Level of lower limb amputation in relation to etiology: an epidemiological study

L. B. EBSKOV

Department of Orthopaedic Surgery, Herlev Hospital, Denmark

Abstract

The Danish Amputation Register and the nationwide National Patient Register are presented.

Based upon the code numbers in the WHO classification system (ICD), 4 etiology groups i.e. vascular insufficiency, diabetes mellitus, malignant neoplasma and trauma were extracted. The purpose was to analyse the relationship between level of amputation (i.e. foot, below-knee, through-knee, above-knee and hip) and etiology (cause of amputation). The material represents all such amputations in Denmark during the period 1978 to 1989 (n=25.767).

The number of amputations because of vascular insufficiency with and without diabetes mellitus decreased over the period studied. The number of tumour and trauma amputations seemed unchanged.

There was a significant reduction in the number of amputations at proximal levels (above-knee) for vascular insufficiency with and without diabetes mellitus and in the trauma group. No such change was found regarding tumour amputations. There was a characteristic pattern in the distribution of level respectively of etiological factors for each etiology group and for each level of amputation.

Introduction

The majority of studies analysing the epidemiology of lower limb amputations describe the distribution of level for the separate etiology groups (e.g. vascular insufficiency, trauma or neoplasm). In some studies the distribution of level is related to a total amputation population without distinguishing separate etiologies (Glattly, 1964; Kay and Newman, 1975; Kald *et al.*, 1989). A number of studies (Hansson, 1964; Kay and Newman, 1975; Pohjolainen and Alaranta, 1989) show considerable differences in the distribution of etiology. No studies have analysed the distribution of etiology at each individual level of amputation. Seen from an epidemiological point of view, it is interesting to analyse the relationship between cause of lower limb amputation and the choice of level on a very large material with national coverage for the years 1978 to 1989. Further the changes observed during the period under study are discussed.

Material and methods

The Danish Amputation Register (DAR) was established in 1972 for the purpose of collecting and analysing data on upper and lower limb amputations in Denmark (Ebskov, 1986). Since 1978 information was also available in the National Patient Register (NPR). The NPR contains details on all patients admitted to Danish somatic hospitals, thus ensuring national coverage and permitting an analysis of the entire Danish in-patient population.

The present study is based upon NPR data from 1978 to 1989. Diagnoses are recorded according to WHO's International Classification of Diseases (ICD). In the present study it was decided to include the 4 etiology groups: vascular insufficiency, diabetes related amputations; malignant bone and soft tissue tumour, and trauma. It may be mentioned that embolism and thrombosis as well as Raynaud's

All correspondence to be addressed to Lars Bo Ebskov, Anyvej 10, DK — 3500 Vaerloese, Denmark.
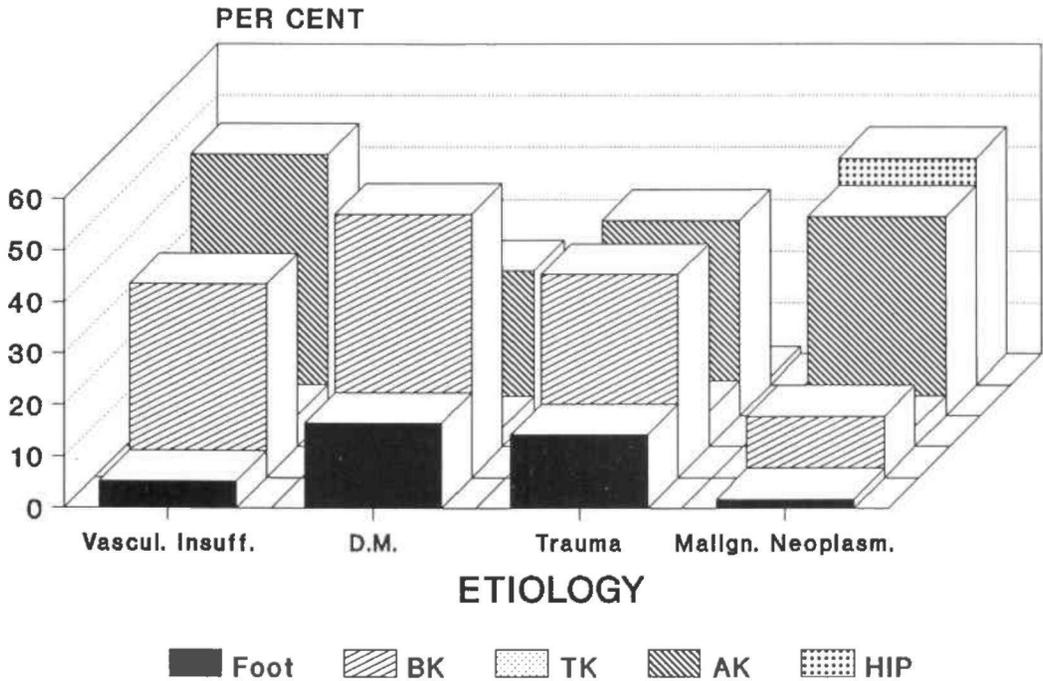
Fig. 1. The level of amputation differs markedly depending upon the etiology of the underlying indication for amputation.

