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Review

Amputation as a marker of the quality of foot care in diabetes

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Abstract

Strategic targets for the management of foot ulcers focus on reducing the incidence of amputation. While data on the incidence of amputation can be obtained relatively easily, the figures require very careful interpretation. Variation in the definition of amputation, population selection and the choice of numerator and denominator make comparisons difficult. Major and minor amputation have to be distinguished as they are undertaken for different reasons and are associated with different costs and functional implications. Many factors influence the decision of whether or not to remove a limb. In addition to disease severity, co-morbidities, and social and individual patient factors, many aspects of the structure of care services affect this decision, including access to primary care, quality of primary care, delays in referral, availability and quality of specialist resources, and prevailing medical opinion. It follows that a high incidence of amputation can reflect a higher disease prevalence, late referral, limited resources, or a particularly interventionist approach by a specialist team. Conversely, a low incidence of amputation can indicate a lower disease prevalence or severity, good management of diabetes in primary and secondary care, or a particularly conservative approach by an expert team. An inappropriately conservative approach could conceivably enhance suffering by condemning a person to months of incapacity before they die with an unhealed ulcer. The reported annual incidence of major amputation in industrialised countries ranges from 0.06 to 3.83 per 10^3 people at risk. Some centres have documented that the incidence is falling, but this is often from a baseline value that was unusually high. Other centres have reported that the incidence has not changed. The ultimate target is to achieve not only a decrease in incidence, but also a low overall incidence. This must be accompanied by improvements in morbidity, mortality, and patient function and mood.

Keywords Amputation · Complications of diabetes · Diabetes · Foot ulcer · Gangrene · Ischaemia · Neuropathy · Osteomyelitis · Peripheral arterial disease · Vascular disease.

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Abbreviations: WHO, World Health Organization

Introduction

Foot ulceration presents a major threat to people with diabetes: it is a common complaint, healing is slow and uncertain, and the overall prognosis is poor [1, 2, 3, 4, 5]. It is also a source of considerable cost to healthcare agencies [3, 6, 7, 8, 9]. However, estimation of the total burden on people and budgets is difficult because the condition is managed by many different health professionals and frequently coexists with other morbidities. Moreover, there is no consensus on ulcer classification or agreement on measures of the

effectiveness of disease management. It is against this background that strategic targets have been set that use the incidence of amputation as the principal marker of the quality of care of the diabetic foot [10, 11, 12, 13].

The advantage of using amputation as an endpoint is that it is superficially simple and easy to define, with assessment facilitated by the need for hospital admission. A large number of studies have investigated the incidence of amputation in many countries and cultures of the world, but comparison of the results has been made difficult by the lack of an agreed definition, the use of different numerators and denominators, and the effect of population selection. Crucially, the incidence of amputation is dependent not just on the severity of the disease and the quality of specialist care, but on many confounding medical, social and economic factors, including professional opinion and the organisation of local health services. The present article discusses the ways in which these factors may influence the incidence of amputation by reviewing the published literature on the subject.

Search methods

The material used for this review is based on the authors' personal knowledge of the literature, cross-references from published work, and repeated searches on PubMed and Medline using diabetes, complications, foot ulcer and amputation as keywords. Unless there was a specific indication, papers referring to activity prior to 1990 were generally excluded.

Data sources in published surveys

Population-based data. Reports should ideally be based on comprehensive, population-wide, prospective capture of all relevant clinical activity, but this is not routinely possible. Publications have therefore required detailed work, with cross-checking of records, such as operating theatre and rehabilitation unit records [6, 14, 15], and the use of capture–recapture methods [16, 17]. This situation should improve with the increasing adoption of comprehensive community-wide registers [18].

Data derived from specialist units. Data from specialist units are more likely to be accurate and complete, but are usually biased by population selection, which is affected by geography, preference, lesion type and severity, and accessibility to other specialists (e.g. vascular, plastic and orthopaedic surgery teams, and podiatric, wound care, diabetes, geriatric and rehabilitation teams). The nature and extent of the selection process may change over time. Given that data from specialist units are selected by referral, interpretation of information on the incidence of amputation requires some indication of lesion type or severity. This has been missing from previous work, mainly because of the lack of an agreed system that is sufficiently specific. New systems have been described and validated in recent years [19, 20], but international consensus is awaited [21].

