

ACTA ORTHOPAEDICA SCANDINAVICA
SUPPLEMENTUM 69

THE LEG AMPUTEE
A CLINICAL FOLLOW-UP STUDY

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Preface

Amputation is a mutilating and permanently disabling intervention after which rehabilitation is required to help the patient find his place in the world. In planning what measures are likely to be most effective for the rehabilitation of leg-amputees, it is important to know the magnitude of the patient's handicap as a result of the amputation.

Against this background, the present investigation was designed to provide information on annual frequencies of leg-amputees in a Swedish urban population in the past, at present and in the future, on amputation rates, on causes of amputation, on postoperative mortality and survival time, and on the clinical and sociomedical function of patients various lengths of time after amputation at different ages.

CHAPTER 1

Introduction

Pilot study

The initial step in this study was to chart what medical and sociomedical problems were likely to arise in an investigation of the clinical fate of leg-amputees. These problems were surveyed by studying those 968 patients who had been fitted with prostheses in the Orthopaedic Department at Gothenburg over the years 1912—1956. This period was chosen because the Orthopaedic Department moved to its present premises in 1912 and it was desired to have an observation period of at least 5 years up to 1961, the year this preliminary assessment was carried out. Addresses were obtained from the Orthopaedic Department and the Workshop. The patients were interviewed by letter.

The result of this poll was that 607 patients or 63 per cent were contacted, 290 patients or 30 per cent had died, and 71 patients or 7 per cent could not be traced. Of the 968 amputees, the majority — 748 or 77 per cent — were men. While the annual number of leg-amputees fitted with prostheses remained substantially constant before 1920, it then rose steadily until 1956. Thus in the quinquennium 1926—1930 the Workshop had 64 patients referred to it, and in the period 1951—1955 the corresponding number was 243.

In this series of 968 patients the amputation causes — as judged from case notes, replies to letters, statements by relatives and information from Public Register Offices — were distributed as follows: accidents in 488 patients or 50 per cent, peripheral vascular disease in 241 patients or 25 per cent, infections in 109 patients or 11 per cent, tumours in 75 patients or 8 per cent, and miscellaneous causes in 65 patients or 7 per cent.

The relative proportions of the amputation causes among the prosthesis-equipped patients changed during the period of observation: accidents became less and peripheral vascular disease more dominant. Of all patients fitted with prostheses, traumatic amputees constituted 67 per cent in 1926—1930 and 29 per cent in 1951—1955, the corresponding figures

for gangrene amputees being 2 per cent and 57 per cent. As from 1951 peripheral vascular disease was the largest aetiological group among these prosthesis-equipped amputees, and before that year accidents were in majority.

Few conclusions could be drawn from the aforementioned figures. Most of the patients had been referred to the Workshop from a region that had changed in size during the period of observation. The age structure of the population had altered, a factor probably contributing to the increased proportion of gangrene amputees. The medical profession has acquired a more active attitude toward elderly patients, causing rising numbers of them to be referred for prosthesis fitting. The amputee's economic status has improved and grants have been introduced to defray the costs of prostheses; as a result the proportion of amputees fitted with prostheses has grown.

This postal-interview study provided no information on the annual number of leg-amputees or on the fate of those that had not been fitted with prostheses.

To answer those questions which had been left open by the pilot investigation, it was necessary to carry out additional studies and to fix the meaning of various concepts.

Definitions

Leg-Amputee: a patient whose lower extremity has been amputated proximal to the ankle joint.

Amputation Year: the calendar year when the patient underwent the first amputation proximal to the ankle joint.

Amputation Age: the patient's age at the time of the first amputation proximal to the ankle joint.

Amputation Cause: the main disease or trauma that gives rise to a condition necessitating amputation. For example, the main disease is peripheral obliterative arteriosclerosis which leads to a condition, gangrene, which in turn calls for amputation. The amputation cause in this example is peripheral obliterative arteriosclerosis.

Postoperative Complications: complications occurring during the six months following the first amputation proximal to the ankle joint.

Duration of Treatment: the length of time elapsed from the day the patient was admitted to hospital to the day he was discharged.

Amputation Level: denoting that the leg was amputated either below or above the knee. Patients whose hip or knee joint had been exarticulated were regarded as above-knee amputees.

Survival Time: the time from the last amputation proximal to the ankle joint to the day of death.

Prosthesis-Walker: a patient who, unaided by another person, has used his prosthesis daily for six months, with or without supporting himself on a cane.

Clinical Function: in this context merely the patient's ability to use his prosthesis.

Sociomedical Function: the patient's ability to benefit from his clinical function in daily life.

CHAPTER 2

Methods

A list was prepared of all the 586 inhabitants of Gothenburg who had undergone leg amputations in Gothenburg over the years 1947 through 1962. Primary information was obtained from the operation schedules for the following departments: Departments of General Surgery I and II, Extremital Surgery, Thoracic Surgery and Orthopaedics, all in Sahlgrenska Sjukhuset, and the Surgical Clinics of the Paediatric Hospital, Ekmanska Sjukhuset and Carlanderska Sjukhemmet. This group of 586 leg-amputees will hereinafter be known as the "586-Series".

Occasionally supplementary data were extracted from case records. The information thus gathered made it possible to analyze the frequencies as well as the age and sex distributions of these leg-amputees. These results are presented in Chapters 4 and 7.

For further analysis personal contact was sought with the amputees. It was desirable to have a long observation period to enable studies of the patient's ability to adapt himself to his handicap. It was necessary to establish whether the leg-amputee's clinical and socio-medical function had improved.

Accordingly conditions for new leg-amputees in Gothenburg during the years 1947 through 1956 and 1961 were further scrutinized. This part of the investigation was commenced in 1961 and concluded the 28th February 1963. These 331 leg-amputees will hereinafter be known as the "331-Series". The decade 1947—1956 was chosen in order to have a substantial number of patients with an observation period of at least five years, and 1961 was included for statistical reasons because a large number of leg amputations were performed in that year. The observation period for the latter patients was at least one year. Among the patients in the 331-Series 84 were alive, all of whom were followed up by the writer with respect to the points included in the form reproduced as Fig. 2:1. Observation periods for these 84 patients will be found in Table 2:1. Of these 84 patients, 50 were seen in the Orthopaedic Department, 13 in their homes

		Date:
		Telephone No.:
	Name:	Address:
1—3	Identity No.:	
4—5	Date of birth:	
6—7	Year of amputation:	
8	Clinic or hospital where amputation was done:	
9—10	Age at amputation:	
11—12	Current age:	
13	Cause of amputation:	
14	Amputation level:	
15	Leg amputated:	
16	Sex:	
17	Postoperative complications:	
18	Type of prosthesis:	
19	No. of prosthesis changes:	
20	Years since first prosthesis fitted:	
21	Distress from prosthesis:	
22	Vocation or trade before amputation:	
23	Vocation or trade after amputation:	
24	Degree of disablement — Pension:	
25	Car ownership — Economy:	
26	Institutional care:	
27	Intercurrent disabling diseases:	
28	General health:	
29	Gait, ability to walk:	
30	Condition of stump:	
31	Stump length:	
32	Phantom pains:	
33	Distress from stump:	
34	Knee/hip joint condition:	
35	Practical function:	
36	Working capacity:	

Fig. 2:1 Form used for follow-up investigation.

Table 2:1. Duration of amputation for 84 followed-up patients in the 331-Series.

Duration of amputation years	No.
1—2	31
5	10
6—10	24
11—15	19

Table 2:2. Number of amputees and duration of amputation in the 133-Series.

Duration of amputation, years	Age at amputation						Total
	— 9	10—19	20—29	30—39	40—49	50—59	
< 11	2	1	6	3	4	6	22
11—20	1	8	11	11	2	2	35
21—30	2	9	7	4	3	1	26
31—40	2	8	8	4	3	0	25
> 40	5	14	5	1	0	0	25
Total	12	40	37	23	12	9	133

and 21 in various institutions in which they were staying. An additional patient — a 13 years old traumatic amputee in 1949 — was regarded as alive but not followed up owing to emigration.

All the 246 other patients had died. Their fate was as far as possible followed from the day of the amputation to the day of death. After discharge from the Surgical Department many of them had been admitted to a Department for Chronics, and available case records were studied. Records of the Orthopaedic Workshop were perused with respect to those who had been fitted with prostheses. Relatives as well were occasionally interviewed. Causes of death were ascertained from autopsy reports and Public Register Offices.

Analysis of the data for the 331-Series produced information on amputation causes, postoperative course, survival time, clinical function and sociomedical function. Results are presented in Chapters 5, 6, 7, 8 and 9.

Owing to the heavy preponderance of elderly leg-amputees in the 331-Series, it did not adequately portray the clinical and sociomedical functions of young leg-amputees. Hence the investigation was supplemented by personal follow-up examinations in the Orthopaedic Department of 133 patients, namely all leg-amputees before 1957 with amputation ages below 60 years who had been fitted with prostheses in the Workshop at Gothenburg and in 1961 were domiciled in Greater Gothenburg (Gothenburg, Kungälv, Kungälv, Kungälv, Mölndal, Sävedalen, Partille). Observation periods versus decades of amputation age are given in Table 2:2. The patients were traced with the aid of information supplied by the Orthopaedic Workshop, the examination comprising the items shown in Fig. 2:1. This group of patients — hereinafter known as the "133-Series" — were characterized by long survival times. The observation period was in no case less than five years. The data for the 133-Series cast light upon the clinical

and sociomedical functions of patients who have undergone amputation and been equipped with prostheses at an active age. The results are presented in Chapters 8 and 9.

As 31 patients were common to the 133-Series and 331-Series, altogether 186 leg-amputees were examined by the writer personally.

Thus three series of patients were studied, *viz.*

- (i) The 586-Series comprising all Gothenburg residents subjected to leg amputation in Gothenburg in 1947 through 1962,
- (ii) The 331-Series comprising all Gothenburg residents subjected to leg amputation in Gothenburg in 1947 through 1956 and 1961,
- (iii) The 133-Series comprising all Gothenburg residents subjected to leg amputation in Gothenburg before 1957 with amputation ages below 60 years, and prosthesis-equipped at the Orthopædic Workshop in Gothenburg, who were domiciled in Greater Gothenburg in 1961.

Thus, as dictated by the necessity of obtaining data suitable for statistical analysis, the investigation embraced different groups of patients for which the observation periods, ages and durations of prosthesis use varied.

Statistical Methods

Standard statistical methods were used for graphical and numerical description of the statistics collected in the present investigation. Simple statistical predictions were sometimes made in connection with census figures. χ^2 methods were used extensively, both regular χ^2 techniques for analysis of qualitative data (cf. Maxwell, 1961) and partition of χ^2 for studying variation within and between sets. Some medical phenomena influenced by a complex network of factors were analyzed in the form of a 2ⁿ contingency table, the observed proportion then being transformed by the logit transformation $z = \ln \frac{p}{1-p}$ and analysis of variance by the method due to Yates. This method not only enables factors of significance to be extracted but also supplies information on interaction between factors. Unless otherwise specified, differences were significant on the 5 per cent level or better.

Reference: Maxwell, A. E.: *Analyzing Qualitative Data*, Methuen & Co Ltd, London 1961.

Clinical Material

Several clinical investigations of amputees and their problems have been published since 1950. (McKenzie, 1953; Gingras *et al.*, 1954; Jansen, 1960; Hirsch, 1961; Wolters, 1961; Bugel & Carlsson, 1961; Widolf, 1961; Alffram & Holmquist, 1961; Felländer, Hallberg & Storck, 1962; Lempke *et al.*, 1963). Some of the series are surveyed in Table 3: 1. Many of these publications come from rehabilitation clinics or prosthesis and amputation centres. The main aim of Swedish investigations in the 1960's has been to evaluate the effectiveness of rehabilitating measures taken at various orthopædic clinics (Hirsch, 1961; Widolf, 1961; Alffram & Holmquist, 1961; Felländer, Hallberg & Storck, 1962; Lundholm, 1963).

In numerous investigations there has been a considerable preponderance of patients over 60 years old. This applies to the British report just mentioned, as well as to Alffram & Holmquist (1961), Felländer, Hallberg & Storck (1962) and Lundholm (1963).

Most papers on leg-amputees have dealt with a majority of men. The magnitude of the masculine dominance has varied with the age distribution of the patients. Series of mainly geriatric patients exhibit small sex differences. For example Alffram & Holmquist had 53 per cent men and Lundholm 54 per cent men. Series of younger amputees include a greater preponderance of men (Jansen, 1960; Hirsch, 1961; Widolf, 1961).

The 586-Series

The numbers of leg-amputees in Gothenburg for each of the years 1947 through 1962 are plotted in Fig. 3: 1. It will be seen that the annual number of amputees rose from 1955. While 21 patients underwent leg amputation in 1954, the corresponding figure in 1955 was 38 and in 1962 it was 69. The age distribution of the 586-Series is shown in Fig. 3:2 In conformity with Gothenburg population statistics for recent years, the amputation age was divided into the decades: —9 years, 10—19 years,

Table 3:1. Number of amputees, observation periods and amputation causes in recent publications.

Authors and year	Observation period	No.	Amputation causes in per cent			
			Peripheral vascular disease	Accidents	Tumours	Miscellaneous
Gingras <i>et. al.</i> Montreal, Canada 1954	1949—53	90	61	21	4	14
Jansen Copenhagen, Denmark 1960	no details	669	56	29	5	10
Annual Report England 1961	1960	2256	63	23	8	6
Widolf Lund, Sweden 1961	1949—58	134	49	16	24	11
Bugel & Carlsson Nashville, Tennessee U. S. A. 1961	1947—60	222	56	38	5	1
Alffram & Holmquist Malmö, Sweden 1961	1949—58	149	84	10	5	1
Dale & Jacobs Nashville, Tennessee U. S. A. 1962	1956—60	385	62	16	6	16
Felländer <i>et. al.</i> Stockholm, Sweden 1962	1954, 1957	87	86	7	6	1
Lundholm Karlstad, Sweden 1963	1951—60	93	85	no details	no details	no details
586-Series Gothenburg 1964	1947—62	586	85	9	4	2

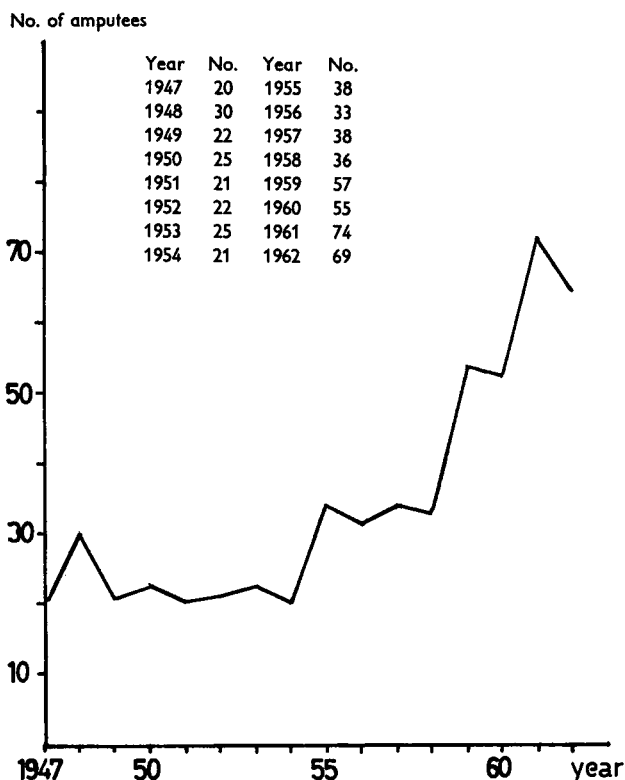


Fig. 3:1. Frequency of leg-amputees in Gotehnborg 1947—1962.

20—29 years, etc. The amputation age of most patients exceeded 60 years, the largest age group being the 70—79 year olds. In the 586-Series 82 per cent of the patients were over 60 years of age at the amputation.

The 586-Series included 347 men or 59 per cent.

The distribution of amputation causes is portrayed by Fig. 3:3. Peripheral vascular disease was responsible for as much as 85 per cent of all the amputations, accidents for 9 per cent and all other causes for 6 per cent.

Being part of the 586-Series, the 331-Series is covered by the aforementioned tables and diagrams and needs no separate presentation.

