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The epidemiology of lower extremity amputations in centres in Europe, North America, and East Asia: results from the Global LEA Study

The Global Lower Extremity Amputation Study Group

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Abstract

Background: This study was established to enable the comparison of lower extremity amputation incidence rates between different centres around the world.

Methods: Ten centres, all with populations greater than 200,000, in Japan, Taiwan, Spain, Italy, United States and England collected data on all amputations occurring between July 1995 and June 1997. Cases were identified from at least two data sources (to allow checks on ascertainment); denominator populations were based on census figures.

Results: The highest rates were in the Navajo population (e.g. 43.9/100,000/ yr for first major amputations in men) and the lowest in Tochigi, Japan (e.g. 3.8/100,000/yr). The incidence of amputation rose steeply with age, with most amputations occurring over the age of 60, in most centres the incidence was higher in men than women, and the incidence of major was greater than that of minor amputations. Diabetes was associated with between 25% and 90% of amputations.

Conclusion: Apart from the Navajo centre, differences in the known prevalence of diabetes can not account for the differences in overall incidence. Differences in the prevalence of peripheral vascular disease are likely to be important but this and the role of other factors, including health care, are worthy of further investigation.

INTRODUCTION

The study described in this paper was established to overcome some of the difficulties encountered in comparing amputation rates from previously published studies. For example, inconsistencies between published studies related to the inclusion or not of people with diabetes in the overall rates, the inclusion of first ever or all amputations in the rates, and differences in the level of amputation presented. In addition age specific rates tended not to be presented making comparison between populations with different age structures difficult. Finally, different studies often used different data sources and numbers of sources to identify amputations. This means it is possible that differences exist in the level of ascertainment of amputations between studies[1].

Thus the main aim of establishing this study was to enable the comparison of the incidence of lower extremity amputations between populations by using a standard approach to data collection and analysis.

METHODS

Recruitment and characteristics of the study centres

Most centres were recruited to the study following publication of the study protocol[1]. Other centres became involved once the study was established - mainly through professional contact with investigators at participating centres. A detailed "Methods of Operation" manual was written and distributed to each centre.

Sufficient data were received from 10 centres, in 5 countries, to be presented in this paper. Data were collected on all amputations occurring between July 1st 1995 and June31st 1997. The names, population sizes and sources of data for LEAs for each of the centres are shown in table I. In order to participate each centre had to have access to up to date demographic data for their population in order to allow the calculation of age and sex specific rates. Tochigi in Japan was only able to collect data on first ever major and minor amputations.

Definition of LEA and collection of data on amputations

The definition of a lower extremity amputation used in this study is the complete loss of any part of the lower limb, for any reason, in the following anatomical planes: in the transverse anatomical plane proximal to and including the subtalar joint, and in the frontal anatomical plane distal to the subtalar joint. For the purposes of this paper we define a "major amputation" as through or proximal to the tarsometatarsal joint and a "minor amputation" as one distal to this joint.

Centres were asked to use more than one source to identify cases - ideally at least three, but where this was not possible two were accepted. Sources from which cases were identified were dependent on local circumstances and so differed between centres. They are shown in Table I. As far as possible, medical records were traced for each case and a standard data abstraction form completed. With the exception of some aspects of personal details the data abstraction form was identical for each of the centres. The data collected included the date and level of the most recent amputation, and conditions associated with it (including diabetes, infection, peripheral vascular disease and trauma); and the presence and level of any previous amputations.

Centres undertook a pilot study to test the feasibility of abstracting data from the different sources, and sent the completed forms to Newcastle (the co-ordinating centre) in order to check that the data collection forms from each centre were completed to a comparable and adequate standard.

Data analysis

Most centres entered their data locally and all data were entered using a standard data base format designed only to allow valid values for each variable. Age and sex denominator population sizes were taken from the most recent census figures for each population. Age specific, crude and age adjusted rates are presented for men and women separately. As all the centres (with the exception of Navajo Area) have relatively old population age structures the standard European population[2] was used as the population for direct age standardisation.

