Effects of Amputation Level on Hospital Costs and Length of Hospital Stay in Diabetic Foot Disease*

Diyabetik Ayak Hastalığında Ampütasyon Seviyesinin Hastane Maliyetleri ve Hastanede Kalış Süresi Üzerindeki Etkileri

Omer Naci Ergin[1], Koray Sahin[1], Emre Kocazeybek[1], Ahmet Mucteba Yildirim[1], Irfan Ozturk[2]

[1] Department of Orthopedics and Traumatology, Istanbul Faculty of Medicine, Istanbul University

[2] Department of Orthopedics and Traumatology, Istanbul Florence Nightingale Hospital

Abstract

Aim: Diabetic foot disease (DFD) is a serious complication of diabetes mellitus and also represents a considerable financial burden to society. In this study, we aimed to evaluate the effects of amputation level on hospital costs and length of hospital stay in patients with DFD who were treated with major amputations.

Materials and Methods: Data of 72 patients who were hospitalized and underwent major amputations after a DFD diagnosis at our hospital between 2010 and 2017 were reviewed retrospectively. According to the level of amputation performed, three patient groups were identified: below-knee amputation (BKA) group, above-knee amputation (AKA) group, and two-stage (first BKA and then AKA) amputation (TSA) group. Data on hospital costs and length of hospital stay were reviewed. Hospital costs were evaluated under four categories: drug costs, resource/material costs, examination/treatment costs, and total costs. Results were compared with Kruskal–Wallis one-way analysis of variance.

Results: The BKA, AKA, and TSA groups consisted of 50 (25 males, 25 females), 11 (10, 1), and 11 (9, 2) patients, with a median patient age of 66, 64, and 66 years, respectively. For the BKA, AKA, and TSA groups, the median drug cost was $1,058, $1,072, and $2,240, the median resource/material cost was $223, $405, and $1,349, the median examination/treatment cost was $2,628, $2,405, and $3,587, the median total cost was $4,612, $5,832, and $6,848, and the median length of hospital stay was 35 days, 33 days, and 63 days, respectively. In terms of all cost categories and length of hospital stay, no statistically significant difference was found between the three groups (p>0.05).

Discussion and Conclusion: In DFD patients treated with major amputations, amputation level does not appear to make a significant difference in the amount of hospital costs and length of hospital stay.

Keywords: amputation; diabetes mellitus; diabetic foot disease, diabetic foot ulcer

Öz

Amaç: Diyabetik ayak hastalığı (DAH), ciddi diyabet (mellitus) komplikasyonlarından biridir ve toplum için önemli bir finansal yük teşkil etmektedir. Bu çalışmada tedavisinde majör ampütasyon uygulanan DAH hastalarında ampütasyon seviyesinin hastane maliyetleri ve hastanede kalış süresi üzerindeki etkilerini değerlendirmek amaçlamıştır.

Gereç ve Yöntemler: 2010—2017 yıllarında DAH tanısıyla hastanemize yatırılan ve majör ampütasyon uygulanan 72 hastaya dair veriler retrospektif olarak incelendi. Ampütasyonun uygulandığı seviyeye göre üç grup hasta tanımlandı: diz-altı ampütasyon (DAA) grubu, diz-üstü ampütasyon (DÜA) grubu, ve iki aşamalı (önce DAA sonra DÜA) ampütasyon (İAA) grubu. Hastane maliyetlerine ve hastanede kalış süresine dair veriler incelendi. Hastane maliyetleri dört kategoride değerlendirildi: ilaç maliyetleri, kaynak/malzeme maliyetleri, tetkik/tedavi maliyetleri, toplam maliyet. Sonuçlar Kruskal–Wallis tek yönlü varyans analiziyle karşılaştırıldı.

