Acta orthop. Scandinav. *XXXV*, 74–89, 1964.

From the Surgical Department of the Maria City Hospital, Helsinki-Helsingfors.
(Head: Prof. P. I. Tuovinen, M.Sc.D.)

FEATURES OF AMPUTATION SURGERY AMONG CIVILIANS DURING THE PERIOD 1930–1960

By

RALF LINDHOLM

Better anesthesia, control of shock, management of sepsis, and new methods in pre- and postoperative care in combination with improved prosthetic devices and rehabilitation programs have brought about changes in amputation surgery since 1939.

Medical and social development have had a great influence upon the morbidity, mortality and age of the population. Technology is responsible for a steadily increasing risk of injury from accident.

These trends must be presumed to have affected the more or less accepted principles and main features of amputation surgery for disease and civilian injury. One change in the professional attitude is in fact the generally adopted replacement of *zur Verth*'s (1923) even lately approved 'sites-of-election' by the more limb saving levels of amputation of today.

PURPOSE OF INVESTIGATION AND METHODS OF STUDY

Mainly with a view to detecting changes in the composition of series, amputation characteristics and philosophy, the author has made a survey of the case records of nearly one thousand clinical amputations. The operations were performed at a unit dealing with patients in need of emergency as well as planned surgery, but without sections of rehabilitation and amputee service. The area covered by this hospital is the capital city, with somewhat under half a million inhabitants by the end of the period surveyed. The number of annually registered patients has been near 5,000, except during the period of war between 1939 and 1945, which reflects the lower numbers of registered civilians

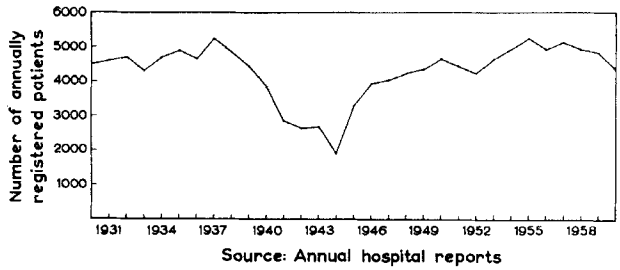

TABLE 1

Annual Distribution of 133,466 Clinical Patients Admitted at the Maria City Hospital Surg. Dept., 1930–1960.

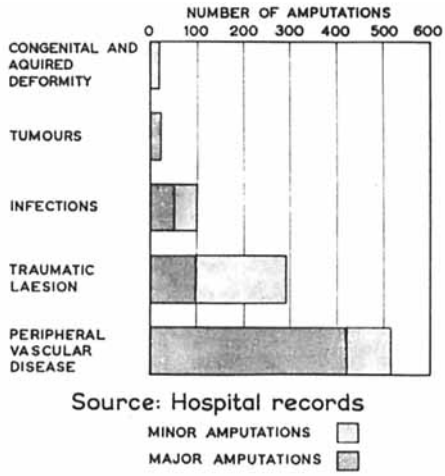

TABLE 2

Amputations on 986 Limbs Performed at the Maria City Hospital Surg. Dept. 1930–1960, by Indications.

(Table 1). Approximately every second patient underwent some kind of surgery. In this report interest is focused upon questions of operative indications, age and sex, frequency of amputation, level of surgery, primary operative risk and evaluation of trends revealed in the course of time.

REASONS FOR AMPUTATION

The indications, subdivided into five main groups, are presented in relation to numbers of amputations, major and minor procedures being indicated (Table 2).

TABLE 3

Sex Distribution of Patients Amputated for Civilian Reasons at the Maria City Hospital Surg. Dept. 1930–1960.

Indication for amputation	Sex		
	Male %	Female %	%
Peripheral vascular disease	59.2	40.8	100.0
Traumatic lesion	86.5	13.5	100.0
Infection	69.1	30.9	100.0
Growth	40.6	59.4	100.0
Deformity	42.3	57.7	100.0
Miscellaneous	68.0	32.0	100.0
Total	66.2	33.8	100.0

Source: Hospital records.