The aim of this study was to measure the incidence of amputations in whole geographically defined populations and not samples of larger populations hence we do not present confidence intervals or use p values. What is relevant is the level of ascertainment of amputations. Estimates of the level of ascertainment were derived using capture-recapture methods[3,4]. These derive their name from their development and use in estimating the size of wildlife populations. They have been increasingly used in epidemiology. With more than one source of cases it is possible to estimate the total number from the numbers of cases identified on one source only and those identified on more than one source[5]. With only two sources the capture-recapture method is based on the assumption that the sources are independent. This assumption is rarely met with health care data, but if the direction of dependency is known it is still possible to derive useful information[6], and this approach has been used here in the situation where only two sources were available. With three or more sources log-linear modelling[5] and a confidence interval for the total number of cases computed using a goodness of fit based method[7]. The numbers of cases were too small to provide robust age specific estimates of ascertainment but it was felt important to examine ascertainment for first and all amputations separately as experience suggested ascertainment amongst these categories may differ. The ascertainment of minor and major amputations was also examined separately. This was because experience also suggested that ascertainment between these two is likely to differ but in addition because some sources, in particular, limb fitting centres, provide data on major but not on minor amputations. In order to have reasonable numbers of cases for these different categories in the analyses men and women were combined.

Population diabetes prevalence figures were not available for all centres, therefore the numbers of people with known diabetes are presented simply as a proportion of all cases of lower extremity amputations in each centre. The proportions of cases noted to be associated with peripheral vascular disease, infection and trauma are also presented.

RESULTS

Overall incidence of amputations

There were marked differences in the overall incidence of both first and all amputations between the study centres (tables 2a&b and 3a&b) with over a 10 fold difference between the highest and lowest areas. The data for first ever major and minor amputations are illustrated in figures 1 and 2. The highest rates for men and women, first and all, major and minor amputations, were in the Navajo area. The lowest rates for first amputations were in the Japanese population of Tochigi. Between the Western European centres there were also marked differences. Rates in Madrid (Spain), Vicenza (Italy) and Leicester (UK) all being substantially lower than those were in the North of England i.e. Leeds, Middlesborough, Newcastle.

Estimated levels of ascertainment

Table 4 shows capture-recapture estimated levels of case ascertainment. Even with the figures for men and women combined (as done here) the confidence intervals on the estimated number of amputations tend to be broad. For minor amputations in Leicester and Ilan the numbers were either too small or the overlaps between the data sources inadequate to enable meaningful capture-recapture estimates to be made. For first amputations estimates of ascertainment were low (less than 70%) in two centres, Tochigi and Vicenza. In three (Leeds, Middlesborough and Montgomery County) they were above 95% for first major and minor amputations. All the rest fell somewhere above 75% and less than 95%. The interpretation and utility of these estimates is addressed in the discussion.

Age and sex distribution of amputations

Although the overall rates varied greatly between centres the age and sex distribution of amputations were very similar. Thus in all centres the incidence of both major and minor amputations in both men and women rose steeply with age, with the largest increases tending to come between the age groups of 40-59 and 60-79 (tables 2a&b and 3a&b). Around two thirds or more of amputations occurred in the ages above 60 with the exception of minor amputations in men and women in the Navajo area and first major amputations in men in Japan. Overall amputation rates were substantially higher in men than in women, from 17% higher crude rates for first major amputations in men compared to women in Leicester, to over 400% higher for all major and minor amputations in Madrid. The exceptions to this were first and all major amputations in Vicenza, where crude and age adjusted rates were higher in women than men (entirely accounted for by high rates in women aged 80 and over), and for first minor amputations in Leeds where the rates in men and women were similar.

Relationship of major to minor and all to first amputations

In most centres the incidence of both first and all major amputations was greater than the incidence of first and all minor amputations respectively (tables 2a&b and 3a&b). The most extreme exception to this is the Navajo area where the incidence of major amputations was between 50% (all, men) and 79% (first, women) of the incidence of minor. As would be expected the incidence of all amputations was greater than the incidence of first amputations in almost all centres. The only exception was for minor amputations in Ilan where the rates were similar. In the other centres rates of all amputations were higher than rates of first amputations from an order of around 10% (major amputations in men in Ilan) up to 251% (major amputations in women in Montgomery county). Most were in the order of 20 to 40% higher.

Conditions associated with amputations

Table 5 shows the percentage of first major and minor amputations associated with trauma, diabetes, infection and peripheral vascular disease (PVD) for men and women in each of the centres. Note that more than one condition may be present per case and so the percentages in the rows can add up to more than 100%.

The percentage of amputations associated with diabetes varied from between 25 and 30% (minor amputations in women in Leeds and major and minor in women in Newcastle) up to 80% and above, such as in men and women in the Navajo area. These are illustrated in figures 3 and 4. Note that these figures provide no information on the incidence of amputations in people with diabetes. In general there is a strong positive relationship between the percentage of amputations associated with diabetes and the percentage associated with infection. Obvious exceptions to this are major amputations in men in Montgomery county and major and minor amputations in men and major amputations in women in Tochigi, Japan.