and Buerger's diseases are included in the vascular insufficiency group.

The remaining relatively rare etiology groups are excluded pseudoarthrosis, benign neoplasm, skin cancer, gangraena emfysematosa, metastasis, chronical venous ulceration, osteomyelitis etc.)

Operations (level) are recorded according to the Danish National Health Board and distributed in 5 level-groups (foot exclusive of toes, below-knee (BK), through-knee (TK), above-knee (AK) and hip (including hemipelvectomy and disarticulation of the hip.

Results

During the period 1978 to 1989, 17,548 lower limb amputations were performed because of non-diabetic vascular insufficiency (arteriosclerosis/gangrene), 6,839 amputations on diabetic patients, 1,095 amputations as a direct consequence of trauma (either direct traumatic amputation or degloving/crushing of the limb) and 285 amputations because of malignant soft tissue or bone tumours.

Figure 1 shows the distribution of level for the etiology groups in the total material.

Figure 2 shows the changes in distribution of level from 1978–80 to 1987–89. Some significant changes are observed i.e. reduction of the proximal levels and a relative increase of the distal levels for the vascular insufficiency group, the diabetes group and in the trauma group. The neoplasm group seems to be unchanged.

The total number of amputations in 1978–80 related to the number in 1987–89 shows no significant changes in the trauma or tumour amputations. The number of diabetic amputations and the number of vascular insufficiency (non-diabetic) show a significant decrease in 1978–80 to 1987–89.

Figure 3 shows the etiology distribution at different level of amputation. At foot level diabetic amputations represent the largest group with 52%; at increasingly higher levels diabetic amputations show a steady decrease until it reaches 5% in the hemipelvectomy group. The vascular insufficiency group dominates BK, TK and especially the AK group, where it constitutes 78%. The neoplasm amputations show another pattern with relatively small fractions from foot to AK, in these groups equalling less than 1%, whereas in
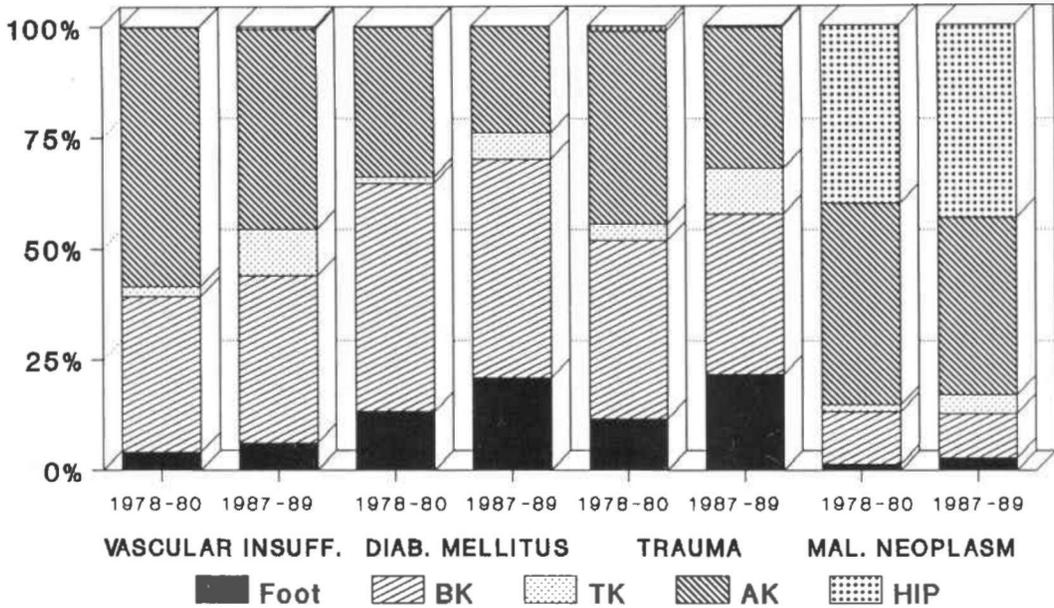
Fig. 2. For the four major causes of lower limb amputation, the distribution of amputation levels is compared for the triennium 1978–1980 and 1987–1989 respectively. In the tumour group no major change is noted. In the remaining three groups there is a marked tendency towards more conservative amputation.