Bulgular: Sırasıyla, DAA, DÜA ve İAA grupları 50 (25 erkek, 25 kadın), 11 (10, 1) ve 11 (9, 2) hastadan oluşmakta olup ortanca hasta yaşı 66, 64 ve 66 yıl idi. Sırasıyla, DAA, DÜA ve İAA grupları için ortanca ilaç maliyeti 1.058$, 1.072$, 2.240$, ortanca kaynak/malzeme maliyeti 223$, 405$, 1.349$, ortanca tetkik/tedavi maliyeti 2.628$, 2.405$, 3.587$, ortanca toplam maliyet 4.612$, 5.832$, 6.848$ olup ortanca yatış süresi ise 35 gün, 33 gün, 63 gün idi. Tüm maliyet kategorileri ve hastanede kalış süresi bakımından üç grup arasında istatistiksel olarak anlamlı fark tespit edilmedi (p>0,05).

Tartışma ve Sonuç: DAH tedavisinde majör ampütasyon uygulanan hastalarda ampütasyon seviyesi hastanede kalış süreleri ve hastane maliyetleri açısından anlamlı bir fark oluşturur görünmemektedir.

Anahtar Sözcükler: ampütasyon; diabetes mellitus; diyabetik ayak hastalığı; diyabetik ayak ülseri

* This paper was presented at the 28th Turkish National Orthopedics and Traumatology Congress (2018, Antalya).

Received/*Geliş* : 27.07.2020
Accepted/*Kabul*: 08.08.2020

DOI: 10.21673/anadoluklin.774704

Corresponding author/*Yazışma yazarı*

Koray Sahin

Turgut Özal Millet Cad., İstanbul Tıp Fakültesi, Ortopedi ve Travmatoloji Anabilim Dalı, 34093 Istanbul, Turkey
E-mail: drkoraysahin@gmail.com

ORCID

Omer Naci Ergin: 0000-0001-6848-6930
Koray Sahin: 0000-0002-4759-4729
Emre Kocazeybek: 0000-0001-5861-8653
A. Mucteba Yildirim: 0000-0003-4460-815X
Irfan Ozturk: 0000-0001-7845-6794

INTRODUCTION

Globally, diabetes mellitus (DM) has become a serious health concern due to the increasing rates of sedentary lifestyle, obesity, unhealthy dietary habits, and tobacco use. The global prevalence of DM, which was 4.7% in 1980, reached 8.5% in 2014 and has since been rapidly increasing (1). Besides serious complications including cardiovascular and cerebrovascular diseases and renal failure, DM can also lead to diabetic foot disease (DFD), which is accompanied by high morbidity and mortality, causing important public health and social problems.

Basically, DFD is caused by impaired peripheral vascular circulation. The peripheral neuropathy can present with a wide range of symptoms. It can cause ulceration that may progress to wound infection, abscess formation, and osteomyelitis. The DFD incidence is expected to rise due to the increasing average life expectancy and DM prevalence. It has been reported that 15–25% of all DM patients worldwide will develop foot ulcer at least one time during their lifetime (2,3). Furthermore, DFD is a chronic pathology, with no definitive treatment in most cases. It is associated with recurrent hospitalizations for long periods of time, during which the treatment may eventually require an amputation of the affected foot (4). Given the related psychological and social problems, clinicians and patients often have great difficulty making the amputation decision and determining the amputation level. Also, DFD imposes a serious financial burden on the society and health-care system. Accordingly, in this study we aimed to evaluate the effects of amputation level on hospital costs and length of hospital stay in patients with DFD who underwent major amputations.

MATERIALS AND METHODS

Data of patients who visited the hospital of the Istanbul University Istanbul Faculty of Medicine between January 2010 and December 2017 and were diagnosed with DM and DM-related complications (according to the International Classification of Diseases-9 and -10, codes 250.00-03 and E10-14, respectively) were reviewed retrospectively. Patients who underwent a below-knee amputation (BKA) or above-knee amputation (AKA) during their DFD treatment were identified. Medical records of the patients revealed that some patients who underwent BKA needed a second amputation, undergoing AKA procedures during the follow-up. These patients were categorized into a third group, the "two-stage amputation" (TSA) group. Hospitalizations of all patients, during which the amputations were performed at affiliated clinics (orthopedics and traumatology, cardiovascular surgery, plastic and reconstructive surgery, undersea and hyperbaric medicine, infectious diseases), were included. Costs recorded during the included hospitalizations were calculated by reviewing the registry and billing system of our institute and classified under four categories (drug costs, resource/material cost, examination/treatment cost, and total cost). All costs were first calculated in Turkish liras (TRY) and then converted into US dollars (USD) using the average currency rates in the corresponding years. Data on length of hospital stay were also noted. Previous hospitalizations and previous minor amputations, hospitalizations at other clinics, and costs related to care at outpatient clinics were excluded.