The 133-Series

Most of the patients domiciled within Greater Gothenburg in 1961 whose amputation age was less than 60 years had been operated on in the years immediately preceding 1956 (cf. Table 3:2). No amputation had

Fig. 3:2. Age at amputation in Gothenburg 1947—1962.

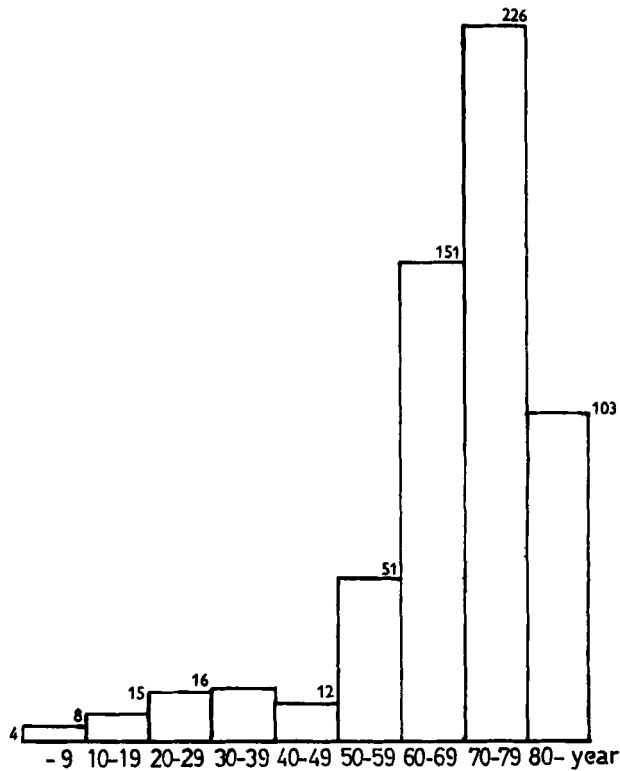


Fig. 3:3. Causes of amputation in Gothenburg 1947—1962.

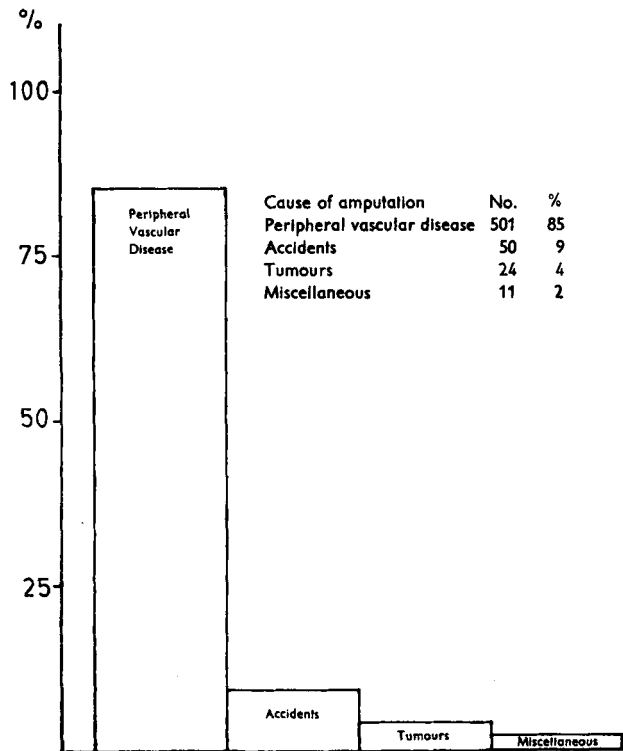


Table 3:2. Year of amputation related to age in the 133-Series.

Year	Age at amputation						Total
	—9	10—19	20—29	30—39	40—49	50—59	
—1919	4	9	5	0	0	0	18
1920—29	3	12	8	4	2	0	29
1930—39	2	9	4	5	2	0	22
1940—49	1	5	12	8	3	2	31
1950—56	2	5	8	6	5	7	33
Total	12	40	37	23	12	9	133

been performed before 1919 on any patient who was then over 29 years old. The next two age groups, 1920—1929 and 1930—1939, included amputees with amputation ages up to 49 years. The patients in the period 1940—1956 were of all ages up to 60 years. The comparatively few amputees in the first period is accounted for by death of subjects older than 30 years at amputation prior to 1919.

The distribution of the 133-Series in amputation age groups of 10 years is shown in Table 3:3. The largest group, comprising 40 patients or 30 per cent, had amputation ages between 10 and 19 years. As many as 112 patients or 84 per cent of the whole series had amputation ages below 40 years. This great preponderance of patients with amputation ages up to 39 years is due to the high incidence of accidents at these ages. The amputation age group of 50—59 years included merely 9 patients.

The 133-Series comprised many more men than women, namely 107 or 80 per cent and 26 or 20 per cent respectively. This should be considered in the light of the high frequency of accidents among men.

The distribution of amputation causes in the 133-Series is shown in Table 3:4. Accidents constituted the largest group with 82 patients or 62 per cent. The majority of accidents took place in traffic, this group comprising 39 patients. The second largest group comprised industrial accidents excluding traffic accidents with 25 patients (see Table 3:5). Tram and railway accidents were responsible for 20 male and 1 female amputees.

Below-knee amputees, including bilateral below-knee amputees, numbered 83, the remaining 50 patients being above-knee amputees. Seven patients were bilateral amputees, all of them below-knee.

Table 3:3. Age at amputation for men and women in the 133-Series.

Age at amputation, years	Men	Women	Total
— 9	8	4	12
10—19	29	11	40
20—29	35	2	37
30—39	20	3	23
40—49	9	3	12
50—59	6	3	9
Total	107	26	133

Table 3:4. Causes of amputation for men and women according to age in the 133-Series.

Cause of amputation	—9		10—19		20—29		30—39		40—49		50—59		Total	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Congenital deformities	4	2	1	2	0	0	0	1	0	1	0	0	5	6
Infections	1	0	2	2	8	0	2	1	1	0	0	1	14	4
Accidents	3	2	23	3	25	0	14	1	5	2	4	0	74	8
Tumours	0	0	3	3	1	1	2	0	1	0	0	2	7	6
Miscellaneous	0	0	0	1	1	1	2	0	2	0	2	0	7	2
Total	8	4	29	11	35	2	20	3	9	3	6	3	107	26

Table 3:5. Types of accidents sustained by men and women in the 133-Series.

Type of accident	Men	Women	Total
Tram and railway	20	1	21
Motorcycle and car	14	4	18
Military	8	0	8
Industrial	24	1	25
Others	8	2	10
Total	74	8	82

CHAPTER 4

Frequency, Sex and Age of Leg-Amputees

Frequencies

The amputation rate varies widely in the few studies published. Russek (1961) stated that the leg-amputee population of the U.S.A. was some 700,000 and estimated that approximately 35,000 new amputations were performed every year.

Some information on the frequency of amputations in England and Wales for 1960 has been published by the British Ministry of Health. The estimated annual frequency of arm and leg amputees in the gross population was 1: 13,000, the ratio of leg-amputees to arm-amputees being approximately 10: 1. In that year 2256 new leg-amputees were treated at all Prosthetic Centres, an 8 per cent increase on the figure for 1959.

Jansen (1960) calculated the approximate amputation rate to be 0.1—0.5 per cent.

Alffram & Holmquist (1961) reported that in the decade 1949—1958 leg amputations were performed on 149 inhabitants of Malmö city, which in 1955 had a population of 210,000. The annual leg-amputation rate during the period studied by these workers was about 1: 14,000. They predicted that the leg-amputee population of Malmö would be 50 per cent higher in 1970 than in 1955, provided the indications for amputation remained unchanged. Felländer, Hallberg & Storck (1962) reported that the total number of Stockholm patients undergoing amputation was 45 in 1954 and 42 in 1957, 3 arm-amputees being included in these figures. Hence the annual amputation rate in Stockholm would be about 1: 18,000.

* * * * *

Amputations were performed at eight clinics in Gothenburg during the years 1947—1962, the patients being distributed by clinics as shown in Table 4:1. The proportion of legs amputated in the departments of general surgery was 89 per cent, and the number of operating surgeons

exceeded 100. Hence there could have been no bias either in indications for amputation or in surgical technique.

Annual frequencies of new amputees in different age groups are set out in Table 4: 2.

Table 4:1. The 586-Series classified according to departments performing the amputation.

Surgical department, hospital	No. of amputees
Surgical department I & II Sahlgrenska hospital	441
Ekmanska hospital	77
Department of surgery for trauma	36
Orthopaedic department	19
Paediatric hospital	7
Carlanderska hospital	5
Thoracic surgery department	1
Total	586

Table 4:2. Age and sex distribution of the 586-Series.

Year	0—9		10—19		20—29		30—39		40—49		50—59		60—69		70—79		80—89		Total	Total	Total
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
1947	0	0	0	0	1	0	1	1	1	0	1	1	3	2	4	2	1	2	12	8	20
1948	1	0	1	0	1	1	1	0	0	0	4	3	5	3	4	3	1	2	18	12	30
1949	0	0	2	0	2	0	0	0	0	1	2	0	2	1	3	6	1	2	12	10	22
1950	0	0	0	0	1	0	3	0	0	0	1	1	1	6	4	5	2	1	12	13	25
1951	0	0	0	1	1	0	2	0	0	0	2	1	3	3	2	5	0	1	10	11	21
1952	0	0	0	0	0	0	1	0	1	1	1	0	7	3	4	2	1	1	15	7	22
1953	0	0	1	0	0	0	2	0	1	0	4	0	4	5	4	2	1	1	17	8	25
1954	0	0	0	0	0	0	0	0	0	0	1	2	2	3	3	4	5	1	11	10	21
1955	2	0	0	1	0	1	1	1	0	0	2	1	7	3	8	9	0	2	20	18	38
1956	0	0	0	0	0	0	0	0	2	0	3	0	4	4	9	6	2	3	20	13	33
1957	0	0	0	0	2	0	0	0	0	0	3	1	4	3	8	8	4	5	21	17	38
1958	0	0	1	0	1	0	0	0	0	0	0	0	5	4	9	8	6	2	22	14	36
1959	0	0	0	0	2	0	2	0	2	0	2	0	13	3	11	11	5	6	37	20	57
1960	1	0	0	0	0	0	1	0	1	0	4	0	6	4	11	13	6	8	30	25	55
1961	0	0	0	0	1	0	0	0	1	0	7	1	16	5	12	11	9	11	46	28	74
1962	0	0	1	0	1	0	0	0	1	0	1	2	11	6	21	14	6	5	42	27	69
Total	4	0	6	2	13	2	14	2	10	2	38	13	93	58	117	109	50	53	345	241	586
Percentage	0.7	0.0	1.0	0.3	2.2	0.3	2.4	0.3	1.7	0.3	6.5	2.2	15.9	9.9	20.0	18.6	8.5	9.0	58.8	41.1	100.

Table 4:3. Male and female populations over 60 and total population over and under 60 years in Gothenburg 1947—1962.

Year	Men > 60 year	Women > 60 year	Total population > 60 year	Total population < 60 year
1947	17860	23165	41025	292247
1948	18628	24089	42717	301261
1949	19429	25050	44479	304666
1950	20265	26044	46309	307378
1951	21029	26875	47904	310290
1952	21822	27732	49554	313446
1953	22645	28617	51262	316317
1954	23499	29530	53029	320404
1955	24381	30476	54857	325585
1956	25045	31470	56515	330546
1957	25727	32496	58223	334354
1958	26427	33555	59982	337223
1959	27146	34649	61795	338992
1960	27885	35776	63661	341591
1961	28644	36942	65586	342706
1962	29424	38146	67570	343321

An amputation age of 60 years was chosen in order to find out if the age shift which has taken place in the gross population was manifested in the amputation frequencies.

Data on the population of Gothenburg in 1947—1962 (Table 4: 3) were taken from "Statistisk Årsbok för Göteborg" (Statistical Yearbook for Gothenburg). The annual amputation rates are expressed as the observed number of new amputees per 100,000 inhabitants (Table 4: 4).

Scrutiny of the annual rates compiled in Table 4: 4 reveals that the amputation rate remained substantially constant up to 1954, whereupon it began to rise for patients over 60 years of age. Notably, as compared with the amputation rate for 1947, that for 1962 was 2.8 times higher for all leg-amputees, 2.9 times higher for men over 60 years old and 2.5 times higher for women over 60 years old. In other words, an increased amputation rate was observed, predominantly in the period 1955—1962, which mainly affected men over 60 years old.

Table 4: 5 reveals how the amputation rate rose with age for the amputees older than 60 years and also that it tended to rise within age groups over the years surveyed. Some years had to be omitted because

Table 4:4. Observed amputation rates per 100.000 inhabitants for the entire population, for all men and women, for the entire population over and under 60 years, and for men and women over 60 in Gothenburg 1947—1962.

Year	Total under 60	Total over 60	Men over 60	Women over 60	All men	All women	Total
1947	2.1	34.1	44.8	25.9	7.5	4.6	6.0
1948	4.0	42.1	53.7	33.2	10.8	6.7	8.7
1949	2.3	33.7	30.9	35.9	7.1	5.6	6.3
1950	2.0	41.0	34.5	46.1	7.0	7.1	7.1
1951	2.3	29.2	23.8	33.5	5.8	6.0	5.9
1952	1.3	36.3	55.0	21.6	8.5	3.7	6.1
1953	2.5	33.2	39.7	28.0	9.5	4.2	6.8
1954	0.9	33.9	42.6	27.1	6.1	5.2	5.6
1955	2.8	52.9	61.5	45.9	10.8	9.2	10.0
1956	1.5	49.5	59.9	41.3	10.6	6.5	8.5
1957	1.8	55.0	62.2	49.2	11.0	8.5	9.7
1958	0.6	56.7	75.7	41.7	11.3	6.9	9.1
1959	2.4	79.3	106.8	57.7	18.9	9.8	14.2
1960	2.0	75.4	82.5	69.9	15.2	12.0	13.6
1961	2.9	97.6	129.2	73.1	23.1	13.4	18.1
1962	1.7	93.2	129.1	65.5	20.9	12.9	16.8

exact figures are not available for the size of Gothenburg's population in the years 1947—1949, 1951—1954 and 1959. The mean amputation rate during the years shown in Table 4:5 was about 1:2800 in the 60—69 years amputation age group, around 1:900 in the 70—79 years group and approximately 1:500 in the 80—89 years group.

The average amputation frequency in the present investigation was around 1:10,000. On this basis the estimated rate for 1947 would be about 1:16,000 and for 1962 approximately 1:6000. This implies that the amputation rate underwent considerable variations from year to year.

Amputation rate variations are shown in Fig 4: 1. Evidently the rate lay fairly constant in the years 1947—1954 but rose sharply in subsequent years. The lowest curve discloses that the amputation rate for subjects under 60 years of age remained unvaryingly low.

It has appeared from the foregoing that the number of new amputations rose markedly over the period 1955—1962. For the relative amputation rate, defined as the ratio of amputees to the total number of potential amputees, has gone up from 0.06 per cent in 1947 to 0.168 per cent in 1962.

Year	Amputation rates in different age groups		
	60—69	70—79	80—89
1950	23.9	66.6	85.8
1955	29.6	101.1	46.7
1958	25.9	96.0	153.8
1960	26.6	117.8	247.0
1961	54.3	107.4	324.4
1962	42.9	157.8	171.2
Total	34.6	111.6	185.6

Table 4:5. Observed amputation rates per 100000 inhabitants in the 586-Series.

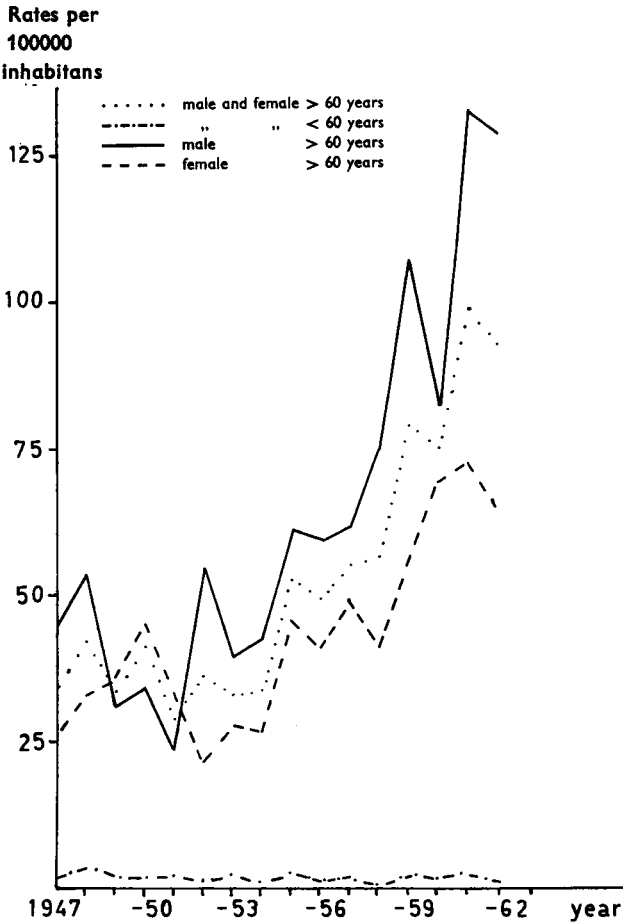


Fig. 4:1. Amputation rates in Gothenburg for males and females of different ages.