the hemipelvectomy group it constitutes 53%. The traumatic amputations again have another pattern, with fractions equalling about 6% in the foot and the hemipelvectomy groups and for the remaining levels about 4%.

Discussion

The relationship between level of amputation and cause of amputation (etiology) is described based upon a large number of amputations and significant changes are found during the period analysed in the distribution of level for vascular insufficiency, diabetes and trauma. Further the etiology distribution is expounded for different levels, which is a new way to display the epidemiological characteristic of the amputation material.

The overall etiological distribution confirms the well-known fact that lower limb amputation because of vascular insufficiency with or without diabetes mellitus is the quantitatively dominant group. Comparison of the etiology distribution with earlier studies is complicated by differences in content and arrangement of the material. This problem is especially pronounced in regard to the diabetic group where toe amputations are frequent (about 20% of the diabetic amputations in 1989) but of less practical importance. In the material

reported here toe amputations are excluded and the diabetic amputations account for 26%, if included (in all the etiology groups) this figure is virtually unchanged. The proportion of diabetic amputations in Denmark seems to be significantly smaller than earlier reported (approximately 40% or more) (Pohjolainen and Alaranta, 1988; Liedberg and Persson, 1983; Tan *et al.*, 1983; Hansson, 1964).

The percentage of traumatic amputations seems to be significantly smaller than in former times (Hansson, 1964) where the typical percentage, in the period about 1940 to 1960, was about 20–30%. Pohjolainen and Alaranta (1988) describe a significant decrease in the number of amputations due to trauma (from 12% in 1970 to 2% in 1985). The reason for the decrease can probably be explained by improved industrial and traffic safety and advances in replantation surgery (Chen and Zeng, 1983; Østrup and Vilkki, 1986). In the present study no significant changes in the number of traumatic amputations were observed.

Also tumour amputation seems to be comparatively infrequent in relation to earlier studies although unclear definition of this amputation group makes it impossible to perform comparison of the results. During the
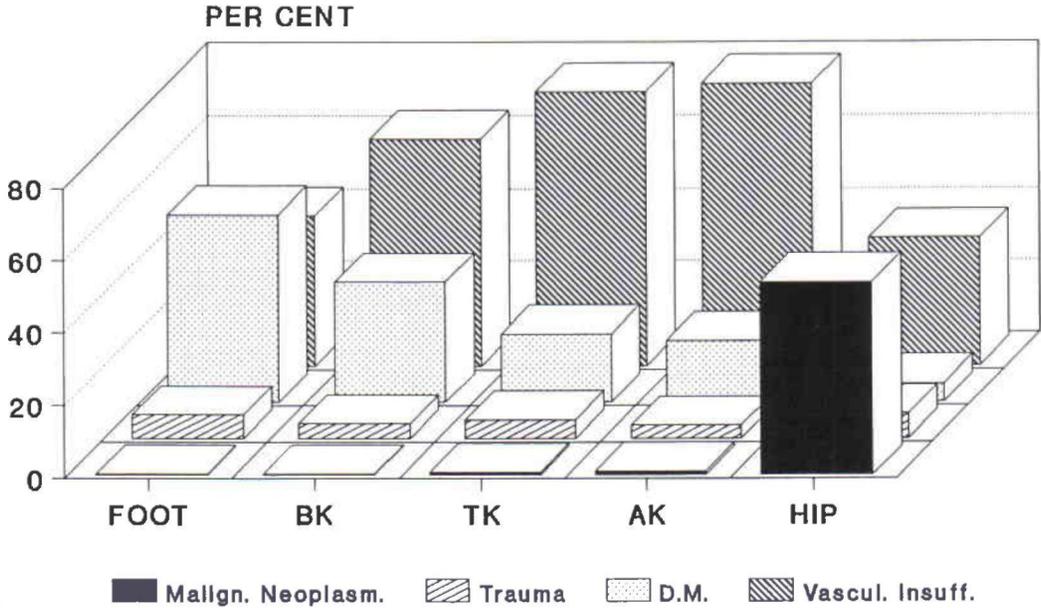
PER CENT