TABLE 4

Per Cent Relations between Main Groups of Indication for Amputation, by Different Sex. Maria City Hospital Surg. Dept. 1930–1960.

Sex	Peripheral vasc. dis. %	Traumatic lesion %	Infection %	Growth %	Deformity %	Miscell. %	Total %
Male amputees	49.3	33.6	9.1	2.8	2.1	3.1	100.0
Female amputees	66.0	10.2	7.9	7.1	5.6	3.3	100.0

Source: Hospital records.

Peripheral vascular disease. This commonest cause of amputation has been shown to comprise non-diabetic gangrene (368), diabetic gangrene (89), embolism (35), and occasional cases of venous thrombosis aortic aneurysm and complication from varicose veins.

Traumatic lesions. Fracture, laceration, and traumatic (accidental) amputation have occurred in equal numbers, amounting to 8/9ths of all injuries. Thermal, chemical, radiation, and electric injury account for the remaining 1/9th.

Infections. This third group in order of frequency consists of cases of non-specific osteitis (49), bone and joint tuberculosis (21), and luetic osteitis (2), with infection of soft tissue and septicaemia accounting for the remaining 1/4th of all bacterial conditions.

Tumours. Malignant growths arising from connective tissue, cartilage and bone, are together equal in number to those of epithelial origin. Only once has amputation been performed for a benign lesion.

Congenital and acquired deformity. These have all been of a minor

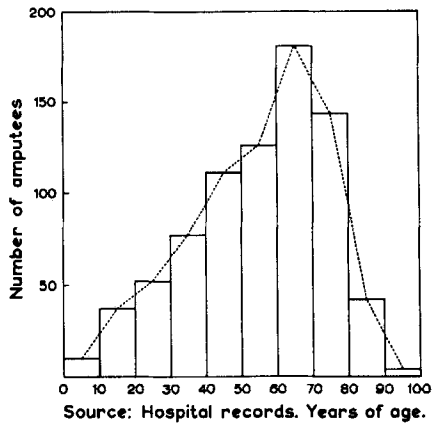

TABLE 5

Age of Amputees at the Time of Surgery. Maria City Hospital, Surg. Dept. 1930–1960.

type, including cases of Dupuytren's contracture, hammer toes, anchylosis and contraction of finger joints, onychogryphosis etc.

Apart from these common reasons for amputation, single cases of pathologic fracture, neurotrophic lesion, and decubital ulcer, and elephantiasis have been met.

Re-amputation in the course of the same hospital stay was performed for advancing gangrene with or without signs of infection on sixty limbs (38 non-diabetic and 22 diabetic). In four instances re-operation was performed in cases where the primary reason for amputation had been infection. Ten re-amputations in traumatic cases were registered. Bilateral amputations amount in number to sixteen for vascular disorder, eleven for frostbites, nine for other traumas, and five for minor toe deformities.

SEX AND AGE CHARACTERISTICS OF AMPUTEES

2/3rds of all amputees were men. This male preponderance depends on the fact that many more men than women have undergone amputation for vascular disease and traumatic injury (Table 3). The internal relation of operative indications, however, is the same in both sex groups; thus, the most frequent reason for amputation among the women was peripheral vascular disorder, which was relatively even commoner than amongst the men (Table 4). This circumstance can be explained by the very sparse occurrence of traumatic incidents leading to amputation among the females.

TABLE 6

Per Cent of Different Main Reasons for Amputation at the Maria City Hospital Surg. Dept. 1930—60 in Ten-Yearly Interval-Groups of Patients' Chronological Age.