To obtain larger and hence more reliable figures, data were calculated for periods of 2 years and the significance of any differences tested by χ^2 analysis. The observed number of amputees was thus compared with the number to be expected if the average amputation rate had applied throughout the period (Tables 4: 6, 4: 7, 4: 8, 4: 9). The differences in amputation rate between the 2-year periods turned out to be significant for the 586-Series as a whole as well as for men and for women over 60 years old. The rate was not increased for subjects under 60 years of age.

Moreover, as expected, it appeared that the frequency of amputees remained substantially constant during the period 1947—1954 and there-

Table 4:6. Numbers of amputees observed vs. expected at constant rate in Gothenburg 1947—1962.

Year	Observed No. of amputees	Mean population	Expected No. of amputees at constant rate
1947—48	50	338625	66
1949—50	47	351416	68
1951—52	43	360597	70
1953—54	46	370506	72
1955—56	71	383752	75
1957—58	74	394891	77
1959—60	112	403020	78
1961—62	143	409592	80
$\chi^2 = 95.45$ d. f. = 7 $P < 0.0005$			

Table 4:7. Numbers of amputees observed vs. expected at constant rate in the male population over 60 years old in Gothenburg 1947—1962.

Year	Observed no. of amputees	Mean male population over 60 years old	Expected No. of amputees at constant rate
1947—48	18	18224	25
1949—50	13	19847	27
1951—52	17	21426	29
1953—54	19	23072	32
1955—56	30	24713	34
1957—58	36	26077	36
1959—60	52	27516	38
1961—62	75	29034	40
$\chi^2 = 56.73$ d. f. = 7 $P < 0.0005$			

Year	Observed no. of amputees	Mean female population over 60 years old	Expected No. of amputees at constant rate
1947—48	14	23627	21
1949—50	21	25547	23
1951—52	15	27304	25
1953—54	16	29074	26
1955—56	27	30973	28
1957—58	30	33026	30
1959—60	45	35213	32
1961—62	52	37544	34
$\chi^2 = 25.52$ d. f. = 7 $0.0005 < P < 0.0001$			

Table 4:8. Numbers of amputees observed vs. expected at constant rate in the female population over 60 years old in Gothenburg 1947—1962.

Year	Observed no. of amputees	Mean male population under 60 years old	Expected No. of amputees at constant rate
1947—48	18	296754	12
1949—50	13	306022	13
1951—52	11	311868	13
1953—54	11	318360	13
1955—56	14	328066	13
1957—58	8	335778	14
1959—60	15	340292	14
1961—62	16	343014	14
$\chi^2 = 6.14$ d. f. = 7 $0.5 < P < 0.6$			

Table 4:9. Numbers of amputees observed vs. expected at constant rate in the population under 60 years old in Gothenburg 1947—1962.

upon increased sharply. To analyze this phenomenon, the χ^2 value found for the entire 586-Series was partitioned into three components measuring, respectively, differences within the years 1947—1954, within the years 1955—1962 and between the periods 1947—1954 and 1955—1962. The results are assembled in Table 4: 10 which discloses that whereas there was no significant increase in amputation rate within the years 1947—1954, this rate rose markedly within the years 1955—1962. In addition, the periods 1947—1954 and 1955—1962 had different amputation rates. Hence it is justified to conclude that the amputation rate was constant during the years 1947—1954 but then rose considerably over the years 1955—1962.

Table 4:10. χ^2 partitioning between the years 1947—1954, the years 1955—1962 and the periods 1947—1954 and 1955—1962.

Basis for comparison	χ^2	d. f.	P
Between years 1947—54	0.84	3	$0.8 < P < 0.9$
Between years 1955—62	38.58	3	$P < 0.0005$
Between periods 1947—54 and 1955—62	56.03	1	$P < 0.0005$
Total	95.45	7	$P < 0.0005$

Considering that 82 per cent of the patients in the 586-Series were older than 60 years at amputation while only 17 per cent of Gothenburg's population was over 60 years of age during the period 1947—1962, the observed increase in the amputation rate over 60 years of age during the period 1955—1962 could be wholly due to the progressive shift towards higher ages in the population at large. This might also modify the aforementioned pronounced increase with rising age over 60 years in the leg amputation rate (cf. Table 4: 5). To ascertain whether the increased amputation rate was wholly due to the age composition of the population or whether there was a true increase of amputation rate within age groups over 60 years, χ^2 analysis was used in the same way as for Tables 4: 6, 4: 7, 4: 8 and 4: 9. The observed amputation rate was thus compared with an expected amputation rate based on a constant mean rate for the years 1950, 1955, 1958 and 1960—1962. It turned out that there was not a significantly increased amputation rate among the 60—69 years olds ($\chi^2 = 7.85$; d. f. = 5). On the other hand, both the 70—79 year olds ($\chi^2 = 74.6$; d. f. = 5; $P < 0.001$) and the 80—89 year olds ($\chi^2 = 14.27$; d. f. = 5; $0.05 > P > 0.01$) exhibited significantly increased amputation rates.

The amputation rates for men and women must be compared within each 2-year period owing to the observed amputation rate differences between the periods 1947—1954 and 1955—1962. Table 4:11 presents χ^2 values for each 2-year period. It appears that, with the exception of 1947—1948, the amputation rate difference between the sexes tended gradually to grow larger. The difference was significant in 1961—1962 ($\chi^2 = 12.35$; d. f. = 1; $P < 0.001$).

Age and Sex

The aforementioned Annual Report from the British Ministry of Health for 1960 stated that the proportion of amputees in the age groups from 0—79 years increased progressively. The 70—79 year olds were the largest

group, representing 23.6 per cent of all the 2256 new cases of leg amputation. 65.5 per cent were over 50 years and 51 per cent over 60 years. Women formed the minority in all age groups. The difference between the sexes was small in the age group 80—89 years which comprised 69 men and 60 women. Among all the amputees the ratio of men to women was 2.4: 1.

In Jansen's (1960) series of 669 leg-amputees, 16 per cent were under 20 years old, 47 per cent 20—60 years and 37 per cent over 60 years. In his series of amputees 28 per cent were women. In Alffram & Holmquist's (1961) series, 76.5 per cent of the patients were over 60 years old, the ratio of men to women being 1.1:1.

Among the patients in the Stockholm series described by Felländer, Hallberg & Storck (1962), 70 per cent were over 60 years old. 66 per cent of the amputees were men.

* * * * *

Table 4:11. Observed biennial amputation rates for men and women over 60 years old in Gothenburg 1947—1962.

Years	Men			Women			χ^2
	Population	No. of amputees.	Biennial amputation rate per 100.000	Population	No. of amputees.	Biennial amputation rate per 100.000	
1947—48	18244	18	98.66	23627	14	59.25	2.094
1949—50	19847	13	65.60	25547	21	82.20	0.416
1951—52	21426	17	79.34	27304	15	54.94	1.090
1953—54	23072	19	82.35	29074	16	55.03	1.431
1955—56	24713	30	121.39	30973	27	87.17	1.574
1957—58	26077	36	138.05	33026	30	90.84	2.912
1959—60	27516	52	188.98	35213	45	127.79	3.746
1961—62	29034	75	258.32	37544	52	138.50	12.345

The age and sex distributions of the 586-Series are shown in Table 4: 2 (p. 21), the age at the primary amputation being specified for bilateral amputees. Among the 586 amputees, 82 per cent had amputation ages over 60 years. The largest amputation age group was 70—79 years with 39 per cent of the patients. At the time of the amputation 9 per cent were less than 50 years old.

In most age groups there was a distinct preponderance of men. Amputation was 7 times as common among men as among women in the age group 30—39 years. With rising age the masculine preponderance diminished and yielded to a preponderance of women in the 80—89 year group. This is because of the great preponderance of women in the population over 80 years of age. In 1955 the population of Gothenburg included over twice as many women as men at the age of 85. The ratio of men to women in the entire 586-Series was 1.4:1, among amputees under 60 years old 4.1:1 and among amputees over 60 years old 1.2:1.

To establish whether a shift towards higher amputation ages was taking place, the median and 75th percentile ages were calculated. Over the period concerned both the median and 75th percentile ages remained unchanged through 1953 and then showed a weak tendency to rise, the median age rising from 65 years in 1953 to 73 years in 1962 (Table 4: 12).

A better impression of the amputation age fluctuations was formed by calculating what proportion of all the amputees had been below a given

Table 4:12. Median and 75th percentile ages within years among amputees in Gothenburg 1947—1962.

Year	Median age	75th percentile age
1947	69.0	77.0
1948	64.0	73.0
1949	73.0	78.0
1950	68.0	78.0
1951	68.0	74.0
1952	68.0	74.0
1953	65.0	71.0
1954	72.0	80.0
1955	69.0	74.5
1956	72.0	77.0
1957	75.0	79.5
1958	74.0	79.0
1959	71.0	76.5
1960	74.0	81.0
1961	72.0	80.0
1962	73.0	77.0

Table 4:13. Cumulative percentage of amputees in age groups during intervals of four and eight years in Gothenburg 1947—1962.

Period	Amputation age								
	0—9	0—19	0—29	0—39	0—49	0—59	0—69	0—79	0—89
	%	%	%	%	%	%	%	%	%
1947—50	1.0	4.1	10.5	16.4	18.6	32.0	55.7	87.6	100
1951—54	0	2.2	3.4	9.0	12.4	24.7	58.4	87.6	100
1955—58	1.4	2.6	5.5	6.9	8.3	15.2	38.6	83.4	100
1959—62	0.4	0.8	2.3	3.5	5.4	12.1	37.0	77.8	100
1947—54	0.5	3.2	7.0	12.9	15.6	28.5	57.0	87.0	100
1955—62	0.7	1.5	3.5	4.7	6.5	13.2	37.6	80.0	100
1947—62	0.7	2.0	4.6	7.3	9.4	17.9	43.5	82.3	100

Table 4:14. Cumulative percentage of inhabitants of Gothenburg in different age groups.

Year	Age at amputation								
	0—9	0—19	0—29	0—39	0—49	0—59	0—69	0—79	0—105
1950	16.0	26.7	42.2	59.5	74.9	86.9	95.2	99.0	100
1955	15.2	28.1	41.1	57.7	73.2	85.6	94.5	98.9	100
1958	14.6	29.0	41.6	57.6	73.1	85.5	94.2	98.7	100
1960	13.7	28.2	41.2	55.9	71.2	84.3	93.6	98.6	100
1961	13.4	28.0	41.0	55.1	70.4	83.7	93.2	98.5	100
1962	13.2	27.7	41.1	54.6	69.9	83.3	93.0	98.4	100

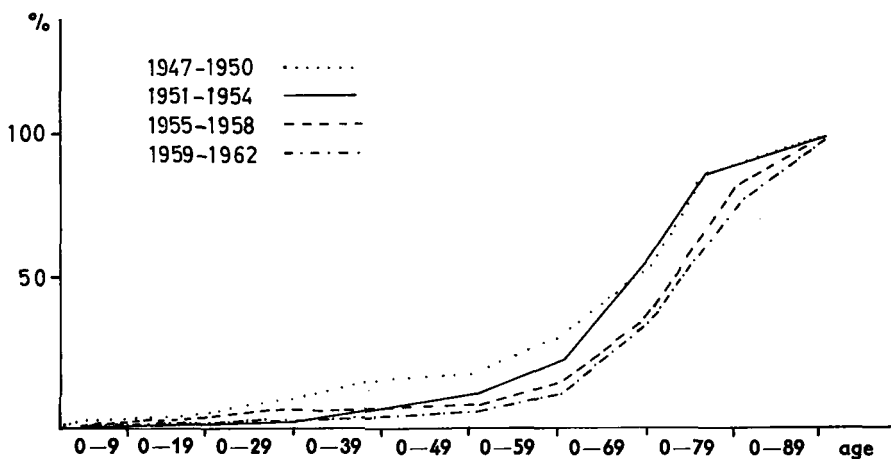


Fig. 4:2. Quadrennial cumulative age distribution of amputees in Gothenburg 1947—1962.

amputation age during a set period. To get an adequate number of subjects in each category, the patients were assembled in 4-year groups; the picture became even clearer when the series was divided into 8-year groups (see Table 4:13 and Fig. 4:2). It was found that the proportion of amputees below successive age limits diminished. While amputees up to 79 years of age constituted 88 per cent of the 586-series in the periods 1947—1950 and 1951—1954, their proportion had fallen to 83 per cent in 1955—1958 and to 78 per cent in 1959—1962. Similarly, the proportion of all amputees with amputation ages up to 60 years was 32 per cent in 1947—1950, 25 per cent in 1951—1954, 15 per cent in 1955—1958 and 12 per cent in 1959—1962. The age changes are illustrated by Fig. 4: 2, showing the cumulative distribution of the amputees in these 4-year periods. The fact that the curves for higher amputation ages are farthest to the right in the figure indicates that the amputation age was rising.

Table 4:14 demonstrates the cumulative distribution in per cent of the corresponding age groups of Gothenburg's population. Evidently the percentage falls steadily in all age groups over 30 years.

Amputation Causes

Pearse & Ziegler (1940) and Conway & Meigher (1942) noted that mostly diabetic gangrene occurred among patients aged 60—70 years. Lempke *et al.* (1963) found that amputation took place 3 years earlier in diabetic than in non-diabetic patients with gangrene. Bell (1957) demonstrated that gangrene was 53 times as common in male diabetics as in non-diabetic men and 71 times as common in female diabetics as in non-diabetic women. Dry & Hines (1941) reported that the incidence of peripheral vascular complications of diabetes was twice as high among men as among women. Among diabetics referred for prosthesis fitting in England and Wales in 1960 there were equal numbers of men and women.

Studying the long-term prognosis in a series of 165 living and 65 deceased diabetics, Lundbäck (1953) found no correlation between the frequencies of diabetic nephropathy and gangrene.

A series of 46 diabetics with gangrene and infection studied by Conway & Meigher (1942) included 26 receiving insulin and 11 on dietetic treatment while the remaining 9 patients were newly diagnosed diabetics.

Diabetes is associated with extensive lesions of the vascular tree, as is illustrated by the high proportion of bilateral amputees and circulatory disturbances from other organs encountered among diabetics. Joslin (1944) reported that 39 of 100 unilateral amputees with diabetes eventually had to have the remaining leg amputated. Silbert (1952) stated that 30 per cent of diabetic amputees had the other leg amputated within three years after the primary amputation and after five years 51 per cent of the survivors were bilateral amputees. Bell (1957) found bilateral gangrene in 26 per cent of diabetic amputees and in 21 per cent of non-diabetic amputees. Claugus *et al.* (1958) noted a high frequency of heart disease in patients with gangrene.

In McKenzie's (1953) series of 344 British amputees over 65 years of age referred for prosthesis fitting there were three times as many non-diabetic as diabetic patients with gangrene. Gingras *et al.* (1954) observed

a preponderance of diabetics among amputees treated in a rehabilitation centre in Montreal. Chapman *et al.* (1959) in the U.S.A. described a series of 51 elderly amputees, a high proportion, 45 per cent, of whom had "arteriosclerotic cardiovascular disease". The majority of gangrene amputees treated at prosthetic centres in England and Wales during 1960 were non-diabetic. In Alffram & Holmquist's (1961) investigation from Sweden diabetics were in majority with 61 patients or 41 per cent of the 149 amputees, followed by 41 non-diabetics or 27 per cent. Most of the gangrene amputees in their series were in the 70—79 year amputation age group. Lempke *et al.* (1963) found that 39 per cent of 200 obliterative-arteriosclerosis amputees suffered from arteriosclerotic cardiac disease.