In the 9 of the 10 centres the percentage of major amputations associated with trauma in men was 10% or less. The exception to this was Ilan in Taiwan where 50% of major amputations were associated with trauma. The highest percentages of major amputations associated with trauma in women were in Newcastle and Ilan where 15 to 16% were associated with trauma. The percentage of major amputations associated with peripheral vascular disease in men ranged from 51.3% in the Navajo Area to 93.3% in Madrid. The percentages were similar in women with the exception of Tochigi where only 29.6% were associated with peripheral vascular disease.

DISCUSSION

In this paper we have presented data on lower extremity amputation from 10 centres in 5 countries. There are some striking contrasts between the centres. There are, for example, marked differences between centres in the incidence of amputations, in the proportion associated with diabetes and in the ratio of first to all amputations. Equally noteworthy are the similarities between the centres in the distribution of amputations by age and sex despite differences in overall rates. The methodology used in this study was designed, within the limits of using routinely available data sources, to provide valid comparisons between the centres. Amputation case definitions and presentation of rates are identical for each centre. Where greater scepticism must exist is whether the level of ascertainment of amputations between centres is comparable and of the comparability of some specific data items from medical records.

In order to both maximise ascertainment and to allow checks on ascertainment level each centre used more than one data source. Estimates of ascertainment using capture recapture methods suggested that there are indeed some differences in levels of ascertainment. Here capture-recapture estimates of ascertainment are used as an aid to interpretation in comparing the results rather than providing robust estimates of the "true" rates. The confidence intervals of many of the estimates in table 4 illustrate the uncertainty around the point estimates and indeed the known difficulty in modelling this type of data[5]. In addition, where only two data sources were available these tended to be positively dependent, meaning that the capture recapture estimate will over estimate the level of ascertainment[6]. Nonetheless the use of this technique provides useful information that can not otherwise be obtained. Thus, the capture recapture estimates suggest that in two of the centres with the lowest rates, Tochigi and Vicenza, there may be substantial underascertainment, in the order of around 50%. However, even doubling the rates of these centres they remain substantially below those in the north of England and North America, particularly those of Japan. We conclude that there remain substantial differences in amputation rates between the centres even when allowing for potential differences in ascertainment, with the lowest rates in Japan and Taiwan and the highest rates the Navajo area. Within Western Europe and to a lesser extent England there are also marked differences in rates between some of the centres.

The high levels of lower extremity amputations in Native American populations are well known[8] and are associated with a high prevalence of diabetes[9,10]. The low incidence of amputations in the centres in Japan, Taiwan, Spain and Italy contrast with the higher rates in the North of England and Montgomery, USA. Recent data and estimates suggest that the prevalence of diabetes in Spain, Italy, Japan and Taiwan is at least twice as high as in England and similar to that in the USA[11]. Clearly therefore a higher prevalence of diabetes is unlikely to be part of the explanation for these differences in amputation incidence. Differences in the prevalence peripheral vascular disease may be, although data are scarce. For example, in the Edinburgh Artery Study the prevalence of peripheral vascular disease was 30% in men and women aged 55 to 74 years[12]. In a study of Italian male and female elderly[13] the prevalence was 10%, and in a Japanese study of village residents aged 60-79 years a prevalence of 0.6% was reported[14]. The WHOinternational study of vascular disease in people with diabetes (ages 35-54 years) found a huge variation in the prevalence of leg vascular disease, with the lowest prevalence in Tokyo and Hong Kong[15]. The relatively low incidence of amputations in Leicester compared to the other English centres fits with previous findings from Leicester[16], in both its general and Indo-Asian populations. Within England data, on the epidemiology of peripheral vascular disease are also scarce but there is evidence for a south to north gradient[17] and for differences by ethnic group[18].

In this paper we also present data on the conditions associated with, or potential causes, of amputation. These data are abstracted from medical records and in presenting these we acknowledge that such data can be prone to omissions and inaccuracies[19]. The highest proportions of amputations associated with trauma were in Ilan, Taiwan, where up to 57% of amputations were reportedly associated with trauma. Excluding cases associated with trauma, as is often done in the presentation of amputation rates, makes little difference to the ranking of the centres by incidence. The proportion of amputations associated with diabetes varied from around 20% (major amputations in women in Vicenza) to 90% and over. The highest proportions for men and women were in the Navajo area. For major amputations in men the lowest proportion associated with peripheral vascular disease was 55% in Tochigi, Japan, and in women was 30% in Tochigi. The proportions associated with peripheral vascular disease tended to be lower for minor amputations with the converse being true for the proportions