Years of age	Peripheral vasc. dis. %	Traumatic lesion %	Infection %	Growth %	Deformity %	Misc. %	Total %
0–10	–	100.0	–	–	–	–	100.0
10–20	2.7	75.7	8.2	10.8	2.7	–	100.0
20–30	1.9	82.7	7.7	5.8	1.9	–	100.0
30–40	26.0	59.7	11.7	–	2.6	–	100.0
40–50	28.8	42.3	11.7	1.8	7.3	8.1	100.0
50–60	56.4	16.7	11.0	8.0	5.5	2.4	100.0
60–70	71.3	8.3	8.8	5.0	2.8	3.8	100.0
70–80	88.2	1.4	4.9	3.5	2.0	–	100.0
80–90	97.6	2.4	–	–	–	–	100.0
90–100	100.0	–	–	–	–	–	100.0
Total	55.0	25.5	8.7	4.2	3.4	3.2	100.0

Source: Hospital records.

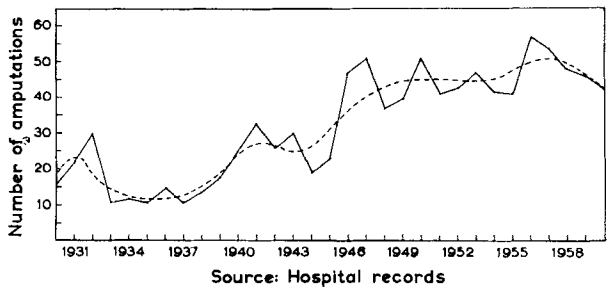

TABLE 7

Annual Distribution of 986 Clinical Amputations on Civilian Indications Performed at the Maria City Hospital Surg. Dept., 1930–1960.

More than fifty per cent of the amputees were aged between 50 and 80 years at the time of surgery (Table 5). A study of ten-year groups from 0 to 100 reveals a continually diminishing proportion of trauma and simultaneously a steadily increasing proportion of amputations for vascular trouble (Table 6).

Up to the age of 50 trauma has been found to dominate, and thereafter the group of vascular disorders has provided the most frequent reason for amputation. Thus, the youngest group includes almost only traumas and the oldest group gangrenes from obliterative arterial disease only. The most tragic cases seem to be the double above-knee child amputees, victims of railroad accidents.

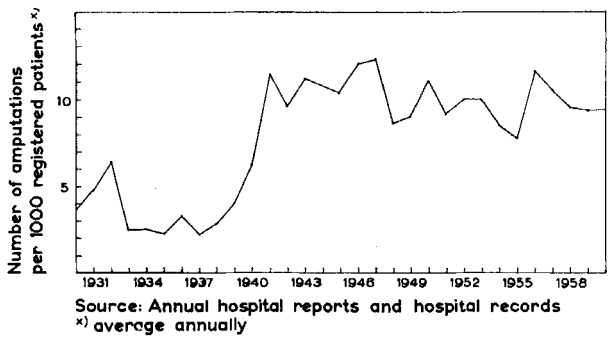

TABLE 8

Amputations on Civilian Indications Performed at the Maria City Hospital Surg. Dept., 1930–1960.

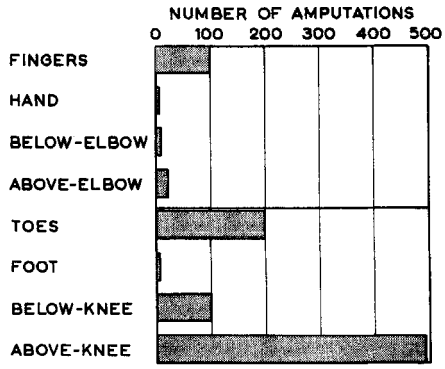

TABLE 9

Amputations on 986 Limbs at the Maria City Hospital Surg. Dept., 1930–1960, by Level of Surgery.

Source: Hospital records.

FREQUENCY OF AMPUTATION

Calculations indicate a frequency of between 3 and 12 amputations per thousand surgical patients admitted (Tables 7 and 8). The former number relates to the period 1930–1940 and the latter to the time after 1945. Thus, there is a rather steep rise of the frequency curve through the period 1940–1945. Taking into consideration that approximately fifty per cent of all registered surgical patients have been operated upon, the rate of amputations in relation to all surgery done makes 6 to 20 per thousand, the latter number being indicative of the figures of later years.