In England and Wales in 1960 industrial accidents were responsible for 32 per cent and traffic accidents for 54 per cent of the amputations among all traumatic amputees. Traffic accidents often resulted in injuries to drivers and passengers in motor vehicles. The ratio of men to women was 6.3:1. Jansen (1960) in Denmark published an investigation of 669 leg-amputees, 36 per cent of whom were traumatic. In the latter category the injuries were due to traffic accidents in 33 per cent and to industrial accidents in 28 per cent.

Classification

The amputation causes in the 331-Series were distributed as shown in Table 5: 1. As a rule the leg-amputee suffers from some primary disease which has given rise to a secondary condition that has made amputation obligatory. The principle adopted in the present investigation was, as mentioned, to specify the primary disease as the cause of amputation. Exceptionally, however, it may be impossible to distinguish the primary disease. Accordingly three cases will now be described and the classification of the amputation cause will be given, though it is debatable what should be regarded as the amputation cause.

Patient 003, male, born July 26, 1873. For at least 70 years he had been treated for osteomyelitis with fistulization in the right femur and humerus. Operative excavation and sequestrectomy were performed most recently, April 23, 1951. Pathological examination of the scrapings disclosed squamous carcinoma probably arising from a fistula. The leg was amputated above the knee May 30, 1951. The wound healed and a prosthesis was fitted, and the patient could manage at home with negligible outside assistance. Died July 22, 1953, in Vasa Sjukhus. Cause of death: cardiosclerosis, pulmonary cancer and prostatic hypertrophy, as noted at autopsy. In this case the amputation cause was regarded as osteomyelitis, which had given rise to secondary cancer.

Patient 129, male, born May 26, 1949. At birth aplastic anaemia was diagnosed, and up to 1955 this condition had called for some 70 blood transfusions. Admitted January 8, 1955, to the Paediatric Hospital's Surgical Ward where splenectomy was performed two

days later. Postoperatively the patient developed a shock-like condition and a vessel was exposed. By misadventure the posterior tibial artery was catheterized. The result was gangrene of the foot, in turn necessitating amputation below the knee, January 27, 1955. The wound was debrided and a reamputation performed on, respectively, February 25 and March 13, 1955. The patient was provided with a prosthesis and learned to use it well. Died September 19, 1956. Cause of death: hypoplastic anaemia and acute pharyngitis, as noted at autopsy. This patient was placed in the accident group.

Patient 192, female, born August 25, 1873. Admitted April 2, 1956, to the Surgical Department in a state of complete disorientation with a comminuted fracture of the left lower leg, calcaneal traction being applied the same day. The 15th April a toe of the left foot exhibited gangrene which progressed so that the leg had to be amputated above the knee May 17, 1956. June 1st the patient was transferred to a hospital for chronics where she died December 24, 1956. Postoperatively the patient was bed-ridden until she died, i.e. 7 months. Cause of death: generalized arteriosclerosis, as verified at autopsy. In this case obliterative arteriosclerosis was regarded as the amputation cause.

Amputation cause	No of amputees	Per cent
Arteriosclerosis with diabetes	143	43.2
Arteriosclerosis without diabetes	93	28.1
Accidents	35	10.6
Embolism and thrombosis	25	7.6
Tumours	17	5.1
Buerger's disease	5	1.5
Raynaud's disease	2	0.6
Congenital tibial pseudoarthrosis	2	0.6
Frost bite	2	0.6
Popliteal artery aneurysm	2	0.6
Osteomyelitis	2	0.6
Chronic leg ulcer	1	0.3
"Vascular disease"	1	0.3
Syphilitic arteritis	1	0.3
Total	331	100.0

Table 5:1. Distribution of amputation causes among amputees in Gothenburg 1947–1956 and 1961.

Obliterative Arteriosclerosis With Diabetes

Of the patients in the 331-Series, 143 or 43 per cent had diagnosed diabetes mellitus. 85 per cent of these diabetics had been under treatment for more than a year before the amputation was performed. Quantitative

Table 5:2. The diagnosis and sex ratio in amputee's of various ages.

Causes of amputation	No.	Men/ Women	Amputation age				
			0—49	50—59	60—69	70—79	80—89
Arteriosclerosis with diabetes	143	$\frac{73}{70} = 1.0$	1	12	59	62	9
Arteriosclerosis without diabetes	93	$\frac{55}{38} = 1.4$	0	4	21	33	35
Accidents	35	$\frac{30}{5} = 6.0$	22	8	1	3	1
Embolism and thrombosis	25	$\frac{14}{11} = 1.3$	0	4	6	10	5
Tumours	14	$\frac{6}{8} = 0.8$	10	1	1	2	0
Miscellaneous	21	$\frac{15}{6} = 2.5$	6	9	3	3	0
Total	331	$\frac{193}{138} = 1.4$	39	38	91	113	50

urinary sugar and qualitative fasting blood sugar tests were made pre-operatively on 137 of the diabetic patients. In one case there was no information regarding laboratory tests, and the laboratory findings were incomplete for the remaining 5 diabetics. Among the diabetic amputees men and women were almost equally represented.

No ideal prognostic classification of diabetes mellitus exists. Patients may be grouped with respect to age at onset, duration and the disease's tendency to be accompanied by vascular complications in the eyes, kidneys, heart and lower extremities. The two former criteria were used in the present investigation. But since the diabetic condition may have a sub-clinical course for several years and the interval between the true onset of diabetes and the day the patient comes under medical management may vary greatly between subjects, neither the age at onset nor the duration of diabetes can reliably be determined.

For most of the diabetics, *i.e.* 85 per cent, the amputation age was 60—79 years. Among diabetics with amputation ages below 70 years, 30 per cent were men and 20 per cent were women. 12 male and 1 female diabetics were less than 60 years old at the time of the amputation (See Table 5:2).

Reckoned from the year diabetes was diagnosed by a physician and treatment instituted to the year of the first amputation proximal to the ankle joint, the clinically known durations of diabetes for these patients are set out in Table 5: 3. The mean duration was 8.7 years. In 16 patients

Duration, years	No.	%
< 1	16	11
1—5	44	31
6—10	22	15
11—15	24	17
16—20	17	12
> 20	14	10
Unknown	6	4
Total	143	100

Table 5:3. Clinically known duration of diabetes among patients whose amputation was due to diabetic gangraene.

Age of onset	No.	%
< 30	1	1
30—39	3	2
40—49	16	11
50—59	41	29
60—69	44	31
70—79	29	20
80—89	3	2
Unknown.	6	4
Total	143	100

Table 5:4. Age at clinical onset of diabetes among patients whose amputation was due to diabetic gangraene.

or 11 per cent, all with durations of less than a year, gangrene lead to the diagnosis of diabetes. In 55 patients or 38 per cent the duration of diabetes exceeded 10 years and in 14 patients it exceeded 20 years. Such variations in duration suggest that the clinical duration of diabetes was not linearly related to the development of gangrene.

The ages at the onset of diabetes were distributed as shown in Table 5: 4. The age at onset was taken as the age when diabetes was diagnosed by a physician and treated. The median age at onset was 62.5 years. The majority, 85 patients, were 50—69 years old at onset of diabetes. Diabetes had set in before the age of 50 in 20 patients.

The chief mode of therapy had been insulin plus diet for 95 patients or 66 ± 8 per cent, diet only for 42 patients or 29 ± 8 per cent, and oral medi-

cation plus diet for 5 patients or 4 per cent. Information on treatment was not available for one patient.

Among the 143 diabetic amputees in the 331-Series, 36 had both legs amputated. At the time of the first amputation 30 of the remaining 107 unilateral amputees exhibited signs of circulatory disturbances in the un-amputated leg in the form of intermittent claudication, chronic ulceration or amputated toes. Signs of circulatory disturbances in the other leg were present throughout the period of observation in 66 patients. A year at most after the first amputation 14 patients were subjected to amputation on the other leg.

At the time of the amputation only 20 diabetics or 14 per cent of the diabetic amputees lacked diagnosed signs of vascular disease other than that which made amputation necessary. However, 8 of these 20 patients died within three months of the operation, the cause of death in all cases being disease of the circulatory system. This suggests that the incidence of intercurrent vascular diseases probably exceeds that recorded in the present investigation. It seems likely that the patient or the examining physician may have overlooked such diseases, a possibility which should be kept in mind in judging the figures to be mentioned hereinafter.

The frequencies of manifestations from the vascular system among the diabetics in the 331-Series were as follows: (i) Cardiac disorders had been noted in 51 patients or 36 per cent of all the diabetics; on admission to hospital "impaired general condition" was recorded for 39 patients or 27 per cent. (ii) Strokes with hemiplegia were seen in 14 patients or 10 per cent. (iii) Senile mental insufficiency due to arteriosclerosis was encountered in 42 patients or 29 per cent; such patients exhibited anything from mild confusional states to senile dementia. (iv) Disabling loss of vision affected 22 patients or 15 per cent.

To give an idea of the extent and degree of vascular lesions sustained by the diabetic amputees, it may be mentioned that 112 of the 125 deceased diabetics died of diseases in the circulatory system or their sequels. The latter group comprised the following diagnoses: generalized arteriosclerosis, cerebrocardiosclerosis, cerebral apoplexy, pulmonary embolism, cardiosclerosis, cardiac decompensation, myocardial infarction, and heart failure. Of the 12 other deceased diabetics, 5 died of malignant tumours and the last 7 of miscellaneous diseases. One patient died in uraemia.

Obliterative Arteriosclerosis Without Diabetes

The age and sex distributions of the non-diabetic gangrene amputees in the 331-Series are shown in Table 5:2 (p. 35). Non-diabetics with arteriosclerosis were preoperatively tested qualitatively for urinary sugar

on several occasions but were always negative. The majority, 55, were men and 38 were women. Gangrene amputees below 70 years of age included 20 men and 5 women, while 19 women and 16 men were in their 80's. Men were affected with non-diabetic obliterative arteriosclerosis in greater numbers and at lower ages than women.

The amputation age exceeded 70 years for the large majority of patients, namely 73 per cent. The largest amputation age group was 80—89 years with 38 per cent.

At the time of the amputation the non-diabetic gangrene amputees exhibited a wide range of vascular abnormalities additional to that constituting the amputation cause. These included: (i) Cardiac disorders in 30 patients or 32 per cent. (ii) Subsequent contralateral amputation in 10 patients; 24 of the remaining 83 patients suffered from circulatory disturbances in the intact leg. (iii) Strokes with hemiplegia in 13 patients or 14 per cent. (iv) Senile mental insufficiency in 24 patients or 26 per cent. On admission to hospital 19 patients or 20 per cent had "impaired general condition". Death was due to disease in the circulatory system in 65 or 92 per cent of the 71 deceased patients.

Diabetic Compared with Non-Diabetic Gangrene Amputees

The 236 subjects in the 331-Series undergoing amputation for peripheral obliterative arteriosclerosis included 143 diabetics and 93 non-diabetics, the non-diabetics to diabetics ratio being 0.65. After 1954 the number of gangrene amputees rose, ($P < 0.001$) the increase being highest ($P < 0.001$) for non-diabetic gangrene amputees (Table 5:5 and Fig. 5:1). Gangrene

Table 5:5. Distributions of amputation causes among leg-amputees in the 331-Series.

Year	Arteriosclerosis		Accidents	Embolism	Tumours	Miscellaneous	Total
	with diabetes	without diabetes					
1947	9	4	3	0	1	3	20
1948	15	5	3	3	1	3	30
1949	8	7	4	1	1	1	22
1950	11	7	1	3	3	0	25
1951	9	5	3	1	2	1	21
1952	13	2	3	2	0	2	22
1953	8	9	6	0	1	1	25
1954	8	5	1	2	1	4	21
1955	17	7	6	4	2	2	38
1956	14	9	3	3	0	4	33
1961	31	33	2	6	2	0	74
Total	143	93	35	25	14	21	331

amputees with and without diabetes did not differ in the frequency of vascular abnormalities (see Table 5:6).

As a rule the diabetics had somewhat lower amputation ages than the non-diabetic gangrene amputees. The median age at amputation was 69 years for diabetics and 72 years for non-diabetics. The proportions of men and women were equal in the group of diabetic gangrene amputees, while in the corresponding group of non-diabetics the majority were men. Above-knee amputees were in majority among both diabetics and non-diabetics; non-diabetic above-knee amputees were somewhat more numerous than diabetic.

Table 5:6. Complicating disabling diseases in patients whose amputation was due to obliterative arteriosclerosis with or without diabetes.

Complication	Obliterative arterio-sclerosis with diabetes		Obliterative arterio-sclerosis without diabetes	
	No.	%	No.	%
Cardiac distress	51	35.7	30	32.2
Multiple manifestations of vascular disease	64	44.8	35	37.6
Impaired general condition	39	27.3	19	20.4
"Strokes"	14	9.8	13	14.0
Senile mental insufficiency.	42	29.4	24	25.8

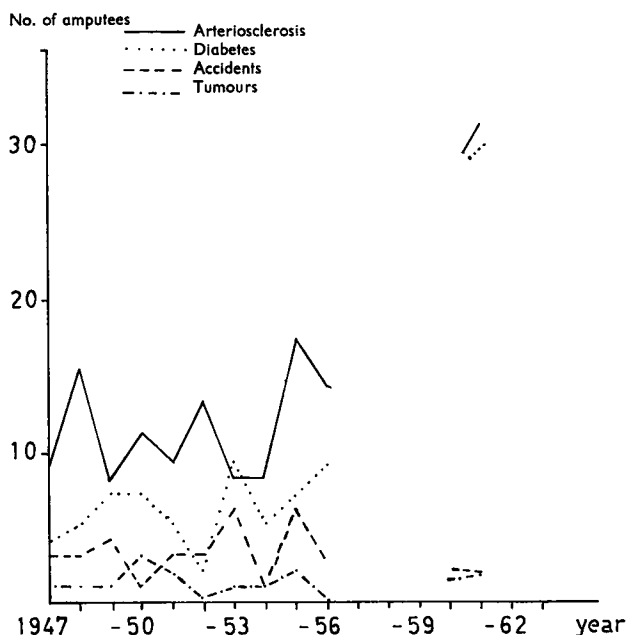


Fig. 5:1. Changes in amputation causes in Gothenburg 1947—1956 and 1961.

Other Amputation Causes

Men dominated among the traumatic amputees. Indeed males were six times as numerous as females in this group. The majority, 30 patients or 86 per cent, were less than 60 years old (see Table 5:2, p. 35).

Yearly frequencies are presented in Table 5:5 and Fig. 5:1. The number of traumatic amputees was on the whole unchanged over the period observed. Owing to the small frequencies no far-reaching conclusions are justified. Despite increased motor traffic and industrial mechanization the number of traumatic amputees did not rise. The average frequency of traumatic leg-amputees in Gothenburg is less than 1:100,000.

The amputation was performed on the day of the accident in 21 cases, after 1 to 15 days in 3 cases, after 15 to 29 days in 4 cases and after more than a month in 7 cases. Signs of inebriation were noted shortly after the accident in 4 patients. Traffic accidents were in majority with 24 patients and among these tram and railway accidents dominated followed by motor cycle accidents. Industrial accidents caused 14 amputations, 6 of them taking place in traffic. The group of "fell over trauma" comprised 2 patients, both of whom sustained a fracture of the lower leg complicated by infection. These two patients were subjected to amputation several months after the accident because it had not been possible to control the infection. For 5 patients the amputation age was less than 15 years, the trauma in these children and youngsters being caused by two train accidents, a motor cycle accident, a car accident, and the aforementioned vascular injury (cf. p. 34).

A high proportion of the traumatic amputees sustained multiple injuries

Type of fracture	No. of patients
Fracture of radius	5
Fracture of skull	3
Fracture of vertebra with spinal cord injury	1
Dislocation of elbow	1
Ankle fracture	1
Fracture of humerus with radial nerve injury	1
Fracture of femoral shaft	1
Fracture of ulnar shaft	1
Total	14

Table 5:7. Fractures among the 35 patients whose amputation was due to accidents in the 331-Series.

(Table 5:7). The accident was fatal for one seventh of the patients. The most serious injuries were caused by motor cycle and train accidents.

