several treatment protocols. While 38 patients (49%) were treated with only medical treatment and debridement, 40 patients (51%) have undergone amputation. Amputation procedure included small joint and bone disarticulation in 21 patients, middle joint and bone disarticulation in 4 patients and large joint and bone disarticulation in 15 of these patients (Figure 3). After debridement procedure, flap, graft and flap+graft were used in 2, 5 and 2 of patients, respectively. Vacuum assisted closure (VAC) therapy was also performed in 2 patients after small joint and bone disarticulation.

Amputation rate in patients with diabetic foot infections was significantly related with lesion grade according to Wagner ulcer classification ($p<0.001$). Amputation rate in patients with grade 3-5 lesions and patients with grade 0-2 lesions were 76% and 30%, respectively. However, amputation rate did not significantly correlate with neuropathy ($p=0.18$), peripheral artery disease ($p=0.86$), ankle brachial pressure index ($p=0.89$), and calcification of large vessels ($p=0.98$). On the other hand, increased rates of osteomyelitis ($p=0.02$) and erythrocyte sedimentation rate ($p=0.04$) were significantly associated with increased amputation rate.

High cost per patient was significantly correlated with increased sedimentation rate, level of CRP, duration of hospitalization and low hemoglobin levels (correlation coefficients were $r=0.492$, $r=0.293$, $r=0.551$, $r=-0.388$, respectively; and p-values were <0.001, 0.01, <0.001, 0.003, respectively). Increased insulin treatment for DM before the diagnosis of diabetic foot infections was significantly related with lower cost per patient with diabetic foot infections ($r=0.248$, $p=0.03$).

Discussion

Diabetic foot infection is the most common risk factor for hospitalization and amputation.

Although the prevalence of isolated microorganisms varies, the most common microorganisms that isolated in wound cultures of diabetic foot infections are gram-negative bacilli, S. Aureus, Streptococci and anaerobic microorganisms (6,7). We isolated these microorganisms in similar rates in our study. Long-term hospitalization, deep ulcers and long-term treatments with broad-spectrum antibiotics cause the development of multidrug-resistant microorganisms in diabetic foot infections (8).

In our study, microorganisms were isolated in wound cultures in 61% of patients with 35% gram negative and 26% gram positive microorganisms. Species of microorganisms isolated in wound cultures was not correlated with the development of osteomyelitis and amputation for lesions.

The risk of amputation is increased in patients with osteomyelitis as a complication of diabetic foot infection (9). Osteomyelitis was detected in 37 patients (46.25%) in our study group and these patients had higher erythrocyte sedimentation rate (ESR). Increased ESR might be a marker in screening of osteomyelitis in patients with diabetic foot infections. Kaleta et al. (10) reported that the optimal cut-off value of the sedimentation rate in diagnosis of osteomyelitis was 70 mm/h with 89.5% sensitivity and 100% specificity. A recently meta-analysis reported that the risk of osteomyelitis was 11 times higher in patients with an ESR over 70 mm/h (11).

Orbia et al. (12) showed significant correlation between the Wagner grade and the risk of amputation. Our study has also shown that amputation rate was significantly higher in patients with high grade diabetic foot infections according to Wagner classification. Early diagnosis and appropriate treatment of diabetic foot lesions can reduce the amputation rates. Pitter et al. (13) reported that amputation was required in 93% of 15 patients with grade 4-5 diabetic foot lesions. On the other, hand there was no significant correlation between Wagner grade of lesions and species of microorganisms isolated in wound cultures in our study.

Eneroth et al. (14) reported that limb ischemia was an independent risk factor for amputation, as Diamantopoulos et al. (15) has shown that limb ischemia was the major factor for bad prognosis of diabetic foot infection. Winkley et al. (16) also reported that ischemia increased mortality three times in patients with diabetic foot ulcers. Although signs of ischemia, such as peripheral artery disease, abnormal ankle-brachial index and calcifications of large vessels were more frequent in patients with amputation, however, it was not statistically significant in our study.

Akıncı et al. (17) showed that reduced creatinine clearance rate was significantly correlated with increased risk of amputation. Another study also reported significant correlation between end stage renal disease and inadequate healing of transmetatarsal amputations

(18). However, there was no significant association between creatinine clearance and risk of amputation (p>0.05).

Cost of diabetic foot infections increases due to long-term hospitalization, long-term antibiotic treatment, surgical procedures and radiological tests. In our study, increased cost per patient correlated with high sedimentation rate, serum CRP levels, long-term hospitalization and low hemoglobin levels. The increased dose of insulin treatment for DM before the diagnosis of diabetic foot infections was significantly correlated with decreased cost per patient.