Fig. 3. The distribution of the four major causes of amputation varies markedly with level of amputation. From foot to AK levels the relative share of diabetic gangrene decreases, whereas the share of arteriosclerotic gangrene increases. Malignant tumour is dominant at the hip level (hip disarticulation and hemipelvectomy), but scarcely represented at all levels distal to the hip.

period 1978 to 1989 no decrease in the number of amputations as a consequence of malignant soft tissue and bone tumours was observed, in spite of attempts to optimise limb-preserving surgery in this group (Alho, 1987; Nambisan and Karakousis, 1987; Potter et al., 1986; Simon et al., 1986; Winkelmann, 1986).

The significant decrease in the number of amputations on diabetics is thoroughly discussed by Ebskov (1991). Probably the main reasons for the decrease are:
1. improved diabetic (blood-glucose) control and self-care programmes;
2. an increasing number of specially trained podiatrists;
3. vascular surgery;
4. improved life-style (smoking-habits, food, exercise etc.).

Contrary to the diabetic amputations the only possible reason for the decrease in the number of vascular insufficiency amputations seems to be an increase in the vascular surgery in Denmark, an issue presently under study.

During the last decades strong efforts have been directed to decreasing the number of AK amputations for vascular insufficiency with or without diabetes mellitus. Comparison of earlier and present studies clearly shows the

impact of these efforts. Most important seems to be an increase in the availability of sophisticated equipment for predicting wound healing in lower limb amputations (Holstein, 1985; Ameli et al., 1989; Burgess, 1983; Dwars et al., 1989; Gebuhr et al., 1989; Malone et al., 1987; McCollum et al., 1988; Oishi et al., 1988; Wagner et al., 1988). The role of increasing vascular surgery in Denmark, in relation to the observed changes in level distribution is uncertain, but may have some importance.

BK and foot amputation are more frequent than the AK amputations in diabetic patients, compared to patients with non-diabetic vascular insufficiency (Ecker and Jacobs, 1970; Hansson, 1964; Pohjolainen and Alaranta, 1988). The difference in the distribution of level between the quantitatively dominating amputation groups, i.e. non-diabetic vascular insufficiency and diabetic patients, is probably a consequence of the difference between the distribution of the vascular disease i.e. the involvement of smaller and more peripheral vessels in the diabetic limbs (Falkel, 1983). The present study (Fig. 3) emphasizes this by showing a considerable decrease in the relative size of the diabetic group as the level becomes more proximal, which stresses the importance

of differentiating between non-diabetic vascular insufficiency and diabetic amputation.

Hemipelvectomy and disarticulation of the hip are relatively rare amputations (about 1% of all). The hemipelvectomy group is dominated by malignant skeletal and soft tissue tumour amputations (54%).

REFERENCES

ALHO A (1987). Okende muligheter til funksjonsbevarende kirurgi ved muskulaskelettale tumores. (New surgical possibilities of preserving the limbs despite musculo-skeletal tumours). *Nord Med* **5**, 157–160.

AMELI FM, BYRNE P, PROVAN JL (1989). Selection of amputation level and prediction of healing using transcutaneous tissue oxygen tension (PtcO2). *J Cardiovasc Surg (Torino)* **30**, 220–4.

BURGESS EM (1983). Amputations. *Surg Clin North Am* **63**, 749–770.