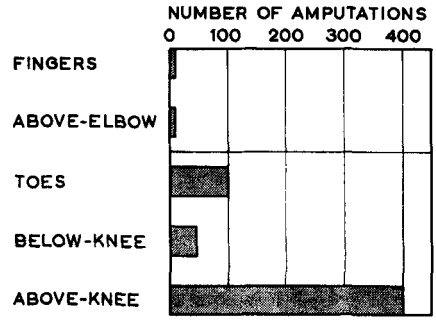

TABLE 10

Amputations on 531 Limbs for Peripheral Vascular Disease Performed at the Maria City Hospital Surg. Dept., 1930–1960, by Level of Surgery. Source: Hospital records.

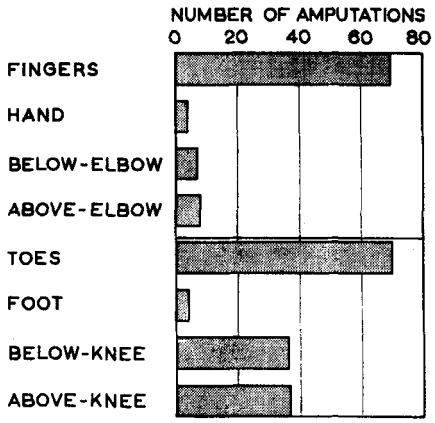

TABLE 11

Amputations on 282 Limbs for Traumatic Lesions Performed at the Maria City Hospital Surg. Dept., 1930–1960, by Level of Surgery. Source: Hospital records.

It has not been possible to obtain a reliable figure for the frequency in relation to the population of the area served on the basis of this series, if all reasons for surgery are taken into account. However, regarding vascular disorders, the figures have in fact been giving significant and valuable ratings. The large majority of patients suffering from arterial disease have been admitted to the hospital in question. The annual frequency of amputation for peripheral vascular disease may thus be estimated at about one amputation per ten thousand in-

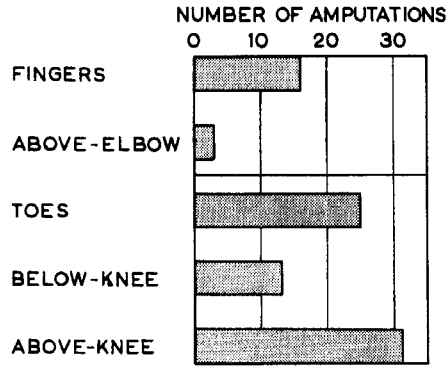

TABLE 12

Amputations on 92 Limbs for Infections Performed at the Maria City Hospital Surg. Dept., 1930–1960, by Level of Surgery.

Source: Hospital records.

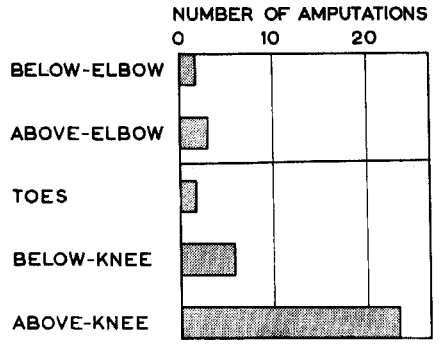

TABLE 13

Amputations on 34 Limbs for Tumours Performed at the Maria City Hospital Surg. Dept., 1930–1960, by Level of Surgery.

Source: Hospital records.

habitants, according to the recent average amputation rate. This implies a rate of one hundred persons yearly in a town with a population of a million.

LEVEL OF SURGERY

Only 12 per cent of the limbs subjected to amputation have been upper extremities, while the majority, or 78 per cent, have been lower extremities (Table 9). Of all amputations 2/3rds have been performed

at a level requiring a prosthesis, at the thigh, leg, ankle and foot or upper arm, lower arm or wrist.

When level is considered in relation to the various reasons for surgery, it can be shown that the lower thigh has been the site of election in vascular disease (Table 10), while thigh and lower leg have been subjected to amputation an equal number of times in cases of trauma (Table 11). Infectious disease has usually been treated by rather nearby amputation (Table 12), while malignant growth has prompted operation at a high level, upper arm or thigh (Table 13). The deformities of this series have been uniformly treated by minor, peripheral amputation.