Incidence of amputation: numerator and denominator

Numerator. The numerator population may refer to all amputations, to the first in any individual, or to the latest. Data may be adjusted for age, or stratified according to race or gender. Other causes of amputation, such as trauma or malignancy, are usually (but not always) excluded. Different criteria are used to define major and minor operations (see below).

Denominator. The denominator may refer to the total (diabetic and non-diabetic) population, or restricted to those with diabetes (type 1, type 2 or both, either previously diagnosed or diagnosed at presentation). Data may be derived from a population at particular risk or a cohort of people selected for prospective study.

Incidence is variously expressed as a percentage of a cohort, either in person-years or per 10^3, 10^4 or 10^5 (total or diabetic) population, in crude or age-adjusted figures. Use of the total (diabetic and non-diabetic) population is necessary when the prevalence of diabetes is not well documented. If incidence is expressed in terms of the diabetic ('at risk') population alone, this figure is itself dependent on the prevalence of known diabetes. If a community adopts systematic screening for diabetes, an increased number of the total amputations will be identified as being diabetes-related. The increased effectiveness of such screening programmes may mask a decrease achieved by improvements in specialist care. In general, however, comparisons within and between centres are more meaningful if data are expressed in terms of the diabetic population. The value of expressing incidence in terms of the total population is limited to assessing the social and economic cost, and cannot be used to examine the effectiveness of clinical care.

Definition of amputation

Amputation and debridement. The term 'amputation' refers to the surgical removal of part of the lower limb by transection of the leg, the foot or a digit, and necessarily includes the removal of bone. However, there may be no distinction between minor amputation and aggressive debridement, especially in cases where a digit is necrotic or where bone is infected and capable of being removed piecemeal from a foot rendered an-

aesthetic by neuropathy. In addition, necrotic toes may occasionally auto-amputate. The loss of a digit during the course of debridement or by auto-amputation is not usually included in estimates of incidence.

Major and lower extremity (lower limb) amputation. The term 'major amputation' has no agreed definition, but generally refers to the loss of a normally functional lower limb as a result of surgery at, above (usually transfemoral, rarely at the hip) or just below (transtibial) the knee. However, some definitions include operations performed below the ankle but proximal to the tarso-metatarsal joints, including Syme's procedure and ankle disarticulation, or any operation that excludes the toes [16]. The terms 'lower extremity amputation' and 'lower limb amputation' are used with imprecision, with no distinction in practice between the terms 'extremity' and 'limb'. Both are generally used to refer to all amputations of the lower limb. In the recently reported World Health Organization (WHO) multinational study of vascular disease in diabetes, the term 'lower extremity amputation' was also extended to include unoperated gangrene [22, 23].

Factors influencing the incidence of amputation

Population. The incidence of amputation may vary with race [24], with the prevalence of earlier major amputation being very high in certain groups. For example, 4.6% of all diabetic Mexican Americans aged >65 years have lost a leg [25]. This may be truly racial and reflect metabolic differences between different groups [26]; however, this is difficult to confirm due to the influence of diet, lifestyle, cultural beliefs and socio-economic factors [27, 28, 29, [30], 31]. If a racial group constitutes an ethnic minority in a multicultural society, then differences between groups may reflect varying access to healthcare services. Such factors may contribute to reported differences between the incidence of amputation in the US (where amputation in more common in those of Afro-Caribbean origin) and the UK (where it is less common in those of Afro-Caribbean origin, especially in men) [32]. Racial differences in the incidence of amputation between Caucasians and South Asians in the UK have been shown to be entirely attributable to differences in smoking and the prevalence of peripheral vascular disease and neuropathy [32, 33].

Aims of amputation. The aims of major and minor amputation differ. Transfemoral and transtibial operations are undertaken when the lower part of the leg is non-viable, or when it is in the patient's best interest (because of pain or incapacity, or because function is never likely to be restored). Major amputations represent a mutilating admission of failure in the face of otherwise untreatable disease. In contrast, minor amputation is intended to limit the extent of the presenting problem in order to maintain reasonable function of the limb. The two approaches should not be regarded simply as different ends of the same spectrum; combining them will mask any changes that may occur in only one approach. Some authors have noted that a decrease in the incidence of major amputations may be accompanied by an increase in the incidence of minor ones [34].