The diagnoses of embolism and thrombosis as amputation causes could not always be documented clinically. It cannot be ruled out that some patients with obliterative arteriosclerosis might have been included in the embolism and thrombosis group, and vice versa, because emboli and thrombi not seldom complicate primary arteriosclerosis. No diabetics were included in the group of patients undergoing amputation for embolism or thrombosis. For 25 patients in the 331-Series the amputation cause was thrombosis or embolism. The age and sex distribution of these patients

Table 5:8. Types of tumour causing amputation in the 331-Series.

Malignancies	Number of Patients
Primary	
Osteogenic sarcoma	5
Fibrochondrosarcoma	2
Melanotic sarcoma	1
Chondromyxosarcoma	1
Not specified	1
Total	10
Metastasis from	
Hypernephroma	1
Cancer of the breast	1
Total	2
Combined with other causative factors	
Cancer secondary to burns	1
Cancer secondary to chronic osteomyelitis	1
Cancer of ovary (metastasis to pelvis suspected of including large vessels) alternatively peripheral obliterative arteriosclerosis	1
Total	3
Semimalignant and benign	
Osteoclastoma	1
Cavernous haemangioma	1
Total	2
Grand total	17

appears in Table 5:2 (p. 35). 10 patients were 70—79 years old and constituted the largest age group. There were no sex differences. Embolectomy was carried out on two patients, 3 and 15 days before the amputation. Above-knee amputations were more common with 19 patients. Of the 25 patients in this group, 15 died within six months of the operation.

Two amputees had an aneurysm of the popliteal artery and attempts to reconstruct the vessel were unsuccessful.

Particulars about the 17 tumour amputees in the 331-Series are given in Table 5: 8. All tumours were diagnosed preoperatively and confirmed by biopsy. The age and sex distribution is shown in Table 5: 2. 10 of these patients, the majority, were less than 50 years old. Of the 5 amputees with osteogenic sarcoma, one is still alive 13 years after the amputation, the other 4 dying within 4 years postoperatively. 2 pathological fractures were observed, and both of them were due to metastases. In one of these cases the amputation was performed in the terminal stage of the disease in order to relieve the patient of pain. The small number of tumour amputees, 17 during 11 years in Gothenburg, illustrates the relative rarity of this amputation cause.

CHAPTER 6

Postoperative Course

Amputation Level

In most publications above-knee amputations have been commoner than below-knee amputations (McKenzie, 1953; Gingras *et al.*, 1954; Dale & Capps, 1959; Jansen, 1960; Bugel & Karlsson, 1961; Widolf, 1961; Dale & Jacobs, 1962; Felländer, Hallberg & Storck, 1962; Lundholm, 1963; Lempke *et al.*, 1963). However, the series studied by Alffram & Holmquist (1961) included a higher proportion of below-knee amputees than of above-knee amputees.

In McKenzie's study 50 of the 344 patients or 15 per cent were bilateral amputees, 38 of them being bilateral above-knee amputees. Gingras *et al.* reported that 19 or 21 per cent of his 90 patients were bilateral amputees, 10 of them bilateral above-knee amputees. Among Jansen's 669 leg-amputees there were 108 bilateral amputees, the majority of whom were bilateral above-knee amputees. Felländer, Hallberg & Storck reported a high frequency of bilateral amputees, and about one-third of the surviving above-knee amputees were bilateral.

The surgeon's decision when the amputation level seems elective may be influenced by a desire to obtain the highest possible primary healing rate. Alternatively he and the patient may be prepared to risk a lower amputation level in order to have the chance of achieving better ultimate function.

Unilateral Amputees

Classification of the amputation level other than above or below the knee was not possible. A patient exarticulated in the knee joint was assigned to the group of above-knee amputees. None of the patients in the 331-Series had been exarticulated in the hip joint or hemipelvectomized.

As appears from Table 6: 1, the distribution of above-knee and below-knee amputees varied with amputation age. In the amputation age group 0—29 years above-knee amputees were preponderant with 12 of 17 patients. Conversely, among the 48 patients with amputation ages of 30—

Table 6:1. Influence of various factors on amputation level.

	Sex		Age										Cause					
	M	F	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	Art. scler. with diabet.	Art. scler. without diabet	Accident	Tumours	Embolism	Miscellaneous	
Above knee	88	73	1	4	7	5	3	11	41	56	35	56	56	15	10	17	9	
Belcw knee	75	42	2	1	2	8	5	16	34	37	10	51	27	19	3	6	9	

59 years 29 were below-knee amputees. At amputation ages of 60 years and up above-knee amputees were once again in the majority with 132 of 213 patients.

This difference in amputation level frequencies between the amputation age groups can partly be accounted for by the amputation cause which is closely associated with the amputation age and greatly influences the choice of amputation level. Tumours in most cases require amputation above the knee, and most such patients were in the amputation age group below 30 years. Traumatic amputations dominated at amputation ages of 30-59 years, and the commonest amputation level in such patients was below the knee. Arteriosclerosis with or without diabetes and thromboembolism are the outstanding amputation causes in elderly patients, whose legs generally are amputated above the knee. This is borne out by the present investigation where the group of 83 non-diabetic patients whose leg was amputated owing to obliterative arteriosclerosis contained 56 above-knee amputees. Similarly, the group of 23 thromboembolic patients included 17 above-knee amputees. The distribution of amputation levels was closely similar among the diabetic patients, with 56 above-knee amputees and 51 below-knee amputees.

The proportion of above-knee amputees was higher among women than among men. Of the 115 female unilateral amputees 63 per cent were above-knee and 37 per cent below-knee amputees. The corresponding figures for men were 54 and 46 per cent.

Bilateral Amputees

The 331-Series included 53 bilateral amputees, 33 men and 20 women. Among these bilateral amputees the 60-79 years amputation age group was most numerous with 36 patients. Only one patient was younger than 49: a 12 years old girl whose second leg, like the first, had been amputated above the knee owing to metastasizing fibrochondrosarcoma (cf. Table 6:2).

Table 6:2. Amputation causes and amputation level in bilateral amputees in 331-Series.

Amputation Cause	Amputation level					
	above-knee Bilateral		below-knee Bilateral		above and below-knee	
	men	women	men	women	men	women
Arteriosclerosis with diabetes	5	7	10	4	5	5
Arteriosclerosis without diabetes	6	0	1	0	2	2
Accidents	0	0	1	0	0	0
Tumours	0	1	0	0	0	0
Miscellaneous	2	1	1	0	0	0
Total	13	9	13	4	7	7

Among the bilateral amputees, the largest group comprised 22 bilateral above-knee amputees followed by a group of 17 bilateral below-knee amputees and a group of 14 above-and-below-knee amputees.

In 47 patients or 96 per cent the amputation cause was peripheral vascular disease with diabetic gangrene in 36 and nondiabetic gangrene in 11 patients. The time elapsed from the primary amputation to the amputation of the second leg was one year or less for 26, 1—3 years for 14 and over 3 years for 13.

Wound Healing

Several workers have reported healing problems after leg amputation. The results of wound healing specified in the literature have been listed in Table 6: 3.

Few have attempted to define what is meant by "primary wound healing". Hence variations in healing may to some extent be due to differences between the adopted criteria for healing. The table shows that after leg amputations the frequency of secondary healing ranged between 12 and 73 per cent and that of reamputations between 3 and 35 per cent. Healing has consistently been inferior after below-knee amputations. Dale & Jacobs (1962) observed that diabetic gangrene amputees healed primarily more often than non-diabetic gangrene amputees. Lempke *et al.* (1963) and Harris, Schwarz & Weese (1961), however, were unable to discern any healing differences between gangrene amputees with and without diabetes.

Table 6:3. Course of wound healing after leg-amputation in the literature.

Authors	Year of publication	No. of patients	Amputation level	Cause of amputation	Reamputations		Secondary healed	
					No.	%	No.	%
Conway & Meigher	1942	46	Toe to-above-knee	Diabetics	16	35*	—	—
Silbert & Haimovici	1950	196	Below-knee	Gangrene with and without diabetics	2	3	18	27°
Smith	1956	50	Below-knee	Diabetics	—	6		
Kelly & Janes	1957	245	Below-knee	131 Pheripheral vascular disease	9	9	41	20*
			Above-knee	114			31	18
Dale & Capps	1959	284	Below-knee	65 Various causes, mostly peripheral vascular disease	—	—	33	51
			Above-knee	219	—	—	75	34
Schlitt & Serlin	1960	96	Below-knee	Peripheral vascular disease	—	—	9	32
			Above-knee		—	—	10	15
Harris <i>et. al.</i>	1961	47	Above-ankle	Peripheral vascular disease	—	19	—	25
Alffram & Holmquist	1961	149	Above-ankle	Various causes, mostly peripheral vascular disease	—	11	—	—
Hoar & Torres	1962	100	Below-knee	Diabetics	3	3	12	12*
Dale & Jacobs	1962	385	Toe- to above-knee	Varios causes, mostly peripheral vascular disease				24
			Above-knee	Arteriosclerotic gangrene				25
			Below-knee	Arteriosclerotic gangrene				39
Engsig — Karup	1963	806	Toe- to above-knee	Peripheral vascular disease		(without drainage)		56*
						(with drainage)		73

* = results deduced by this writer from the publications.

° = healing only of amputees with primary sutures.

In the present investigation information on healing was extracted from case notes. As case notes often tend to be somewhat vague in regard to healing, the data on healing given hereinafter should be regarded with great reservation.

The case notes furnished far too little information with respect to the peripheral circulation and the adopted operative techniques, so the association between wound healing and these factors could not be analyzed.

The analysis of wound healing was confined to patients who survived at least a month after the operation. Primary healing was considered to have taken place in those patients whose wound healed spontaneously during the first postoperative month. All others were secondary healed.

Of the 225 unilateral amputees 82 or 36 ± 6 per cent healed primarily and 135 or 60 ± 6 per cent healed secondarily. Above-knee amputations had a more favourable healing process. No information was available for 8 patients. Among the 135 secondary healed 37 underwent debridement and 18 reamputation from below to above knee. The debridement group contained as many as 12 traumatic amputees and also a high proportion of below-knee amputees, 25 patients. The cause of all above-knee reamputations on below-knee amputees was gangrene.

In 51 patients or 23 per cent of all the unilateral amputees the amputation below or above the knee had been preceded by unsuccessful foot and toe amputations. Operations on the foot included 35 toe amputations, 8 subtotal foot amputations, and 8 local debridements on the foot. All but one of these operations on the foot were caused by gangrene. The exception was a traumatic amputation through the transverse tarsal joint which through wound failure was followed by below-knee amputation.

Complications

As direct sequels to the operation there occurred one case of irreversible shock, one thyreotoxic crisis, two cases of post-traumatic anuria, five cases of sepsis, and seven cases of cerebral injury.

Decubital ulceration over the sacrum and on the heel of the intact leg were noted in 18 patients. Four of the 53 unilateral amputees who died during the first postoperative month had time to develop decubital ulcers. All decubital ulcers involved gangrene amputees. The majority of patients with decubital ulceration were 70—79 years old and only one was below 60 at amputation.

Postoperative thromboembolism affected 18 of the 225 unilateral amputees. The amputation cause in 14 of these patients was obliterative arteriosclerosis and in the other 4 it was thromboembolism. All but two of these patients died during the first postoperative month.

Duration of treatment in surgical ward, months	No.	Died before discharge from surgical ward	Transferred to chronics hospital	Transferred to other institution
< 1	91	36	32	7
1—3	112	11	50	4
3—6	52	2	23	1
> 6	17	—	3	1
Out-patients	6	—	—	—
Total	278	49	108	13

Table 6:4. Duration of post-operative treatment for unilateral amputation in the 331-Series.

Duration of Treatment

In the present context the term "duration of treatment" included all time spent in hospital for treatment in conjunction with a leg amputation. However, before treatment in the surgical department is discussed, some comments are called for about those unilateral amputees who already had been deemed in need of therapy prior to the amputation. In the latter category were included all patients who had been under preoperative treatment for at least six months in a hospital for chronics or a similar institution. It appeared that 30 of the 278 unilateral amputees or 11 per cent had been receiving preoperative treatment — 18 in a hospital for chronics, 9 in mental hospital, 1 in a paediatric department, and 2 in an institution for sociomedical cases. 26 of these 30 preoperatively treated patients underwent amputation owing to peripheral vascular disease and the remaining 4 for miscellaneous causes.

Information on the duration of postoperative treatment is presented in Table 6:4. None of those surviving the first month spent less than a month in the surgical department. One expression of the amputee's need of prolonged postoperative treatment is the high frequency of patients transferred to Vasa Sjukhus, a hospital for chronics, which admitted 114 or 41 per cent of the 278 unilateral amputees. 20 of these were discharged from Vasa Sjukhus after 6 months to a year and 58 after more than a year. Of the unilateral amputees with diabetes 57 or 53 per cent were transferred to Vasa Sjukhus. The same applied to 45 or 55 per cent of the non-diabetic unilateral gangrene amputees. The large majority — 112 patients or 98 per cent — of the transferees to Vasa Sjukhus were over 60 years of age. After treatment in the surgical department 31 of the 53 bilateral amputees

were transferred to Vasa Sjukhus, where 11 of them remained for more than a year. Altogether as many as 150 patients or 45 per cent of the 331-Series required continued treatment in a department for chronics.

Survival Time

Data on the postoperative mortality of amputees in previous investigations have been collected in Table 6:5, showing that the postoperative mortality rate varies between the limits of 7 per cent, as reported by Hoar & Torres (1962), and 50 per cent, as observed by Lewin & Dealey (1935). The figures in the table are not comparable because the series of patients varied widely in size and composition and also because the concept "post-operative mortality" has not been consistently defined.

Several workers have studied the survival time after amputation (Smith, 1956; Alffram & Holmquist, 1961; Hoar & Torres, 1962; Felländer, Hallberg & Storck, 1962). The mean survival time varies from 5½ years in Smith's series to 2 years in that of Hoar & Torres. Silbert & Haimovici noted that of 16 postoperative deaths 8 were due to heart failure and 2 to pulmonary embolism. Alffram & Holmquist stated that the cause of death was identical to the amputation cause in 12 of 16 deaths among amputees below 60 years of age. Dale & Jacobs pointed out that 30 of 36 post-operative deaths among amputees were due to cardiovascular complications or pulmonary embolism. Arteriosclerotic manifestations in the heart or brain caused most deaths in Hoar & Torres's series of amputees. The same was the case in the study of Lempke *et al.*

The survival time after amputation is influenced by a variety of factors. Thus McKenzie (1953) observed a higher postoperative mortality rate among male than among female amputees, namely 10.5 versus 6 per cent. Dale & Capps (1959) reported the inverse situation with a mortality of 21 per cent for women and 14 per cent for men. The mortalities recorded by Felländer, Hallberg & Storck were 22 of 30 female and 27 of 57 male amputees.

Silbert & Haimovici maintained that diabetics have lower mortality after below-knee than above-knee amputation, like Schlitt & Serlin (1960) who found a mortality of 7 per cent for below-knee and 13 per cent for above knee amputees with peripheral vascular disease. Conversely, Lempke *et al.* found no significant difference in mortality after amputation above and below the knee. But Engsig-Karup (1963) demonstrated death rates of 18.8 and 30.6 per cent, respectively, for below-knee and above-knee amputees.

In McKenzie's series the death rate rose with age. Similarly, Schlitt & Serlin noted a mortality of 12 per cent in the 61—70 years amputation

Table 6:5. Postoperative mortality and survival time in published series.

Authors	Year	Patient category			Postoperative mortality		Mean survival time after 0.5 years, 1 year etc.
		No.	Cause	Level	No.	%	
Levin & Dealy	1935	24	Diabetics	Above knee	12	50	—
Solley	1942	34	Diabetics	Toe-to-above knee	—	26.5	—
Silbert & Haimovici	1950	172	Diabetics	Below knee	16	9.3	—
Smith	1956	50	Diabetics	Below knee	—	12	Mean survival-time 5.5 years
Schlitt & Serlin	1960	96	Peripheral vascular disease	Toe-to-above knee	13	13.6	—
Alffram & Holmquist	1961	149	Peripheral vascular disease	Below and above knee	20	13.4	47 (31.5 %) dead within 6 months postoperatively, 40 % aged over 60. dead within 1 year postoperatively Mean survival time 2 years 3 months
Hoar & Torres	1962	100	Diabetics	Below knee	7	7	Mean survival time of 30 discharged patients: 2 years
Dale & Jacobs	1962	385	Miscellaneous causes mostly peripheral vascular disease	Below and above knee	36	11	—
Felländer <i>et. al.</i>	1962	87*	Miscellaneous causes mostly peripheral vascular disease	Below and above knee	—	—	40.5 % dead within 3 years 71.7 % within 6 years post-operatively
Lundholm	1963	93	Miscellaneous causes mostly peripheral vascular disease	Below and above knee	22	24	—
Lempke <i>et. al.</i>	1963	200	Peripheral vascular disease	Toe-to-above knee	24	12	—

* = including three patients with arm amputations.

age group and of 44 per cent for ages from 71 years. Felländer, Hallberg & Storck found that the amputation age influenced the mortality, especially at ages over 60 years.