TABLE 14

Death Rates in Different Main Groups of Indication for Amputation Surgery Performed at the Maria City Hospital, 1930–1960.*

Indication for amputation	Dead %
Peripheral vascular disease	26.6
Traumatic reason	5.5
Infection	11.8
Growth	12.9
Deformity	0.0
Total (major amputations)	22.6
Total (all)	15.1

* Per cent total number amputated patients in each group of indication.
Source: Hospital records.

OPERATIVE RISK

The results have been calculated in terms of risk of death in the postoperative period of hospital stay. The figures appear to indicate the importance of underlying disease as a cause of failure rather than operative trauma and stress (Table 14).

The greatest risk has been encountered in vascular disease. The deaths from amputation for infections were mostly due to sepsis, which is nowadays of little more than historic importance (Table 15).

Of the deaths, 24 (21 per cent) occurred during the first day postoperatively, 19 after amputation for vascular disease and 5 for traumatic lesions. Of all 138 deaths, 71 (51 per cent) took place in the period before the eighth day postoperatively, 43 (31 per cent) in from the eighth to the thirtieth day, 17 (12 per cent) in from the thirtyfirst to the sixtieth day, and 7 (5 per cent) after the sixtieth day.

TABLE 15

Number of Deaths among Patients Amputated for Civilian Reasons at the Maria City Hospital Surg. Dept., 1930–1960, by Indications for Surgery.*

Main groups of indication	Preoperative diagnosis	Number of deads	
Peripheral vascular disease	obliterative arterial disease	79	
	diabetic arterial disease	23	
	embolic arterial disease	10	82.6 %
	aortic aneurysm	1	
	caval thrombosis	1	
Traumatic lesion	laceration	4	
	fracture	2	
	traumatic amputation	4	
	burns	1	7.9 %
Infections	sepsis	6	
	osteitis	1	5.8 %
	tuberculous disease	1	
Growth	malignant growth	4	2.9 %
Miscellaneous	pseudarthrosis	1	0.8 %
	Total.....	138	100.0 %

* During primary stay in surg. dept. after operation.
Source: Hospital records.

Primary mortality during hospital stay after above-knee amputation rated 25 per cent. Of all deaths, the majority (125/138) followed above-knee amputation. The below-knee amputation rate was found to be 2 per cent only. The surprisingly high operative risk in above-elbow amputation (7/19) was caused by heart disease (with embolism) (3), progressing sepsis (2), multiple, complicated trauma (1), and crush injury (1). Four patients succumbed after minor amputations, three after removal of one or more gangrenous toes for vascular reasons and one after amputation of a finger for infection of soft tissue with signs of septicaemia, all these because of progressing, generalized disease, and none immediately after surgery.

TRENDS APPARENT FROM A STUDY OF CHRONOLOGIC SEQUENCE

Comparison of the period 1930–1944 and 1945–1960 has revealed a significant rise in the mean age of persons undergoing amputation for

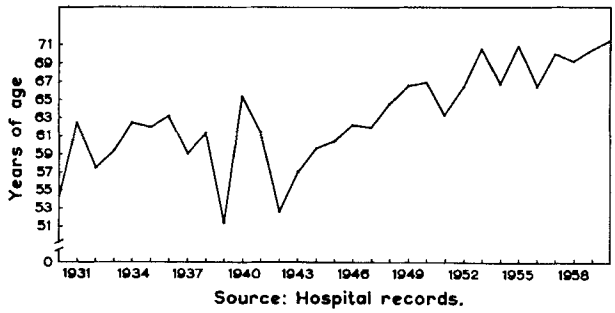

TABLE 16

Mean Age of Patients Amputated for Peripheral Vascular Disease. Maria City Hospital Surg. Dept., 1930–1960.

TABLE 17

Mean Age of Patients Amputated for Civilian Reasons at the Maria City Hospital Surg. Dept., 1930–1960, by two Time-Intervals of Observation.