Minor amputation. The indications for undertaking minor amputation are subject to variation and, to a certain extent, depend on the specialist training of the clinician in charge. If the clinician is not surgically trained, minor amputation requires referral to another specialist, which may constitute a significant administrative barrier. The decision to opt for early minor surgery is also influenced by prevailing medical orthodoxy. For example, minor amputation for osteomyelitis of the forefoot is regarded as routine or recommended practice in some medical cultures [35, 36], whereas the conclusion drawn from numerous observational studies is that there is a good case for managing the condition conservatively [37].

Major amputation. The incidence of major amputation is influenced by many factors, including the prevalence of diabetes, lesion severity at the time of specialist referral, the options available, and agreement between the patient and the expert that loss of the limb is (or is not) the best option. A high incidence could therefore reflect greater disease prevalence, late referral, and limited resources, but may also indicate a particularly interventionist approach by a specialist team. It is known that the incidence of major amputation varies between four-fold [38, 39] and eight-fold [40] within the same country. In the UK, this has been shown to be associated with varying professional opinion to an appreciable extent [41]. The decision of whether or not to operate may also be influenced by the system for professional and institutional funding.

The corollary of this is that a low incidence of amputation may indicate a low level of disease prevalence or disease severity, with particularly good management of diabetes in primary and secondary care, and good management of established ulcers. However, it can also reflect an inappropriately conservative approach by an expert team, and such an approach might enhance suffering by condemning a person to months of incapacity before they die with their ulcer unhealed.

Patient's beliefs and wishes. The attitude of the patient (and/or family and carers) is a major factor in the decision of whether to amputate. Some patients will not consider the option of amputation. Faced with limited life expectancy, some will prefer to have a non-viable limb removed as soon as possible, while others will

Table 1. Total incidence of amputation (major and minor) in diabetes expressed per 10^5 total (diabetic and non-diabetic) population

Incidence	Year of study	Study population	Identification	Reference
2.8	1994–1996	Madrid, Area 7	Multiple	Calle-Pascual [6]
5.7	1989–1991	Newcastle, UK, City-wide	Multiple	Deerochanawong [14]
5.8	1996	Campania Region, Italy	Discharge data of regional hospitals	Vaccaro [43]
9.4	1982–1993	Two healthcare districts, Sweden	Records of single hospital in area	Larsson [44]
14.0	1995–1998	Australia[a], Nationwide	National hospital morbidity database	Payne [45]
18.1	1997	Taiwan, Nationwide	National database	Chen [46]
43.9	1995–1997	Navajo Indians	At least two sources	Group [15]

Note the factors listed in the main text that hamper comparison between centres. [a] Excluding two states

Table 2. Total incidence of amputation (major and minor) in diabetes expressed per 10^3 at-risk (diabetic) population

Incidence	Year of study	Study population	Identification	Reference
0.46	1994–1996	Madrid, Area 7	Single hospital records	Calle-Pascual [6]
1.10	1995–1997	Leicestershire, UK, Urban and rural	Multiple	Canavan [38]
1.47	1992–1997	Afro-Caribbeans managed in one of four hospitals in London, UK	Case control study, multiple sources	Leggetter [32]
1.81	1992–1994	Rio de Janeiro, City-wide	Multiple	Spichler [17]
2.05	1995–1997	Newcastle, UK, City-wide	Multiple	Canavan [38]
2.19	1992–1997	Europeans managed in one of four hospitals in London, UK	Case control study, multiple sources	Leggetter [32]
2.48	1993–1994	Tayside, Scotland, Community-wide	Diabetes register, multiple sources	Morris [18]
3.61	1991	Netherlands, Nationwide	National database	van Houtum [1]
4.17	1995–1997	Leeds, UK, City-wide	Multiple	Canavan [38]
4.66	1990–1991, 1994–1998	Leverkusen, Germany, City-wide	Records of all regional hospitals	Trautner [47]
4.99	1991	California total population[a]	State database	van Houtum [1]
5.9	–	All	Selected cohort study	Lavery [29]
7.4	–	Mexicans	Selected cohort study	Lavery [29]
4.1	–	Non-Hispanic whites	Selected cohort study	Lavery [29]
4.46	1995–1997	Middlesborough, UK Mainly urban	Multiple	Canavan [38]
6.6	1990, 1995	Rural Germany, two counties	Theatre records	Stiegler [48]
7.2	1999	Four public hospitals in Louisiana, USA	Hospital records	Birke [49]
11.3	1990s	Single VA centre in Seattle, USA	Male cohort	Adler [50]
18.0	1980s	Oklahoma Indians	Selected cohort study	Lee [51]
96.0	1998–1999	Louisiana (USA) high-risk group	Selected cohort study	Patout [26]