In the study of Lempke *et al.* non-diabetic gangrene with intercurrent cardiac disease resulted in a conspicuously high mortality; moreover, the same investigation disclosed that the mortality associated with arteriosclerotic heart disease was unaffected by amputation level and intercurrent diseases.

* * * * *

For the purpose of mortality calculations in the present investigation, the survival time of bilateral amputees was calculated from the date of the last amputation.

In the 331-Series the postoperative mortality was 59 patients or 18 per cent during the first month, 119 or 36 per cent during the first 6 months and 136 or 41 per cent during the first year (cf. Table 6:6).

The mean survival time for the entire 331-Series was one year and eight months, the corresponding figures for patients with amputation ages under and over 60 years being 2 years and 2 months and 1 year and 7 months respectively. The mean postoperative survival time exhibited no sex differences.

Of the group with amputation ages below 60 years, three male traumatic amputees with severe cerebral lesions and one female amputee with thyreotoxic crisis and extensive frostbite died within the first postoperative

Table 6:6. Dead within 1 st postoperative year in the 331-Series.

Survival time	Amputation age < 60 years		Amputation age > 60 years	
	Men	Women	Men	Women
< 1 week	3	1	16	10
1 week— 1 month	3	1	12	13
1—3 months	4	1	17	19
3—6 months	0	0	9	10
6—12 months	2	0	6	9
Total	12	3	60	61

week. In the same group 12 men and 3 women — the majority diabetic-gangrene or traumatic amputees — died during the first postoperative year.

Patients over 60 years old at the time of amputation who died during the first postoperative year comprised 57 diabetic and 47 non-diabetic gangrene amputees, 15 thromboembolic, 1 traumatic and 1 osteomyelitic amputees, among whom 60 were men and 61 women.

Of the 53 bilateral amputees 22 died within a year of the last amputation.

The causes of death were in 185 cases, or 75 per cent of the 256 cases based on findings at a *post mortem* examination, and in the remaining cases on the diagnoses specified on the death certificates filed at Public Register Offices.

The causes of death during the first postoperative year were distributed as shown in Table 6:7.

Cause of death	Patients < 60 years		Patients > 60 years	
	No.	%	No.	%
Cardiovascular disease	5	33	109	90
Tumours	2	13	7	6
Miscellaneous	8	53	5	4
Total	15	99	121	100

Table 6:7. Causes of death for patients dying during 1st postoperative year in the 331-Series.

Among patients over 60 years of age dying during the first year, arteriosclerosis with fatal cardiopulmonary and cerebral complications caused 90 per cent of the deaths. The amputation was not *per se* the direct cause of any death in the 331-Series.

The causes of death and the amputation causes coincided in 28 or 90 per cent of the 31 patients who were younger than 60 years at the amputation and died during the subsequent 5 years. Merely 3 of these patients died of a disease other than that which had made the amputation necessary. Similarly, in the group with amputation ages over 60 years the causes of amputation and death could be traced to the same basic disease in 89 per cent of the cases. The most common condition was arteriosclerosis which gave rise to gangrene and in more advanced stages to fatal complications from the heart.

Analysis of survival times were facilitated by dividing the 331-Series both into patients younger and older than 60 years at the time of amputation and also into new amputees added during the periods 1947—1951, 1952—1956 and 1961, the survival time being defined as the interval between the last amputation and the day of death. (See Tables 6:8, 6:9). For the group of patients with amputation ages over 60 years the survival times were compared with the annual mortality at different ages, as given in "Statistical Yearbook for Gothenburg".

Alive after 5 years were 42 of 67, or 63 per cent, of those patients who were younger than 60 years at amputation during the period 1947—1956 (Table 6:8). During the periods 1947—1951, 1952—1956 and 1961, the survival rates one year postoperatively were 82, 93 and 40 per cent respectively. Three years after the last operation about 25 per cent of the group younger than 60 years at amputation had died.

Table 6:8. Survival rate of amputees with amputation performed before the age of 60 in the 331-Series.

Period	No. of ampu-tees	No. of survivors after										Alive	
		1 year		2 year		3 year		4 year		5 year		28/2 1963	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1947—1951	38	31	81.5	28	73.6	28	73.6	24	63.1	22	57.8	17	44.7
1952—1956	29	27	93.1	26	89.6	22	75.8	21	72.4	20	68.9	18	62.0
1961	10	4	40.0									4	40.0

Table 6:9. Survival rate of amputees with amputation performed after the age of 60 as compared with normal life expectancy in the 331-Series.

Period	No.	331-Series Normal life expectancy	Survival rate after										A ve 28/2 1963
			1 year		2 year		3 year		4 year		5 year		
			No.	%	No.	%	No.	%	No.	%	No.	%	
1947—1951	80	331-Series	43	53.8	33	41.3	25	31.3	20	25.0	13	16.5	2
		Normal life expectancy	75	93.8	70	87.5	65	81.3	62	77.5	58	72.5	—
1952—1956	110	331-Series	61	55.5	46	41.8	29	26.5	25	22.7	22	20.0	17
		Normal life expectancy	103	93.6	97	88.2	91	82.7	86	78.2	81	73.6	—
1961	64	331-Series	29	45.3	—	—	—	—	—	—	—	—	27
		Normal life expectancy	59	92.2	55	85.9	51	79.7	47	73.4	44	68.8	—

Data on survival times for patients older than 60 years at the time of amputation are presented in Table 6:9 and have been plotted in Fig. 6:1. At the end of the first postoperative year the survival rates during the periods 1947—1951, 1952—1956 and 1961 were 54, 56 and 45 per cent respectively, implying that about half the patients in this older group died within a year of the last amputation. Four years postoperatively 25 per cent of those patients subjected to amputation in 1947—1951 and 23 per cent of those undergoing amputation in 1952—1956 were alive. This means that approximately three quarters of the patients died within four years postoperatively. Analogously, after five years 13 of 80 or 16 per cent of the new amputees in 1947—1951 and 22 of 110 or 20 per cent of the new amputees in 1952—1956 remained alive. The mortality of these elderly amputees was highest during the first postoperative year, whereupon it fell and reached a minimum between the 4th and 5th postoperative years.

During the periods 1947—1951 and 1952—1956 those undergoing amputation older than 60 years and surviving at least two years post-

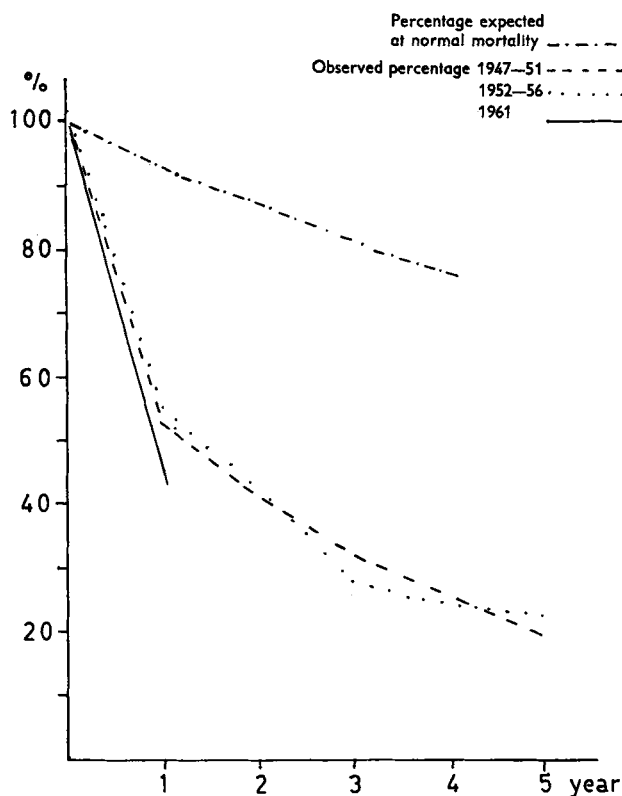


Fig. 6:1. Percentage of amputees over 60 years old surviving in Gothenburg after 1, 2, 3, 4 and 5 years, 1947—1951, 1952—1956 and 1961.

operatively were about half as many as one would expect from the figures for the gross population. A similar low survival rate was recorded as little as a year after amputation in 1961. The observed survival time for the older amputees five years after the operation was on average less than a quarter of that specified in "Statistical Yearbook for Gothenburg" as applying to a population having a similar age distribution. The great survival time difference between the amputees and a corresponding segment of the gross population is illustrated in Fig. 6:1.

The periods exhibit no differences in the number surviving the first postoperative year. The observation period was too short for calculation of survival rates for the second postoperative year among those undergoing amputation in 1961.

Patients older than 60 years at amputation with peripheral obliterative arteriosclerosis were selected for analysis of some factors that seemed likely to be capable of affecting the survival time, namely sex, amputation level, amputation age and intercurrent disease with a usually fatal course. No allowance was made for any individual variations present between the various vascular disorders. The life span of the normal population is known to have increased during recent decades. Such deviations could not be taken into account in this analysis. Nor could such factors be taken into consideration as the operative technique and the social background, both of which conceivably might influence the mortality.

In order to make the analysis easier to understand, the material was rearranged so as to have eight categories, one characterized by the presence and another by the absence of each of the four factors, thus under sex: male, female; under amputation level: above-knee, below-knee; under amputation age: 60—74 years, 75—89 years; under intercurrent disease: presence and absence. Here the term "usually fatal disease" connotes severe impairment of general condition before, during or after the first postoperative month, e.g. failing heart function, pulmonary embolism, renal insufficiency, metastasizing cancer and, lastly, cerebral haemorrhage.

The factors cannot be analyzed individually, i.e. the whole series cannot simply be classified with respect to the alternatives under a single factor and the survival time studied in the groups thus obtained. For interaction may exist between two or more factors. Occasionally the effect of a single factor may obscure the other factors. It is not certain that age has the same action in both sexes, nor that the effect of amputation level is independent of intercurrent "fatal" disease. Hence the entire series must be subdivided with respect to all the factors (Table 6:10). These four factors yield 16 groups in which the annual mortality rate in per cent must be sought.

Table 6:10. Relations between sex, amputation level, amputation age, intercurrent fatal disease and 1-year mortality for amputees over 60 years with peripheral vascular disease.

Sex	Men 125								Women 114							
Amputation level	Above knee 78				Below knee 47				Above knee 77				Below knee 37			
Amputation age No.	75—89 33		60—74 45		75—89 15		60—74 32		75—89 32		60—74 42		75—89 16		60—74 21	
Intercurrent fatal disease	with	without	with	without	with	without	with	without	with	without	with	without	with	without	with	without
	12	21	23	22	7	8	17	15	19	16	25	17	9	7	14	7
1-year mortality	7/12	8/21	13/23	1/2	5/7	3/8	10/17	1/5	15/19	1/2	12/25	8/17	7/9	3/7	2/7	1/7

Table 6:11. Analysis of variance in 1-year mortality due to sex, amputation level, amputation age and intercurrent fatal disease.

Cause of variation	Degrees of freedom	Variance	P
Sex	1	0.0001	—
Level	1	0.1984	0.01 < P < 0.025
Age	1	0.6058	0.001 < P < 0.005
Fatal disease	1	1.0106	P < 0.001
Interaction between sex and level	1	0.0694	—
„ sex and age	1	0.2730	0.01 < P < 0.025
„ sex and fatal disease	1	0.0040	—
„ level and age	1	0.2490	0.01 < P < 0.05
„ level and fatal disease	1	0.1524	0.01 < P < 0.05
„ age and fatal disease	1	0.0777	—
Errors	5	0.0202	—

To estimate the effect of the four factors, if one or more interactions were present, the annual mortality proportions were subjected to analysis of variance with the aid of Yates's technique.

Analysis of variance yielded the results presented in Table 6:11. The residual variance was estimated from the sum of squared interactions of order 2 or higher. The factors considered interact in a complex manner.

Interactions significant on the 5 per cent level or better were present between sex and amputation age, amputation level and amputation age and also between level and intercurrent "fatal" disease. On the other hand, independent effects were exerted by sex and amputation level, intercurrent "fatal" disease and amputation level as well as amputation age and intercurrent "fatal" disease.

Allowance must be made for these interactions in evaluations of the significance of the various factors. This implies that when we study, say, amputation level, we must divide the patients into four subgroups corresponding to each of the two categories under each factor: amputation level interacted both with amputation age and with intercurrent "fatal" disease.

The one-year mortality in each such subgroup was studied by χ^2 analysis.

Table 6:12. χ^2 tests of strength of interactions between sex, amputation age, amputation level and intercurrent fatal disease.
* = significant on 5 per cent level.

Sex	75—89 years		χ^2
			2.195
	60—74 years		0.674
Amputation level	75—89 years	With fatal disease	0.026
		Without fatal disease	0.009
	60—74 years	With fatal	0.137
		Without fatal	4.359 *
Amputation age	Men	Below knee	0.252
		Above knee	0.210
	Women	Below knee	4.737 *
		Above knee	1.854
Intercurrent fatal disease	Below knee		5.661 *
	Above knee		2.295

Differences marked with an asterisk (*) in Table 6:12 are significant on the 5 per cent level or better. In order to simplify interpretation of the results, the observations made have been illustrated graphically in Fig. 6:2, where the annual mortality in per cent is marked off along the ordinate and the two categories under each factor appear along the abscissa. Mortality differences between groups are represented by the slope of the lines: the steeper the slope the greater the probability of a significant mortality difference between the groups under study. Significant differences are denoted by solid lines, others by broken lines.

The only interaction between sex and amputation age was studied by dividing the patients into older 75—89 years and younger 60—74 years patients. It appears that the 1-year mortality for older men was 48 per cent (23/48) versus 65 per cent (33/51) for older women. These mortality rates are not significantly unequal (broken line in Fig. 6:2). The corres-

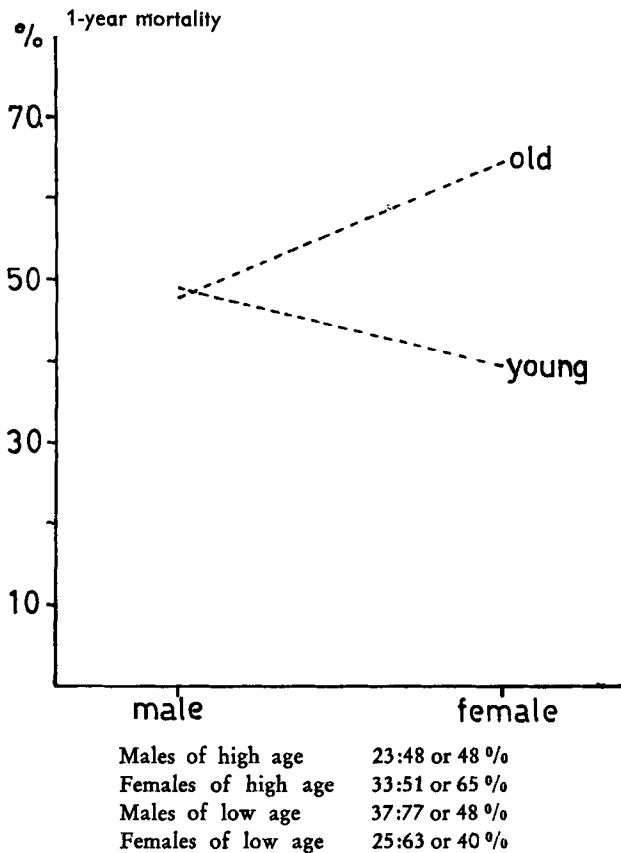


Fig. 6:2 Effect on survival time of sex combined with age at amputation.

ponding figures for younger men and women were 48 per cent (37/47) and 40 per cent (25/63), the difference not being significant. We see, therefore, that sex lacked significant effect on one-year mortality in this group of gangrene amputees.