Period years	Mean age in years *)						
	Peripheral vasc. dis.	Traumatic lesion	Infection	Growth	Deformity	Misc.	Total
1930–44	59.0	35.7	45.1	54.0	46.8	36.3	50.3
1945–60	67.3	36.0	54.7	53.2	51.7	48.6	56.5
Total	65.0	35.9	50.9	53.3	50.2	46.6	54.8

* At the moment of surgery.

Source: Hospital records.

vascular disease (Table 16), and infection, while no rise in the mean age of amputees operated for trauma can be shown (Table 17).

Moreover, an actual as well as a relative increase in the number of operations for vascular disorders and traumatic lesions can be detected coincidentally with the rise in the mean age (Table 18). The slight decrease in the frequency of amputations for traumatic reasons since 1957 is evidently explained by the establishment of other units taking over a part of the accident service in the region covered.

Concerning the level of surgery, peripheral amputations of a minor type were performed in 12 per cent of all operations for vascular disease before 1945 and in 19 per cent after that date. Correspondingly, of the former limbs about 23 per cent were re-operated at a major site and of the latter 26 per cent. This seems to indicate a moderately increased inclination to peripheral surgery of later years, the gain, however, being

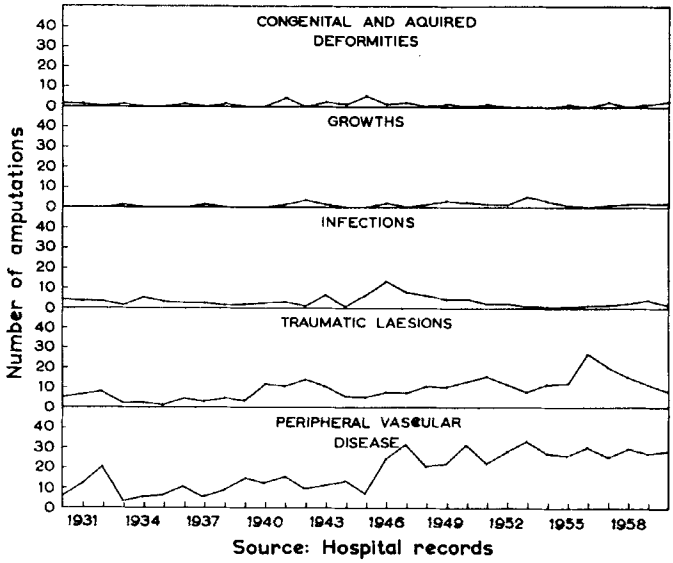

TABLE 18

Amputations Performed at the Maria City Hospital Surg. Dept., 1930–1960, by Indications.

compensated by a moderate increase in the rate of failure from progressing lesion, involving re-amputation. The incidence rate (30 per cent) of re-amputation after below-knee amputation is based on too small a figure to allow comparison in time.

CONCLUSIONS AND DISCUSSION

In the near future, we are rather likely to experience a growing number of elderly amputees, sufferers from vascular disorders, alongside with more people undergoing amputation for traumatic injury. This will place a heavy load upon our institutions providing rehabilitation service.

Effective organization of prophylaxis and rehabilitation requires knowledge of the causation, frequency and results of amputation surgery. This series supports the opinion that the medical and social progress during the last two decades has not been of any prophylactic value. Regarding rehabilitation, we know that success in fitting young and middle-aged people with limbs is the rule, in contrast to the case of geriatric amputee, who presents a more difficult problem. Opinions differ widely concerning this problem. Reports indicate that not more

than fifty per cent of the people amputated after 65 years of age will use their prosthesis. A very pessimistic view is presented by *Kelley & Janes* from the Mayo clinic, who found that only 29 per cent below-knee and 14 per cent above-knee geriatric amputees were successfully limb-fitted and able to walk. It should not be forgotten that prescription of an artifical limb is one task and to gain satisfactorily from limb-fitting another. Avoiding waste requires the co-ordination of surgery, training and prosthetic research and the acceptance of certain principles. Such questions, however, go beyond the purpose of this investigation. It may be mentioned that there are fresh opinions which favour the prescription of at least a provisional prosthesis for every amputee over 65 years of age, if not bedridden. It has not been possible to have the end results of this series yet, apart from primary mortality. It thus contributes knowledge to the point, where the special prosthetic training, in the old meaning, begins.