Study ethics

Prior to the study, the study protocol was approved by the Ethics Committee of the Istanbul University Istanbul Faculty of Medicine (approval no. 3.7.2020-918).

Statistical analysis

Statistical analyses were performed using the NCSS 10 software (2015 Kaysville, Utah, USA). The normality of the distributions was tested by the Shapiro–Wilk test and checked graphically by histograms, Q-Q plot and box-plot graphs. Qualitative variables were described by percentages and frequencies while quantitative variables were described by median, minimum and maximum values. The groups were compared with Kruskal–Wallis one-way analysis of variance. No *post hoc* analysis was performed as no difference was found between the groups after statistical analysis. The groups were also assessed in terms of sex-related differences by Fisher's exact probability test. $p<0.05$ was considered statistically significant.

Table 1. Demographic and clinical data of the patients

	Below-knee amputation	Above-knee amputation	Two-stage amputation	*p*
Sex (female percentage)	25 males / 25 females (50)	10M / 1F (9.1)	9M / 2F (18.2)	0.016*
Median age, yr, (min.–max.)	66 (46–92)	64 (44–99)	66 (57–84)	0.897**
Patient number	50	11	11	
Number of amputated extremities	53	11	11	

max.: maximum; min.: minimum; yr: years

* Fisher's exact probability test

** Kruskal–Wallis one-way analysis of variance

Table 2. Study results given as median (minimum–maximum) values

	Below-knee amputation	Above-knee amputation	Two-staged amputation	*p*
Drug costs, $	1,058 (36–22,200)	1,072 (70–5,494)	2,240 (504–6,159)	0.109*
Resource/material costs, $	223 (19–10,139)	405 (27–2,543)	1,349 (175–8,115)	0.086*
Examination/treatment costs, $	2,628 (626–17,802)	2,405 (670–9,288)	3,587 (1,714–13,000)	0.231*
Total costs, $	4,612 (871–43,572)	5,832 (1,205–21,556)	6,848 (2,965–21,129)	0.162*
Length of hospital stay, days	35 (6–450)	33 (5–152)	63 (24–204)	0.186*

* Kruskal–Wallis one-way analysis of variance

RESULTS

After the evaluation of medical records, a total of 72 patients were found to meet the inclusion criteria. The BKA, AKA, and TSA groups consisted of 50 (25 males, 25 females), 11 (10, 1) and 11 (9, 2) patients (p=0.016), with a median patient age of 66, (range: 46–92), 64 (44–99), and 66 (57–84) years (p=0.897), respectively. Medical records of 3 patients who underwent BKA revealed that a second BKA was performed on the contralateral extremities during the follow-up. Therefore, the BKA group analyses of hospital costs and hospital stay were performed considering 53 extremities of 50 patients (Table 1).

For the BKA group, the median drug cost was $1,058 (range: $36–22,200), the median resource/material cost was $223 ($19–10,139), the median examination/treatment cost was $2,628 ($626–17,802), the median total cost was $4,612 ($871–43,572), and the median length of hospital stay was 35 (6–450) days.

For the AKA group, the median drug cost was $1,072 ($70–5,494), the median resource/material cost was $405 ($27–2,543), the median examination/treatment cost was $2,405 ($670–9,288), the median total cost was $5,832 ($1,205–21,556), and the median length of hospital stay was 33 (5–152) days.

For the TSA group, the median drug cost was $2,240 ($504–6,159), the median resource/material cost was $1,349 ($175–8,115), the median examination/treatment cost was $3,587 ($1,714–13,000), the median total cost was $6,848 ($2,965–21,129), and the median length of hospital stay was 63 (24–204) days (Table 2).