One-year mortality is influenced by amputation age, interacting both with sex and with amputation level (Fig. 6:3). Hence the patients must be divided into four groups; male above-knee amputees, male below-knee amputees, female above-knee amputees and female below-knee amputees. Evidently amputation age influenced the mortality of female below-knee amputees: the higher the amputation age the greater the one-year mortality. No significant differences appeared in the other groups. The

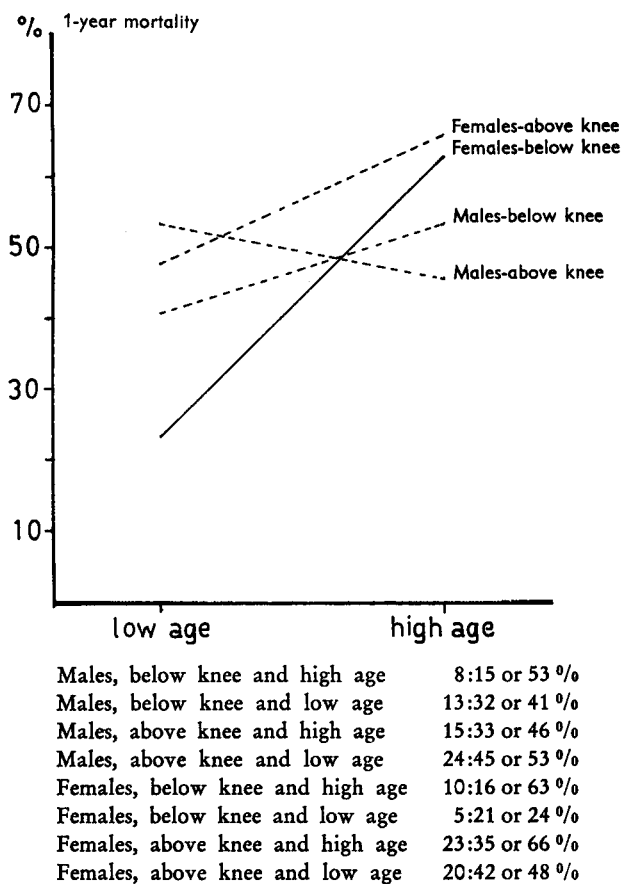


Fig. 6:3 Effect on survival time of age at amputation combined with sex and amputation level.

one-year mortality rate for female below-knee amputees with high amputation age was 63 per cent (10/16) while it was 24 per cent (5/21) for the corresponding group with low amputation age.

Amputation level influences the one-year mortality rate by interacting with amputation age and with intercurrent "fatal" disease (fig. 6:4) It will be seen that a significant and conspicuous mortality rate difference was present between below-knee and above-knee amputees with low amputation age. Thus the 1-year mortality rate in this group was 18 per cent (4/22) for below-knee amputees and 49 per cent (19/39) for above-knee amputees. No other differences were significant.

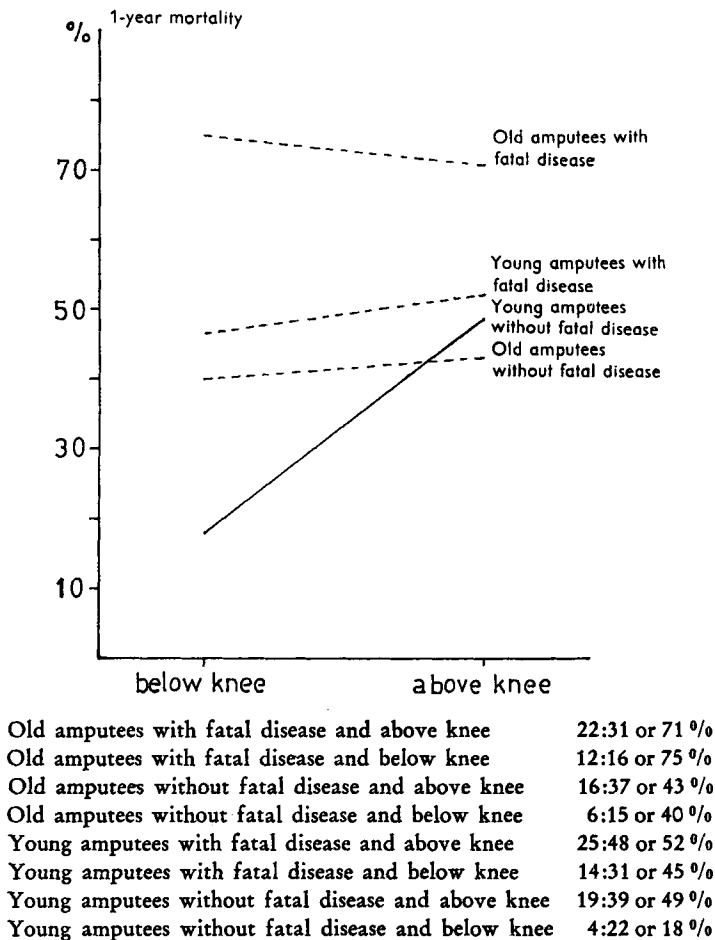


Fig. 6:4 Effect on survival time of amputation level combined with age at amputation and intercurrent fatal disease.

Lastly the effect was studied of intercurrent "fatal" disease at the time of the amputation on the 1-year mortality rate (Fig. 6:5). It appears that the 1-year mortality of below-knee amputees was significantly higher for those with than for those without intercurrent "fatal" disease. This mortality rate also tended to be higher in above-knee amputees with intercurrent disease.

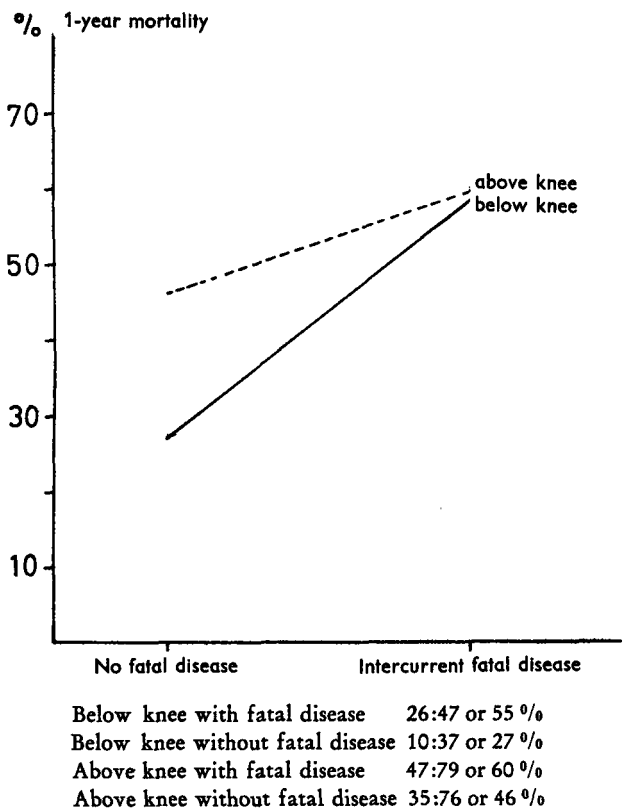


Fig. 6:5 Effect on survival time of intercurrent fatal disease combined with amputation level.

CHAPTER 7

The Leg-Amputee Population Trend up to 1970

As an aid in planning hospital and rehabilitational facilities for leg-amputees, an attempt was made to predict the frequencies of living leg-amputees over 60 years of age for each of the years 1962—1970.

While the number of new leg-amputees below 60 years of age remained substantially constant during the observation period 1947—1962, the frequency of such subjects over 60 years rose. If this trend should continue, there are good grounds for creating greater resources to care for the future needs of these patients.

This analysis was based on figures for Gothenburg's population trend, from a prognostication by Gothenburg's Statistical Office in 1963 (Table 7:1). The expected numbers of elderly amputees were found by multiplying the observed mean amputation rates for males and females over

Table 7:1. Population of Gothenburg over 60 years of age at end of years 1960—1970.

Year	Age: 60—69			70—79			80—89			90—			> 60		
	Men	Women	Tot.	Men	Women	Tot.	Men	Women	Tot.	Men	Women	Tot.	Men	Women	Tot.
1960	17150	20540	37600	8725	11650	20375	1925	3400	5325	75	275	350	27875	35775	63650
1961	17525	21100	38625	9150	12075	21225	2025	3525	5550	100	275	375	28800	36975	65775
1962	17975	21625	39600	9475	12650	22125	2150	3750	5900	100	300	400	29700	38325	68025
1963	18350	22175	40525	9850	13075	22925	2275	3875	6150	100	300	400	30575	39425	70000
1964	18825	22675	41500	10150	13475	23625	2450	4075	6525	125	325	450	31550	40550	72100
1965	19175	22975	42150	10550	14025	24575	2600	4325	6925	150	350	500	32475	41675	74150
1966	19700	23525	43225	10925	14500	25425	2775	4575	7350	150	375	525	33550	42975	76525
1967	20325	24200	44525	11225	14825	26050	3000	4850	7850	175	400	575	34725	44275	79000
1968	20875	24800	45675	11625	15325	26950	3150	5150	8300	175	400	575	35825	45675	81500
1969	21575	25600	47175	11925	15750	27675	3300	5350	8650	200	450	650	37000	47150	84150
1970	22300	26100	48400	12250	16275	28525	3475	5600	9075	200	450	675	38225	48425	86550

Table 7:2. Predicted number of living leg-amputees of over 60 years old in Gothenburg 1962–1970.

Year to end	Predicted Population			Predicted number of living amputees		
	Men	Women	Total	Men	Women	Total
1962	29700	38325	68025	52	39	91
1963	30575	39425	70000	61	44	105
1964	31550	40550	72100	65	50	115
1965	32475	41675	74150	71	53	124
1966	33550	42975	76525	73	58	131
1967	34725	44275	79000	80	59	139
1968	35825	45675	81500	82	63	145
1969	37000	47150	84150	86	67	153
1970	38225	48425	86650	88	70	158

60 in 1960—1962, namely 0.001140 for men and 0.000605 for women, by the predicted population over 60 in each of the years up to 1970. Survival times for the amputees were estimated with the aid of observations for the group of new amputees during the period 1947—1951, the only group that would provide mortality figures for a sufficient number of years. The specified number of living amputees over 60 years at the end of 1962 is the sum of the numbers surviving after amputation in each of the years 1958, 1959, 1960, 1961 and 1962. This method does not provide an exact figure for the number of living amputees at the end of 1962, but the important figures are those for the years near 1970 rather than those for the early 1960's. Moreover, the figures for the years around 1970 are influenced little if at all by any survivors after amputation before 1958 because only 2.5 per cent of patients older than 60 at the time of amputation survive for as long as 12 years. Hence no allowance was made for such patients. This presupposes, however, that the survival times for leg-amputees will not undergo any significant changes before 1970. Nor was the apparent rise of the amputation rate taken into account. The figures given here are, of course, predictions for the future and should therefore not be used as a basis for far-reaching conclusions. Future medical advances may perhaps reduce the number of gangrene amputees. Moreover, the indications for amputation may not remain constant.

The estimated frequencies of leg-amputees are presented in Table 7:2 and illustrated in Fig. 7:1. It will be seen that the leg-amputee frequency rises steadily up to 1970, most sharply for women. Thus the number of

female amputees over 60 years old predicted for 1962 was 39 while the corresponding number for 1970 was 70, in other words an increase of 79 per cent. The corresponding figures for men were 52 in 1962 and 88 in 1970, a rise of 69 per cent. In the series as a whole the predicted number for 1962 was 91 and in 1970 it had increased by 68 patients to 158, that is by 75 per cent.

No rise in the frequency of patients undergoing amputation before age 60 was noted during the period 1947—1962. During peacetime it seems unlikely that the number of such amputees surviving will grow more than can be accounted for by their lengthening mean survival time combined with the life span of the population as a whole.

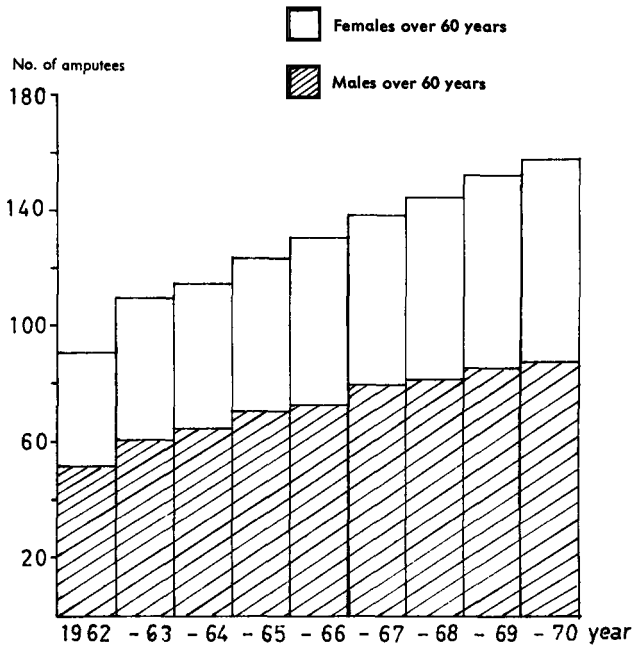


Fig. 7:1 Predicted number of amputees over 60 years old living in Gothenburg at end of each year from 1962 through 1970.

Clinical Function

Some frequencies of prosthesis-walkers in the literature are assembled in Table 8: 1. The publications listed therein were concerned primarily with the prosthesis function of elderly gangrene amputees. McKenzie's (1953) series of 344 prosthesis-equipped amputees over 65 years old, for example, included 171 or 49.7 per cent prosthesis-walkers. Similar observations — that about half those elderly amputees equipped with prostheses become prosthesis-walkers — have been reported by Bertelsen & Rønn (1960), Wolters (1961), and Alffram & Holmquist (1961). Conversely, Widolf (1961), studying a series of predominantly young tumour and traumatic amputees, noted 83.3 per cent prosthesis-walkers.

Elderly patients find it especially difficult to master the art of walking with prostheses. A variety of factors exist which, acting singly or in combination, influence prosthesis function. A common impediment to prosthesis-walking is the presence of additional handicaps, usually in the form of circulatory disturbances in the other leg, cardiopulmonary diseases and joint disorders. But the patient's physical condition and morale have a decisive influence on prosthesis function (McKenzie, 1953; Gingras, Mongeau & Bergeron, 1954; Schlitt & Serlin, 1960; Chapman *et al.*, 1959; Wolters, 1961). Stump condition also affects the patient's ability to use prostheses, although modern prosthetic techniques can overcome most of the difficulties due to a poor stump. Women have a higher failure rate than men in learning to use prostheses (McKenzie, 1953; Russek, 1961).

An advanced amputation age is not *per se* an obstacle to prosthesis walking (McKenzie, 1953; Wolters, 1961). The reason why elderly patients have poorer chances of becoming prosthesis walkers is the higher prevalence of additional handicaps among them.

Above-knee amputees are less successful prosthesis-walkers than below-knee amputees (McKenzie, 1953; Claugus *et al.*, 1958; Schlitt & Serlin, 1960; Widolf, 1961; Russek, 1961).

Table 8.1. Frequency of prosthesis-users in published series.

Authors	Year	Patient category			Prosthesis users	
		No.	Cause	Level	No.	%
Conway & Meigher	1942	31	Diabetics	Above-knee	9	
Mc Kenzie	1953	344	> 65 years miscellaneous causes mostly peripheral vascular disease	Above ankle	171	49.7
Mc Goey	1954	105	> 65 years arteriosclerosis	Above ankle	1 patient > 70 years old used and walked with prosthesis *	
Gingras <i>et. al.</i>	1954	56	Majority > 50 years old with peripheral vascular disease	Above ankle	32	44*
Warren	1957	41	Arteriosclerosis	Above ankle	23	57
Claugus <i>et. al.</i>	1958	47	Peripheral vascular disease	Below knee	23	49
		71	50-70 years old	Above knee	21	30
Park & Miller	1958	18	> 55 years peripheral vascular disease	Above ankle	8	
Chapman <i>et. al.</i>	1959	47	Majority peripheral vascular disease	Above ankle	26	55.3*
Bertelsen & Rønn	1960	238	Over age 65 miscellaneous cause mostly peripheral vascular disease	Above ankle	120	48.5*
Schlitt & Serlin	1960	96	Peripheral vascular disease	Toe-to-above knee	12	12.5
Bugel & Carlson	1961	128	Mean age 65 years majority with peripheral vascular disease	Above ankle	60	47 *
Alffram & Holmquist	1961	35	< 60 years	Above ankle	29	83
		114	> 60 years miscellaneous causes		57	50
Widolf	1961	72	Tumours, diabetics, accident	Above ankle	60	83.3
Wolters	1961	75	> 60 years old peripheral vascular disease	Above knee	32	50*
Felländer <i>et. al.</i>	1962	87	Mostly peripheral vascular disease, amp. in 1954 and 1957	Below and above knee	16*	
Hoar & Torres	1962	100	Diabetics	Below knee	63	

* At time of follow up.