Note the factors listed in the main text that hamper comparison between centres. [a] Excluding VA hospitals. VA, Veterans' Affairs

prefer to avoid major surgery and cope as best they can. Such attitudes are influenced by the advice of their carers and by the relative weight attached to professional and patient choice in the prevailing medical culture.

Reported incidence of amputation

All of the aforementioned factors influence the reported data on incidence listed below; therefore, apparent differences have to be assessed with great care [40, 42]. Because of the considerable changes that have taken place in all aspects of healthcare over the last 20 years, limited reference has been made to the older literature. When centres have reported incidence more than once, that provided in the Tables is the most recent.

All amputations (major and minor) in diabetes. The reported total incidence of amputation (major and minor) in diabetes ranges from 2.8 to over 40 per 10^5 total inhabitants (Table 1). When expressed per 10^3 people with identified diabetes, the incidence ranges from 0.46 to approximately 7 in the majority of industrialised countries, although very much higher values have been reported in some ethnic and socially disadvantaged groups (Table 2). The incidence in the US is approximately double that in The Netherlands [1]. Within Europe, the incidence varies by a factor of five to ten, with rather higher figures in Germany and Switzerland [22] compared with most of the UK and

Table 3. Incidence of major amputation in diabetes expressed per 10^5 total (diabetic and non-diabetic) inhabitants

Incidence	Year of study	Study population	Identification	Reference
3.5	1996	Campania Region, Italy	Discharge data of regional hospitals	Vaccaro [43]
3.6	1982–1993	Two healthcare districts, Sweden	Records of the single hospital in the area	Larsson [44]
3.83	1996–1997	Medicare claims, USA	306 health referral regions	Wrobel [40]
4.4	1994–1997	Trondheim	Records of University Hospital	Witsø [52]
4.55[a]	1982–1993	All Danish women	National patient register	Ebskov [53]
4.70[b]	1982–1993	All Danish men	National patient register	Ebskov [53]
4.7	1990–1991, 1994–1998	Leverkusen, Germany, City-wide	Records of all regional hospitals	Trautner [47]
5.7	1989–1991	Newcastle, UK City-wide	Multiple	Deerochanawong [14]
6.9	1995	Central Copenhagen	Records of a single specialist unit	Holstein [34]
8.8	1997	Taiwan, Nationwide	National database	Chen [46]

Note the factors listed in the main text that hamper comparison between centres. [a] Mean incidence over 11 years (lowest annual incidence 3.2); [b] mean incidence over 11 years (lowest annual incidence 3.6)

Table 4. Incidence of major amputation in diabetes expressed per 10^3 at-risk (diabetic) population

Incidence	Year of study	Population	Identification	Reference
0.056	1997–1999	Madrid, Area 7, women	Single hospital records	Calle-Pascual [16]
0.12	1997–1999	Madrid Area 7, men	Single hospital records	Calle-Pascual [16]
2.30	1990–1991, 1994–1998	Leverkusen, Germany, City-wide	Records of all regional hospitals	Trautner [47]
2.48	1993–1994	Tayside, Scotland, Community-wide	Community	Morris [18]
3.83	1996–1997	MedicareUSA	Claims from 306 health referral regions	Wrobel [40]
6.0	1994–1996	Chippewa Indians	Cohort study	Rith-Najarian [54]
18.0	1980s	Oklahoma Indians	Cohort study	Lee [51]

Note the factors listed in the main text that hamper comparison between centres

The Netherlands. Whether expressed in terms of total inhabitants or at-risk population, the incidence reported for Madrid (Spain) is the lowest [6, 16].