No statistically significant difference was found between the three groups in terms of all cost categories and length of hospital stay (p>0.05) (Table 2).

DISCUSSION AND CONCLUSION

Awareness about DM and its complications has been on the rise in recent years as DM is considered the epidemic of the 21st century due to its high prevalence (5). However, DFD, one of the most serious complications of DM, has been a common study subject for its social and financial implications as well. Although findings reported in those studies can vary according to the socioeconomic facts of the country focused on, one common result is that DFD imposes a major financial burden on the society and national healthcare system.

In the United States, at least 33% of all DM-related costs were reported to be associated with DFD treatment (6). The mean per-admission cost of DFD, which was around $9,397 between 2005 and 2010, was reported to be significantly higher in patients with infection. It was also stated that 83% of all major

and 96% of all minor amputations were performed due to DFD, and that the presence of DM could increase the foot ulcer treatment costs by 10-fold (7). A systematic review found that the mean per-hospitalization cost of DFD was around $14,922 and could reach up to $81,364 in the case of an amputation (8). In the United Kingdom, the mean per-patient total annual DFD cost to the National Health Service was estimated at £7,800. During the years 2015 and 2016, the mean annual costs per healed, unhealed, and amputated foot were reported to be £2,140, £8,800, and £16,900, respectively (9). A Canadian study estimated that the total annual DFD cost to the national health-care system was $547 million or $21,371 per case in 2011. The authors stated that the average cost of DFD treatment increased beyond inflation, attributing this increase to the use of new treatment options including bioactive gauzes and the recent focus on peripheral vascular surgery for preventing amputations (10). In Europe, the 2008 Eurodiale study showed that mean per-patient cost of DFD varied from €7,147 to €18,790 and could increase up to €24,540 if an amputation was performed (11).

In developing countries, even though the total costs of DFD care appear to be lower than those observed in developed countries, DFD still causes large costs when compared to other national health expenditures. A study carried out in Turkey estimated the mean per-patient direct total cost of DFD at $14,287, and attributed 51.5% of this cost to inpatient treatment (12). In India, it was reported that the mean per-patient total and in-hospital costs of DFD care were $3,526 and $2,547, respectively (13).

The cost of DFD care increases if the wound is complicated, and the highest costs are observed in the case of a major amputation. In this study, we focused on this fact and aimed to compare the hospital costs of DFD patients who underwent major amputations. To our knowledge, it is a first study to compare the effects of amputation level on hospital costs in this patient population. Moreover, a detailed evaluation was made by analyzing the cost data under certain categories. Our results showed that patients who underwent two-stage amputations caused higher health-care expenditures and experienced longer hospital stays, compared to patients treated with single-stage BKAs or AKAs. However, the differences between the three groups were not found to be statistically significant.

It is known that hospital costs do not constitute the most important factor while determining the amputation level in patients with DFD. Instead, the condition of the affected limb, comorbidities in the case, expectations of the patient and his family are and should be the primary considerations during the treatment. The amputation should be followed by adequate orthosis-based patient mobilization, with minimum risk of re-operation. However, it is also true that the financial burden of DFD treatment on health-care systems is unignorable. Therefore, in this study we presented data on direct hospital costs associated with DFD. However, the actual costs are greater when indirect costs caused by disability and losses of work capacity are also taken into account. Accordingly, recent studies have put emphasis on the importance of preventive medicine and limb salvage procedures, reporting that multidisciplinary approach is the mainstay of the management of DFD, providing better outcomes and lower amputation rates (14–17).

Finally, other limitations of our study should also be noted, the main of which are its retrospective design, use of a small number of patients from a single center, and lack of outpatient follow-up and home-care cost data. Also, despite our meticulous efforts, we obtained our study data from the registry system of our institute by using the ICD codes and errors due to coding mismatches are possible. As a result, it is possible that our findings might not represent the actual costs with sufficiently high accuracy.

In conclusion, our results suggest that amputation level in DFD treatment with major amputations does not make a significant difference in hospital costs and length of hospital stay. However, further larger-scale studies are needed to better reflect and estimate the actual financial costs of DFD.