Regarding the frequency of amputation, published reports are scarce. Reliable figures come from limb-fitting units (Roehamptom, Great Britain and Orthopaedic Hospital, Copenhagen). These indicate a somewhat higher incidence of amputation for traumatic reasons than does this series. This feature is well explained by the high incidence of failure of recovery and the uselessness of limb-fitting many sufferers from arterial disease, represented in abundance in this series. The high rate of major re-amputation after minor, peripheral amputation illustrates clearly the systemic character and unfavourable prognosis in vascular disorders.

The essential tasks, thus, seem to be situated in the fields of traumatic and geriatric medicine. All successful efforts to rehabilitate young amputees will no doubt be well rewarded. The importance of the training of the geriatric amputee is a humanitarian rather than a strictly economically justified, social necessity. The trends speak in favour of decentralizing measures in the organization of amputee training for the quiescent, old people, whereas the young and still adjustable amputee needs specialized training and education, which can only be offered by a few centralized units.

There is no need even to stress that reparative and reconstructive vascular surgery may come to play the most important rôle in the sphere of prophylaxis and treatment of disorders causing amputation.

SUMMARY

Nearly one thousand clinical amputations performed at a surgical unit not equipped with a special amputee service are surveyed.

The reasons for amputation and their frequency were: 1) Peripheral vascular disease (54 per cent), traumatic lesion (29 per cent), infections (9 per cent), tumours (3 per cent), congenital and acquired deformity (2 per cent), and miscellaneous (3 per cent).

The male preponderance in 2/3rds of all amputations was found to depend on a higher incidence of vascular disease and trauma as a cause of amputation. In the ten year age groups, most amputations were performed between 60 and 70 years. More than fifty per cent were 50–79 years old, at the time of surgery. Trauma dominates up to the age of 50 and thereafter vascular disorder prevails as a reason for amputation.

The rate of amputations in relation to all kind of operations has been estimated to be 6–20 per thousand, the higher figure being indicative of later years, while annual frequency of amputation for peripheral vascular disease is about one per ten thousand inhabitants.

The different levels of amputation in relation to the various indications are depicted; 12 per cent of the limbs were upper extremities and 78 per cent lower extremities; 2/3rds of the total were amputated at a major site.

The primary mortality rate of above-knee amputation equalled 25 per cent and below-knee amputation 2 per cent only. Most deaths (51 per cent) took place during the first week postoperatively, somewhat fewer (31 per cent) in the following second, third and fourth weeks. The risk of death in the postoperative period of the hospital stay seemed apparently to depend more on the underlying disease than the surgical trauma.

RESUME

Il a été procédé à l'étude de près d'un millier d'amputations cliniques effectuées dans un département chirurgical non équipé d'un service spécial d'amputation.

Les raisons de l'amputation et leur fréquence étaint: 1) maladie vasculaire périphérique (54 pour cent), lésion traumatique (29 pour cent), infections (9 pour cent), tumeurs (3 pour cent), déformité congénitale et acquise (2 pour cent), et divers (3 pour cent).

Il ressort de cette analyse que la prépondérance masculine de 2/3 de toutes les amputations était due à une fréquence plus élevée des maladies vasculaires et traumatiques comme causes de l'amputation. Si

l'on répartit les malades dans des groupes d'âge de dix ans, la plupart des amputations ont été effectuées entre 60 et 70 ans. Plus de 50 pour cent étaint entre 50 et 79 ans au moment de l'opération. Les lésions traumatiques dominent jusqu'à l'âge de 50 ans, après quoi ce sont les troubles vasculaires qui sont la cause de l'amputation.