Major amputation in diabetes. Reported data on the incidence of major amputation alone (however defined and/or selected) are shown in Tables 3 and 4. If high-risk populations are excluded, the incidence of major amputation per 10^3 people at risk is generally less than 4.0 (Table 4). One group studied the incidences of different types of major procedure (per 10^3) and found that the incidence of transtibial amputation was 1.80 in The Netherlands and 2.21 in California (USA), while the corresponding values for the incidence of transfemoral amputation were 0.36 and 0.65, respectively [1].

Reported changes in amputation rate

All diabetic and non-diabetic amputations. The incidence of non-traumatic amputation has been closely monitored in an attempt to evaluate the massive increase in the number of angioplasty and other revascularisation procedures performed. However, the results have been conflicting. Tunis and colleagues reported no change in the total incidence of amputation in Maryland, USA between 1979 and 1989 [55], while Feinglass and colleagues reported that there was a small decrease in the incidence of major amputation in the US in the early 1990s that was not maintained [56]. In contrast, the incidence of major amputation is reported to have decreased in the UK (although the fall largely preceded the increase in angioplasty) [57] and in Denmark [58]. A reduction in all amputations was reported by a study on Veterans Health Administration facilities (a predominantly male, lower-income study population) [59]. One Finnish study reported a decrease in the incidence of major amputation [60], whereas a different group from Finland failed to observe a decrease in the total incidence of amputation. It should be noted that in some of the cases where a decrease was observed, the baseline and final incidences were higher than those in equivalent populations.

Amputation in diabetes. Following the introduction of targeted education and care programmes in high-risk populations in the US, a decrease in the total incidence of amputation in diabetes has been reported by some groups [26, 49, 62], but not all [63]. In the Veterans Health Administration population, the decrease

in incidence was confined to the non-diabetic subjects [59]. The overall incidence of amputation for diabetes in the US has not changed [64].

The data from Europe are conflicting. Various groups have reported a decrease in the total incidence of amputation in diabetes [16, 18, 44, 53]; however, in some cases the baseline incidence was high [18, 44]. Nevertheless, the decrease observed across Denmark was from a more modest baseline [53], while that in Madrid was already low [6]. In contrast, two community-based studies from Germany failed to demonstrate any decrease over periods of 8 and 5 years respectively [47, 48]. Significant decreases in the incidence of major amputation have also been reported from Denmark [34, 58] and Sweden [44], but the baseline was high in each case. The estimated decrease over 11 years in Tayside, Scotland is subject to the same limitation [18]. More encouragingly, recent nationwide data from The Netherlands have indicated a significant decrease in the incidences of amputations at all levels between 1991 and 2000, even though the baseline was not high [65]. In Madrid, the low baseline incidence of major amputation has been further reduced [16].

Conclusions

There are many reasons why there is wide variation in the reported incidence of amputation. These relate to medical, cultural and social issues, and are very dependent on the structure of healthcare services, as well as on the attitudes of the professionals involved. However, reported figures are also critically dependent on population selection and on the way in which the data are collected and analysed. Future analyses and comparisons will not be meaningful unless considerable efforts are made to optimise and harmonise the methods used. Until this occurs, the incidence of amputation must be regarded as a flawed measure of the quality of clinical care. Ultimately, however, the aim should be to achieve not only a reduction, but also an overall low incidence of amputation. Furthermore, a low incidence of major amputation needs to be qualified by measures of the morbidity and mortality of those who do not undergo surgery so as to ensure that their suffering is not increased. There is a clear need for a consensus panel to be established under the auspices of the WHO or the International Diabetes Federation to determine how the quality of care of the diabetic foot can be best monitored.