While cost of diabetic foot infections was reported to be 28.000$ per patient in an American study in 1999 (19), in a Swedish study in 2000 (20), it was reported to be 34.000$ and 18.000$ per patient with or without amputation, respectively. Habib et al. (21) reported that cost per patient with diabetic foot ulcers was between 8953$ and 17893$ depending on early or late diagnosis of ulcers. In the present study,the mean cost per patient with diabetic foot ulcers was found to be 2.573$. We assume that low cost of these patients was due to low cost of health care in our country.

Diabetic foot infection is an important complication of DM due to impaired quality of life, work loss, development of psychosocial trauma, increased frequency and duration of hospitalization, and increased cost of treatment. Daily foot care and self-examination, in addition to early diagnosis and appropriated treatments, seem an important factor to reduce the costs of diabetic foot infections which is an important cause of DM-related mortality and morbidity.

References

1. Reiber GE, Lipsky BA, Gibbons GW. The burden of diabetic foot ulcers. Am J Surg 1998;176(2A Suppl):5S-10S.
2. Palumbo PJ, Melton LJ. Peripheral vascular disease and diabetes. In: Haris MI, Hamman RF, (Ed). Diabetes in America. Washington: US Government Printing Office 1985:16-21.
3. Pecoraro RE, Reiber GE, Burgess M. Pathways to diabetic limb amputation: Basis for prevention. Diabetes Care 1990;13:513-21.
4. Margolis DJ, Allen-Taylor L, Hoffstad O, Berlin JA. Diabetic neuropathic foot ulcers and amputation. Wound Repair Regen 2005;13:230-6.
5. Rogers LC, Lavery LA, Armstrong DG. The right to bear legs- an amendment to health care: how preventing amputation can save billions fort the US healthcare system. J Am Podiatr Med Assoc 2008;98:166-8.
6. Abdulrazak A, Bitar ZI, Al-Sahamali AA, Mobasher LA. Bacteriological study of diabetic foot infections. J Diabetes Complications 2005;19:138-41.
7. Bader MS. Diabetic foot infection. Am Fam Physician 2008;78:71-9.
8. Fincke BG, Miller DR, Christiansen CL, Turpin RS. Variation in antibiotic treatment for diabetic patients with serious foot infections: a retrospective observational study. BMC Health Serv Res 2010;10:193.
9. Newman LG, Waller J, Palestro CJ, et al. Unsuspected osteomyelitis in diabetes monitoring by leukocyte scanning with indium In 111 oxyquinoline. JAMA 1991;266:1246-51.
10. Kaleta JL, Fleischli JW, Reilly CH. The diagnosis of osteomyelitis in diabetes using erythrocyte sedimentation rate: a pilot study. J Am Podiatr Med Assoc 2001;91:445-50.
11. Butalia S, Palda VA, Sargeant RJ, Detsky AS, Mourad O. Does this patient with diabetes have osteomyelitis of the lower extremity? JAMA 2008;299:806-13.
12. Oyibo SO, Jude EB, Tarawneh I, et al. A comparison of two diabetic foot ulcer classification systems: The Wagner and University of Texas wound classification system. Diabetes Care 2001;24:84-8.
13. Pitter D, Wyssa B, Herter-Clavel C, et al. Outcome of diabetic foot infections treated conservatively. Arch Intern Med 1999;159:851-6.
14. Eneroth M, Apelqvist J, Stenstrom A. Clinical characteristics and outcome in 223 diabetic patients with deep foot infections. Foot Ankle Int 1997;18:716-22.
15. Diamantopoulos EJ, Haritos D, Yfandi G, et al. Management and outcome of severe diabetic foot infections. Exp Clin Endocrinol Diabetes 1998;106:346-52.
16. Winkley K, Stahl D, Chalder T, Edmonds ME, Ismail K. Risk factors associated with adverse outcomes in a population-based prospective cohort study of people with their first diabetic foot ulcer. J Diabetes Complications 2007;21:341-9.
17. Akıncı B, Yesil S, Bayraktar F, et al. The effect of creatinine clearance on the short-term outcome of neuropathic diabetic foot ulcers. Prim Care Diabetes 2010;4:181-5.
18. Pollard J, Hamilton GA, Rush SM, Ford LA. Mortality and morbidity after transmetatarsal amputation: retrospective review of 101 cases. J Foot Ankle Surg 2006;45:91-7.
19. Ramsey SD, Newton K, Blough D, et al. Incidence, outcomes and cost of foot ulcers in patients with diabetes. Diabetes Care 1999;22:382-7.
20. Tennvall GR, Apelqvist J, Eneroth M. Cost of deep foot infections in patients with diabetes mellitus. Pharmacoeconomics 2000;18:225-38.
21. Habib SH, Biswas KB, Akter S, Saha S, Ali L. Cost-effectiveness analysis of medical intervention in patients with early detection of diabetic foot in a tertiary care hospital in Bangladesh. J Diabetes Complications 2010;24:259-64.