Le taux des amputations par rapport à toutes les catégories d'opérations a été évalué entre 6 et 20 pour mille, le chiffre le plus élevé étant l'indicatif des dernières années et la fréquence annuelle de l'amputation pour maladie vasculaire périphérique s'établit à environ un par dix mille habitants.

Les différents niveaux des amputations par rapport aux indications variées ont été établis; il s'agissait des extrémités supérieures dans 12 pour cent et des extrémités inférieurs dans 78 pour cent des cas, les deux tiers ayant été amputés à un endroit majeur.

Le taux de mortalité primaire pour l'amputation au-dessus du genou s'élève à 25 pour cent et seulement à 2 pour cent pour l'amputation au-dessous du genou. La plupart des décès (51 pour cent) se sont produits dans la première semaine post-opératoire, un peu moins (31 pour cent) dans les seconde, troisième et quatrième semaines suivantes. Le risque de décès dans la période post-opératoire du séjour à l'hôpital semble apparemment dépendre plus de la maladie que du traumatisme chirurgical.

ZUSAMMENFASSUNG

Beinahe tausend klinische Amputationen, die an einer, nicht mit speziellen Amputationsorganisation, ausgerüsteten chirurgischen Abteilung ausgeführt wurden, werden überblickt.

Die Anzeigen für die Amputation und ihre Häufigkeit waren: 1) Periphere Gefässerkrankungen (54 Prozent), traumatische Beschädigungen (29 Prozent), Infektionen (9 Prozent), Tumoren (3 Prozent), kongenitale und erworbene Verbildungen (2 Prozent) und verschiedene Ursachen (3 Prozent).

Das männliche Übergewicht von 2/3 aller Amputationen war in dem grösseren Vorkommen von Gefässerkrankungen und Trauma als Amputationsanzeige zu suchen. Die meisten Amputationen wurden zwischen dem 60. und 70. Lebensjahre ausgeführt. Mehr als 50 Prozent waren zur Zeit des chirurgischen Eingriffes 50–79 Jahre alt. Das Trauma ist bis zum 50. Lebensjahre und hernach ist die Gefässerkrankung die vorherrschende Amputationsursache.

Das Verhältnis von Amputationen in Beziehung zu allen Arten von

Operationen wurde auf 6–20 per tausend geschätzt. Die höhere Zahl weist auf die späteren Jahre und die jährliche Häufigkeit der Amputation wegen peripherer Gefässerkrankungen von ungefähr einer auf zehntausend Einwohnern hin.

Die verschiedenen Amputationshöhen in Bezug auf die verschiedenen Anzeigen werden dargestellt. 12 Prozent der Gliedmassen betrafen die oberen und 78 Prozent die unteren Extremiteten und 2/3 davon wurden an den Hauptstämmen amputiert.

Die primäre Sterblichkeit der Oberschenkelamputationen war 25 Prozent und der Unterschenkelamputationen nur 2 Prozent. Die meisten Todesfälle (51 Prozent) traten in der ersten post-operativen Woche auf. Etwas seltener (31 Prozent) ereigneten sie sich in der folgenden zweiten, dritten und vierten Woche. Die Gefahr des Todes in der post-operativen Periode des Krankenhausaufenthaltes schien augenscheinlich mehr von der zu-grundeliegenden Erkrankung als vom chirurgischen Trauma abzuhängen.

REFERENCES

Gillis, L.: Amputations.—William Heinemann Medical Books Ltd., London 1954.

Jansen, K.: Amputation: Frequency and Cause.—Prosthetics international. Committee on prostheses, braces and technical aids. International Society for the Welfare of Cripples. Copenhagen 1960.

Kelley & Janes: Quoted by Marquardt, W. in Handbuch der Orthopädie Band IV/Teil 2.—Georg Thieme Verlag, Stuttgart 1961.

Klopsteg, P. & Wilson, P.: Human Limbs and their Substitutes. McGraw-Hill Book Company, Inc., New York–Toronto–London 1954.

Marquardt, W.: Gliedmassenamputationen und Gliedersatz.—Wissenschaftliche Verlagsgesellschaft MBH, Stuttgart 1955.