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References

1. van Houtum WH, Lavery LA (1996) Outcomes associated with diabetes-related amputations in the Netherlands and in the state of California, USA. J Intern Med 240:227–231
2. Reiber GE, Lipsky BA, Gibbons GW (1998) The burden of diabetic foot ulcers. Am J Surg 176:5S–10S
3. Ramsey SD, Newton K, Blough D et al. (1999) Incidence, outcomes, and cost of foot ulcers in patients with diabetes. Diabetes Care 22:382–387
4. Moulik PK, Mtonga R, Gill GV (2003) Amputation and mortality in new-onset diabetic foot ulcers stratified by etiology. Diabetes Care 26:491–494
5. Jeffcoate WJ, Harding KG (2003) Diabetic foot ulcers. Lancet 361:1545–1551
6. Calle-Pascual AL, Redondo MJ, Ballesteros M et al. (1997) Nontraumatic lower extremity amputations in diabetic and non-diabetic subjects in Madrid, Spain. Diabetes Metab 23:519–523
7. Van Houtum WH, Lavery LA, Harkless LB (1995) The costs of diabetes-related lower extremity amputations in the Netherlands. Diabet Med 12:777–781
8. Tennvall GR, Apelqvist J, Eneroth M (2000) Costs of deep foot infections in patients with diabetes mellitus. Pharmacoeconomics 18:225–238
9. Clarke P, Gray A, Legood R, Briggs A, Holman R (2003) The impact of diabetes-related complications on healthcare costs: results from the United Kingdom Prospective Diabetes Study (UKPDS Study No. 65). Diabet Med 20:442–450
10. World Health Organization (Europe) and International Diabetes Federation (Europe) (1990) Diabetes care and research in Europe: the St Vincent Declaration. Diabet Med 7:360
11. Department of Health and Human Services (1991) Healthy people 2000: national health promotion and disease prevention objectives. US Government Printing Office, Washington D.C.
12. Department of Health and Human Services (2000) Healthy people 2010: understanding and improving health, Vol. 1. US Government Printing Office, Washington D.C.
13. Colagiuri S, Colagiuri R, Ward J (1998). National diabetes strategy and implementation plan. Diabetes Australia, Canberra
14. Deerochanawong C, Home PD, Alberti KG (1992) A survey of lower limb amputation in diabetic patients. Diabet Med 9:942–946
15. Group TG (2000). Epidemiology of lower extremity amputation in centres in Europe, North America and East Asia. The global lower extremity amputation study group. Br J Surg 87:328–337
16. Calle-Pascual AL, Garcia-Torre N, Moraga I et al. (2001) Epidemiology of nontraumatic lower-extremity amputation in Area 7, Madrid, between 1989 and 1999. Diabetes Care 24:1686–1689
17. Spichler ERS, Spichler D, Lessa I, Costa e Forte A, Franco LJ, La Porte RE (2001) Capture-recapture methods to estimate lower extremity amputation rates in Rio de Janiero, Brazil. Rev Panam Salud Publica 10:334–340
18. Morris AD, McAlpine R, Steinke D et al. (1998) Diabetes and lower-limb amputations in the community. Diabetes Care 21:738–743
19. Armstrong DG, Lavery LA, Harkless LB (1998) Validation of a diabetic wound classification system. Diabetes Care 21:855–859
20. Treece KA, Macfarlane RM, Pound P, Game FL, Jeffcoate WJ (2004) Validation of a system of foot ulcer classification in diabetes mellitus. Diabet Med 21:987–991