Conflict-of-Interest and Financial Disclosure

The authors declare that they have no conflict of interest to disclose. The authors also declare that they did not receive any financial support for the study.

REFERENCES

1. Sarwar N, Gao P, Seshasai SR, Gobin R, Kaptoge S, Di Angelantonio E, et al. Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. Lancet. 2010;375(9733):2215–22.
2. Bild DE, Selby JV, Sinnock P, Browner WS, Braveman P, Showstack JA. Lower-extremity amputation in people with diabetes. Epidemiology and prevention. Diabetes Care. 1989;12(1):24–31.
3. Singh N, Armstrong DG, Lipsky BA. Preventing foot ulcers in patients with diabetes. JAMA. 2005;293(2):217–28.
4. Hobizal KB, Wukich DK. Diabetic foot infections: current concept review. Diabet Foot Ankle. 2012;3:10.3402/dfa.v3i0.18409.
5. Jaacks LM, Siegel KR, Gujral UP, Narayan KM. Type 2 diabetes: a 21st century epidemic. Best Pract Res Clin Endocrinol Metab. 2016;30(3):331–43.
6. Driver VR, Fabbi M, Lavery LA, Gibbons G. The costs of diabetic foot: the economic case for the limb salvage team. J Vasc Surg. 2010;52(Suppl. 3):17S–22S. [with correction in J Vasc Surg. 2010;52(6):1751].
7. Hicks CW, Selvarajah S, Mathioudakis N, Sherman RL, Hines KF, Black JH, et al. Burden of infected diabetic foot ulcers on hospital admissions and costs. Ann Vasc Surg. 2016;33:149–58.
8. Petrakis I, Kyriopoulos IJ, Ginis A, Athanasakis K. Losing a foot versus losing a dollar; a systematic review of cost studies in diabetic foot complications. Expert Rev Pharmacoecon Outcomes Res. 2017;17(2):165–80.
9. Guest JF, Fuller GW, Vowden P. Diabetic foot ulcer management in clinical practice in the UK: costs and outcomes. Int Wound J. 2018;15(1):43–52.
10. Hopkins RB, Burke N, Harlock J, Jegathisawaran J, Goeree R. Economic burden of illness associated with diabetic foot ulcers in Canada. BMC Health Serv Res. 2015;15:13.
11. Prompers L, Huijberts M, Schaper N, Apelqvist J, Bakker K, Edmonds M, et al. Resource utilisation and costs associated with the treatment of diabetic foot ulcers. Prospective data from the Eurodiale Study. Diabetologia. 2008;51(10):1826–34.
12. Oksuz E, Malhan S, Sonmez B, Numanoglu Tekin R. Cost of illness among patients with diabetic foot ulcer in Turkey. World J Diabetes. 2016;7(18):462–9.
13. Shobhana R, Rao PR, Lavanya A, Vijay V, Ramachandran A. Foot care economics--cost burden to diabetic patients with foot complications: a study from southern India. J Assoc Physicians India. 2001;49:530–3.
14. Driver VR, Goodman RA, Fabbi M, French MA, Andersen CA. The impact of a podiatric lead limb preservation team on disease outcomes and risk prediction in the diabetic lower extremity: a retrospective cohort study. J Am Podiatr Med Assoc. 2010;100(4):235–41.
15. Driver VR, Madsen J, Goodman RA. Reducing amputation rates in patients with diabetes at a military medical center: the limb preservation service model. Diabetes Care. 2005;28(2):248–53.
16. Zayed H, Halawa M, Maillardet L, Sidhu PS, Edmonds M, Rashid H. Improving limb salvage rate in diabetic patients with critical leg ischaemia using a multidisciplinary approach. Int J Clin Pract. 2009;63(6):855–8.
17. Hartemann-Heurtier A, Ha Van G, Danan JP, Koskas F, Jacqueminet S, Golmard JL, et al. Outcome of severe diabetic foot ulcers after standardised management in a specialised unit. Diabetes Metab. 2002;28(6 Pt 1):477–84.