CHEN ZW, ZENG BF (1983). Replantation of the lower extremity. *Clin Plast Surg* **10**, 103–113.

DWARS BJ, RAUWERDA JA, VAN DEN BROEK TAA, DEN HOLLANDER W, HEIDENAL GAK, VAN RIJ GL (1989). A modified scintigraphic technique for amputation level selection in diabetics. *Eur J Nucl Med* **15**, 38–41.

EBSKOV B (1986). The Danish Amputation register 1972–1984. *Prosthet Orthot Int* **10**, 40–42.

EBSKOV LB (1991). Lower limb amputations for vascular insufficiency. *Int J Rehabil Res* **14**, 59–64.

ECKER ML, JACOBS BS (1970). Lower extremity amputation in diabetic patients. *Diabetes* **19**, 189–195.

FALKEL JE (1983). Amputation as a consequence of diabetes mellitus. *Phys Ther* **63**, 960–965.

GEBUHR P, JORGENSEN JP, VOLLMER-LARSEN B, NIELSEN SL, ALSBJORN B (1989). Estimation of amputation level with a laser Doppler flowmeter. *J Bone Joint Surg* **71B**, 514–517.

GLATTLY HW (1964). A statistical study of 12,000 new amputations. *South Med J* **57**, 1373–1378.

HANSSON J (1964). The leg amputee: a clinical follow-up study. *Acta Orthop Scand (Suppl).* **35** (suppl 69), 1–104.

HOLSTEIN P (1985). Skin perfusion pressure measured by radioisotope washout for predicting wound healing in lower limb amputation for arterial occlusive disease. *Acta Orthop Scand* (suppl). **56** (suppl 213), 1–47.

KALD A, CARLSSON R, NILSSON E (1989). Major amputation in a defined population: incidence, mortality and results of treatment. *Br J Surg* **76**, 308–310.

KAY HW, NEWMAN J (1975). Relative incidence of new amputation. *Prosthet Orthot Int* **29**, 3–16.

MALONE JM, ANDERSON GG, LALKA SG, HAGAMAN RM, HENRY R, MCINTYRE KE, BERNHARD VN (1987). Prospective comparison of non-invasive techniques for amputation level selection. *Am J Surg* **154**, 179–184.

MCCOLLUM PT, SPENCE VA, WALKER WF (1988). Amputation for peripheral vascular disease: the case for level selection. *Br J Surg* **75**, 1193–1195.

NAMBISAN RN, KARAKOUSIS CP (1987). Vascular reconstruction for limb salvage in soft tissue sarcomas. *Surgery* **101**, 668–677.

OISHI CS, FRONEK A, GOLBRANSON FL (1988). The role of non-invasive vascular studies in determining levels of amputation. *J Bone Joint Surg* **70A**, 1520–1530.

ØSTRUP LT, VILKKI SK (1986). Reconstructive microsurgery — a review. *Acta Orthop Scand* **57**, 395–401.

POHJOLAINEN T, ALARANTA H (1988). Lower limb amputation in southern Finland 1985–85. *Prosthet Orthot Int* **12**, 9–18.

POTTER DA, KINSELLA T, GLASTEIN E, WESLEY R, WHITE DE, SEIPP CA, CHANG AE, LACK EE, COSTA J, ROSENBERG SA (1986). High-grade soft tissue sarcomas of the extremities. *Cancer* **58**, 190–205.

SIMON MA, ASCHLIMAN MA, THOMAS N, MANKIN HJ (1986). Limb-salvage treatment versus amputation for osteosarcoma of the distal end of the femur. *J Bone Joint Surg* **68A**, 1331–1337.

TAN MH, GWEE HM, YEO P, LIM P, BOSE K (1983). Diabetic amputee in Singapore. *Tokohu J Exp Med* **141** (suppl), 575–582.

WAGNER WH, KEAGY BA, KOTB MM, BURNHAM SJ, JOHNSON G (1988). Noninvasive determination of healing of major lower extremity amputation: the continued role of clinical judgment. *J Vasc Surg* **8**, 703–710.

WINKLEMANN WW (1986). Hip rotationplasty for malignant tumours of the proximal part of the femur. *J Bone Joint Surg* **68A**, 362–369.