21. Schaper N (2004) Diabetic foot ulcer classification system for research purposes. Diabet Metab Res Rev 20 [Suppl 1]:S90–S95
22. Lee ET, Keen H, Bennett PH, Fuller JH, Lu M (2001) Follow-up of the WHO multinational study of vascular disease in diabetes: general description and morbidity. Diabetologia 44 [Suppl 2]:S3–S13
23. Chaturvedi N, Stevens LK, Fuller JH, Lee ET, Lu M (2001) Risk factors, ethnic differences and mortality associated with lower-extremity gangrene and amputation in diabetes. The WHO multinational study of vascular disease in diabetes. Diabetologia 44 [Suppl 2]:S65–S71
24. Lavery LA, Ashry HR, Van Houtum W, Pugh JA, Harkless LB, Basu S (1996) Variation in the incidence and proportion of diabetes-related amputations in minorities. Diabetes Care 19:48–52
25. Otiniano ME, Du X, Ottenbacher K, Black SA, Markides KS (2003) Lower extremity amputations in diabetic Mexican American elders. Incidence, prevalence and correlates. J Diabetes Complications 17:59–65
26. Patout CA, Birke JA, Horswell R, Wilimas D, Cerise FP (2000) Effectiveness of a comprehensive diabetes lower-extremity amputation prevention program in a predominantly low-income African-American population. Diabetes Care 23:1339–1342
27. Resnick HE, Valsania P, Phillips CL (1999) Diabetes mellitus and nontraumatic lower extremity amputation in black and white Americans. Arch Intern Med 159:2470–2475
28. Collins TC, Johnson M, Henderson W, Khuri SF, Daley J (2002) Lower extremity nontraumatic amputation among veterans with peripheral arterial disease: is race an independent factor? Med Care 40 [Suppl 1]:106–116
29. Lavery LA, Armstrong DG, Wunderlich RP, Tredwell J, Boulton AJM (2003) Diabetic foot syndrome: evaluating the prevalence and incidence of foot pathology in Mexican Americans and non-Hispanic whites from a diabetes disease management cohort. Diabetes Care 26:1435–1438
30. Young BA, Maynard C, Reiber G, Boyko EJ (2003) Effects of ethnicity and nephropathy on lower-extremity amputation risk among diabetic veterans. Diabetes Care 26:495–501
31. MMWR (2003) Lower extremity amputation episodes among persons with diabetes—New Mexico. MMWR Morb Mortal Wkly Rep 52:66–68
32. Leggetter S, Chaturvedi N, Fuller JH, Edmonds ME (2002) Ethnicity and risk of diabetes-related lower extremity amputation: a population-based, case-control study of African Caribbeans and Europeans in the United Kingdom. Arch Intern Med 162:73–78
33. Chaturvedi N, Abbott CA, Whalley A et al. (2002) Risk of diabetes-related amputation in South Asians vs Europeans in the UK. Diabet Med 19:99–104
34. Holstein P, Ellitsgaard N, Olsen BB, Ellitsgaard V (2000) Decreasing incidence of major amputations in people with diabetes. Diabetologia 43:844–847
35. American Diabetes Association (1999) Consensus development conference on diabetic foot wound care. Diabetes Care 22:1354–1360
36. Norden CW (1999) Acute and chronic osteomyelitis. In: Armstrong D, Cohen J (eds). Infectious diseases, vol 2. Mosby, London, pp 43.1–43.8
37. Jeffcoate WJ, Lipsky BA (2004) Controversies in diagnosing and managing osteomyelitis of the foot in diabetes. Clin Inf Dis 39 [Suppl 2]:S115–S122
38. Canavan R, Connolly V, McIntosh J, Airey M, Burden F, Unwin N (2003) Geographic variation in lower extremity amputation rates. Diabetic Foot 6:82–89
39. Van Houtum WH, Lavery LA (1996) Regional variation in the incidence of diabetes-related amputations in the Netherlands. Diabetes Res Clin Pract 31:125–132
40. Wrobel JS, Mayfield JA, Reiber GE (2001) Geographic variation of lower-extremity major amputation in individuals with and without diabetes in the Medicare population. Diabetes Care 24:860–864
41. Connelly J, Airey M, Chell S (2001) Variation in clinical decision making is a partial explanation for geographical variation in lower extremity amputation rates. Br J Surg 88:529–535
42. Van Houtum WH, Lavery LA (1997) Methodological issues affect variability in reported incidence of lower extremity amputations due to diabetes. Diabetes Res Clin Pract 38:177–183
43. Vaccaro O, Lodato S, Mariniello P, De Feo E (2002) Diabetes-related lower extremity amputations in the community: a study based on hospital discharge diagnoses. Nutr Metab Cardiovasc Dis 12:331–336
44. Larsson J, Apelqvist J, Agardh CD, Stenstrom A (1995) Decreasing incidence of major amputation in diabetic patients: a consequence of a multidisciplinary foot care team approach? Diabet Med 12:770–776
45. Payne CB (2000) Diabetes-related lower-limb amputation in Australia. Med J Aust 173:352–354
46. Chen SY, Chie WC, Lan C, Lin MC, Lai JS, Lien IN (2002) Rates and characteristics of lower limb amputations in Taiwan, 1997. Prosthet Orthot Int 26:7–14
47. Trautner C, Giani G, Haastert B et al (2001) Unchanged incidence of lower-limb amputations in a German city, 1990–1998. Diabetes Care 24:855–859
48. Stiegler H, Standl E, Frank S, Mendler G (1998). Failure of reducing lower extremity amputations in diabetic patients: results of two subsequent population based surveys in 1990 and 1995 in Germany. Vasa 27:10–14
49. Birke JA, Horswell R, Patout CA Jr, Chen SL (2003) The impact of a staged management approach to diabetes foot care in the Louisiana public hospital system. J La State Med Soc 155:37–42
50. Adler AI, Boyko EJ, Ahroni JH, Smith DG (1999) Lower-extremity amputation in diabetes. Diabetes Care 22: 1029–1035
51. Lee JS, Lu M, Lee VS, Russell D, Bahr C, Lee ET (1993) Lower-extremity amputation. Incidence, risk factors, and mortality in the Oklahoma Indian Diabetes Study. Diabetes 42:876–882
52. Witsø E, Ronningen H (2001) Lower limb amputations: registration of all lower limb amputations performed at the University Hospital of Trondheim, Norway 1994–1997. Prosthet Orthot Int 25:181–185
53. Ebskov B, Ebskov L (1996) Major lower limb amputation in diabetic patients: development during 1982 to 1993. Diabetologia 39:1607–1610
54. Rith-Najarian S, Branchaud C, Beaulieu O, Gohdes D, Simonson G, Mazze R (1998) Reducing lower-extremity amputations due to diabetes. Application of the staged diabetes management approach in a primary care setting. J Fam Pract 47:127–132
55. Tunis SR, Bass EB, Steinberg EP (1993) The use of angioplasty, bypass surgery, and amputation in the management of peripheral vascular disease. N Engl J Med 325:556–562
56. Feinglass J, Brown JL, LoSasso A et al. (1999) Rates of lower-extremity amputation and arterial reconstruction in the United States. Am J Public Health 89:1222–1227
57. Gutteridge B, Torrie P, Galland B (1994) Trends in arterial reconstruction, angioplasty and amputation. Health Trends 26:88–91

58. Ebskov LB, Schroeder TV, Holstein PE (1994) Epidemiology of leg amputation: the influence of vascular surgery. Br J Surg 81:1600–1603
59. Mayfield JA, Reiber GE, Maynard C, Czerniecki JM, Caps MT, Sangeorzan BJ (2000) Trends in lower limb amputation in the Veterans Health Administration, 1989–1998. J Rehab Res Devel 37:23–30
60. Eskelinen E, Eskelinen A, Hyytinen T, Jaakkola A (2001) Changing pattern of major lower limb amputations in Seinäjoki Central Hospital, 1997–2000. Ann Chir et Gynaecol 90:290–293
61. Pohjolainen T, Alaranta H (1999) Epidemiology of lower limb amputees in Southern Finland in 1995 and trends since 1984. Prosthet Orthot Int 23:88–92
62. Meltzer DD, Pels S, Payne WG, Mannari RJ, Ochs D, Forbes-Kearns J, Robson MC (2002) Decreasing amputation rates in patients with diabetes mellitus. J Am Podiatr Assoc 92:425–428
63. Bruckner M, Mangan M, Godin S, Pogach L (1999) Project LEAP of New Jersey: lower extremity amputation prevention in persons with type 2 diabetes. Am J Manag Care 5:609–616
64. MMWR (1997) Hospital discharge rates for nontraumatic lower extremity amputation by diabetes status—United States. MMWR Morb Mortal Wkly Rep 50:954–958
65. van Houtum WH, Rauwerda JA, Ruwaard D, Schaper NC, Bakker K (2004) Reduction in diabetes related lower extremity amputations in the Netherlands: 1991–2000. Diabetes Care 27:1042–1046