Table 8:2. Frequency of prosthesis users of different patient categories in the 331-Series.

Patient category	No.	Prosthesis users	
		No.	%
Whole series	331	103	31
Unilateral amputees	278	94	34
Bilateral amputees	53	9	17
Unilateral amputees > 60 years old	213	45	21
Unilateral amputees < 60 years old	65	50	77
Unilateral amputees > 60 years surviving at least 1 year	108	45	42
Unilateral amputees < 60 years surviving at least 1 year	52	49	94

A high proportion of bilateral amputees become bound to their wheel-chair. None of the 76 bilateral above-knee gangrene amputees in Erlacher's (1958) series became prosthesis-walkers. The latter worker found, however, that practically all bilateral amputees with one functioning knee joint could learn to walk, except gangrene amputees.

Prosthesis-Equipment and Prosthesis-Walking in the 331-Series

Among the 331 patients undergoing amputation in the years 1947—1956 and 1961, analysis of prosthesis function was mainly confined to those surviving at least a year after the last amputation, who were classified into three groups: unilateral amputees with amputation ages under 60 years, unilateral amputees with amputation ages over 60 years, and bilateral amputees. No grading of the patients' gait was attempted.

Within the first year after the last amputation 105 of the 213 unilateral amputees older than 60 years had died. Of the remaining 108 unilateral amputees who survived the last amputation for a year or more 45 or 42 per cent became able to walk with their prosthesis. (cf. Table 8: 2)

This group of 45 prosthesis-walkers comprised 30 men and 15 women. Below-knee amputees were in the majority with 25 patients against 20 above-knee amputees. Additional handicaps were present in 14 of the 45 prosthesis-walkers over 60 years old at amputation which in 37 cases was due to gangrene.

The group of 63 unilateral amputees surviving at least a year post-operatively who did not become prosthesis-walkers comprised 30 men and 33 women. Here there was thus a small preponderance of women, unlike the group of prosthesis-walkers with twice as many men as women. Among the non-walkers 39 were above-knee amputees and 24 below-knee amputees. Accordingly the ratio of below-knee to above-knee amputees

Years after amputation	No. of survivors	Prosthesis-users	
		No.	%
1	85	37	43
2	69	30	43
3	46	27	58
4	39	25	64
5	33	23	69

Table 8.3. Prosthesis users among survivors over 60 years old 1, 2, etc, years after amputation in 1947—1956.

walking with a prosthesis was nearly 1.5 times the corresponding ratio for those unable to walk with a prosthesis. As many as 49 of the 63 non-walker had additional handicaps. The cause of amputation was gangrene in 60 or 95 per cent of the non-walkers.

Of the 63 unilateral amputees who did not become prosthesis-walkers 40 had and 23 had not been equipped with a prosthesis. These 23 patients had not been fitted with a prosthesis because of cardiac decompensation in 11 cases, senile dementia in 8 cases, advanced contractures in 2 cases and, lastly, marked circulatory disturbances in the intact leg in 2 cases.

Only 2 of the 105 unilateral amputees who died within a year post-operatively had been fitted with a prosthesis, and neither became able to use it.

Frequencies of prosthesis-walkers in successive years among the survivors after amputation over age 60 in 1947—1956 are set out in Table 8: 3. Because the observation period was too short 1961 was omitted. It will be seen that the frequency of those able to use a prosthesis among the survivors rose each year after the operation. Thus a year after amputation 37 of 85 or 44 per cent walked with a prosthesis, three years after amputation 27 of 46 or 59 per cent did so, and five years after amputation 23 of 33 surviving unilateral amputees could walk with their prosthesis, in other words 69 per cent. None of those who had not become able to use a prosthesis within a year after amputation became able to walk with a prosthesis. This means that the prognosis for prosthesis function is poor in patients with amputation ages over 60 years who have not learnt to walk with a prosthesis during the first postoperative year.

Among the 65 unilateral amputees younger than 60 years 13 died less than a year postoperatively. Two of the latter had been fitted with a prosthesis: one of them managed to walk with it, the other failed owing to heart disease. The group of 52 surviving younger patients included 49 or 94 per cent who became prosthesis-walkers, 39 men and 10 women. The leg had been amputated above the knee in 22 and below it in 30 patients. Additional handicaps occurred in 12 patients.

As mentioned, the group of 52 unilateral amputees younger than 60 years included 3 who did not acquire the ability to walk with a prosthesis. One of the latter was a mentally retarded, 33 years old male epileptic whose leg was amputated below the knee for diabetic gangrene; another was a woman of 55 with organic heart disease and recurrent attacks of pulmonary oedema undergoing above-knee amputation for embolism; and the third was a 54 years old blind man with heart disease whose leg was amputated below the knee for diabetic gangrene.

Particulars about the prosthesis-walkers among those bilateral amputees surviving at least a year after the last amputation are given in Table 8: 4.

Table 8:4. Frequency of prosthesis users and bilaterally prosthesis equipped among 31 bilatelateral amputees surviving at least 1 year.

Bilateral amputees	No.	%
Prosthesis-equipped walkers	9	29
„ „ non-walkers	7	22
Not prosthesis equipped	15	48
Total	31	100

Of the altogether 53 bilateral amputees in the 331-Series 31 survived for at least a year after the last amputation and 9 of the latter became able to walk with prostheses, namely 5 bilateral below-knee amputees, 3 bilateral above-knee amputees and 1 above-and-below-knee amputee. At the last amputation 5 were under and 4 over 60 years old. The amputation cause was gangrene in 7, tumour in 1 and an accident in 1 case. No bilateral above-knee amputee older than 60 years became able to walk with prostheses.

Younger than 60 years at the last amputation was only 1 of the 22 bilateral amputees who never managed to walk with his prostheses. Half of these 22 patients were bilateral above-knee amputees. As the interval between amputations varied among walkers as well as among non-walkers, this factor would seem to have had little or no effect on the frequency of prosthesis-walkers among bilateral amputees.

As has appeared elsewhere (cf. Fig. 2:1), all patients who were followed up were asked about phantom pains. None of the interviewed patients in either the 331-Series or the 133-Series complained of reduced function due to such symptoms.

In order to establish how certain factors affect prosthesis function, the associations between prosthesis-walking and sex, amputation level and

additional handicaps were analyzed in a group of 99 patients, all of whom had undergone unilateral amputation above or below the knee for peripheral obliterative arteriosclerosis with or without diabetes and survived for at least a year after the last amputation. Here additional handicaps include all conditions other than amputation that could interfere with the patient's ability to walk with a prosthesis. These conditions are specified in Table 8: 5.

Intercurrent disabling disease	No.
Circulatory disturbances in intact leg	30
Arteriosclerotic heart disease	13
Senile mentale insufficiency, schizophrenia	11
"Strokes"	6
Joint disorders	3
Blindness	1

Table 8:5. Distribution of disabling diseases among 64 of 99 unilateral gangrene amputees over 60 years of age.

The prosthesis service offered these 99 patients must be regarded as of fairly uniform standard. All patients fitted with a prosthesis received their prosthesis from the Workshop of the Orthopædic Department, Gothenburg, where no major changes in organization or production took place during the relevant period, namely 1947—1956 and 1961. No pylons were issued. All below-knee amputees were fitted with a conventional lower-leg prosthesis provided with knee-joint mechanisms af various types and a thigh corset. Above-knee amputees were equipped with prostheses having a triangular socket and suspension braces for attachment to the body. The knee joint of above-knee prostheses consisted of a lockable central joint, and above-knee amputees older than 60 years were trained to walk with the knee locked. One patient was admitted to the Orthopædic Department for four days for prosthesis fitting and gait training. The other patients were trained in surgical wards or wards for chronics. Two amputees were given gait training as out-patients in the Orthopædic Department.

Inadequate information on stump condition obviated analysis of the effect of this factor upon prosthesis function.

At the time of amputation 42 of these 99 patients were in their 60's, 43 in their 70's and 14 in their 80's.

The 99 patients were distributed according to sex, amputation level, and presence or absence of additional handicaps. (See Table 8:6). Since each

Table 8:6. Relations between ability to use prosthesis and sex, amputation level and intercurrent disabling disease in 99 unilateral gangrene, with amputation age over 60 years and surviving at least 1 year after last amputation.

Sex	Men 55								Women 44							
Amputation level	Above knee 30				Below knee 25				Above knee 23				Below knee 21			
Intercurrent disabling disease	Yes 21		No 9		Yes 12		No 13		Yes 16		No 7		Yes 15		No 6	
Prosthesis users	Not users	Users	Not users	Users	Not users	Users	Not users	Users	Not users	Users	Not users	Users	Not users	Users	Not users	Users
	19	2	2	7	5	7	3	10	13	3	4	3	13	2	2	4

factor was divided into two categories, a 2 x 2 x 2 table was required, and in each of the 8 subgroups the proportion of prosthesis-walkers was analyzed in the same way as in Table 6:10, p. 56, with respect to survival time. Then, after logit transformation, analysis of variance according to Yates was carried out. This disclosed that first order interactions were not significant compared with the second order interaction, which was used for estimating the residual variation. When all interaction effects were pooled and the variance of the residual variation was estimated with 4 degrees of freedom, the following conclusions could be drawn (Table 8:7):

The frequency of prosthesis-walkers among the 99 patients subject to amputation for peripheral obliterative arteriosclerosis was affected most markedly by additional handicaps. Thus the frequency of prosthesis-walkers

Table 8:7. Analysis of variance of sex, amputation level and intercurrent disabling disease in ability to use prosthesis among unilateral gangrene amputees older than 60 years surviving at least 1 year.

Source of variation	Degrees of freedom	Variance	P
Sex (A)	1	0.3770	—
Amputation level (B)	1	0.3029	—
Disabling disease (C)	1	2.0646	0.025 < P < 0.05
Interaction AB	1	0.1203	
” AC	1	0.0121	—
” BC	1	0.0492	
” ABC	1	0.5066	

was significantly reduced by the presence of additional handicaps compared with the corresponding group without additional handicaps. There was no significant difference between the sexes nor between below-knee and above-knee amputees in the frequency of prosthesis-walkers. No interactions existed between the factors, and therefore the presence of additional handicaps affected prosthesis function independently of either sex or amputation level.

The effect of additional handicaps is illustrated graphically in Fig. 8:1, where the percentage of prosthesis-walkers is marked off along the ordinate and the presence and absence of additional handicaps is marked off on the abscissa. The diagram shows that whereas 22 per cent of the patients with additional handicaps became able to walk with a prosthesis, 69 per cent of those without additional handicaps acquired this ability.

While 12 or 27 per cent of the 44 women became prosthesis-walkers, 26 or 47 per cent of the 55 men did so.

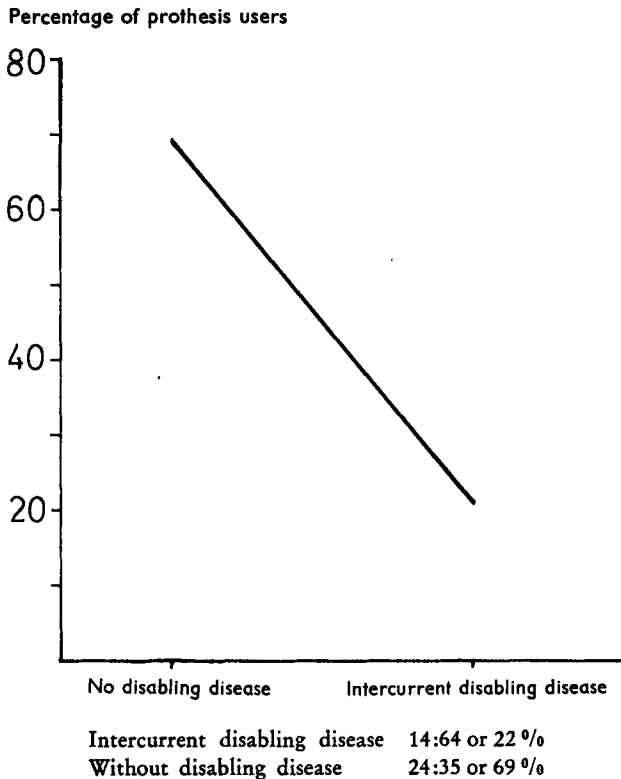


Fig. 8:1 Effect on prosthesis usage of intercurrent disabling disease.

In the group of 53 above-knee amputees 15 or 28 per cent managed walking with a prosthesis, the corresponding figures for the below-knee amputees being 23 of 46 or 50 per cent.

Even if the latter two differences are not significant, they do suggest that proportionately fewer women than men became prosthesis-walkers and also that below-knee amputees tended to become prosthesis-walkers more often than above-knee amputees.

Prosthesis-Walking, Prosthesis Complaints and Gait in the 133-Series

All the amputees in the 133-Series had been fitted with a prosthesis. One patient did not use her prosthesis but walked with the aid of the intact leg and two crutches. This was a woman of 61 who at the age of 55 had been subjected to disarticulation in the hip joint for sarcoma. Though a prosthesis had been issued to her postoperatively she had received no training. In addition to the amputation the patient suffered from obesity and a crural ulcer on the intact leg. She was able to do light household work.

The types of prosthesis the patients were fitted with are specified in Table 8: 8.

Table 8:8. Types of prosthesis fitted in the 133-Series.

Prosthesis type	No.
"Canadian type" exarticulation prosthesis for hip-joint exarticulation	3
Above knee prosthesis — triangular socket with suspension braces	11
Above knee prosthesis — suction socket	33
Exarticulation end-bearing prosthesis for knee joint	3
Below knee prosthesis, conventional type with thigh corset	90

When directly questioned whether the prosthesis caused them any trouble, 91 gave negative replies and 41 complained of the prosthesis chafing when they had walked for a couple of hours. At the follow-up examination abrasions due to a poorly fitted prosthesis were encountered in 5 patients.

The gait of these patients was classified as a mild, moderate or marked limp, and it was noted whether or not the patient used a cane. This was a subjective assessment made at the follow-up examination while the patient demonstrated his walking. Details of the gait of the 132 prosthesis-walkers will be found in Table 8: 9.

	G A I T					
	Slight limp		Moderate limp		Severe limp	
	No.	%	No.	%	No.	%
Without cane	56	42.4	38	28.8	4	3.0
With cane	0	0.0	23	17.4	11	8.3

Table 8:9. Gait of 132 prostheses-users in the 133-Series.

None of the 56 patients or 42 per cent whose gait had a mild limp used a cane. This group comprised 51 below-knee and 5 above-knee amputees. A cane was used by 33 of the 61 patients — 46 per cent of the total — whose gait had a moderate limp, the latter category including 33 above-knee and 28 below-knee amputees. In the group of 15 markedly limping patients 11 used a cane, and 11 were above-knee and 4 below-knee amputees.

CHAPTER 9

Sociomedical Function

INTRODUCTION

Gingras, Mongeau & Bergeron (1954) treated 90 patients over 50 years old at the time of amputation. Among these patients 82 per cent were living in their homes and the remaining 18 per cent in hospital. Chapman *et al.* (1959), following up 32 patients over 55 years old at amputation, found that 19 were able to manage on their own, 9 had to have assistance in the activity of daily living, and 4 required institutional care. Wolters (1961) interviewed 32 above-knee amputees older than 50 years at amputation, finding that 33 per cent were institutional cases, 42 per cent exhibited considerable functional impairment, and 25 per cent were gainfully employed. Hirsch (1961) studied 58 traumatic amputees, most of them men, and noted that 35 per cent of them were unable to work. Russek (1961) pointed out that the leg-amputee in good social circumstances as a rule had an excellent social prognosis. Most of his private patients spent the rest of the lives outside hospital. Alffram & Holmquist (1961) remarked that a group of 19 followed-up survivors after amputation before age 60 comprised 8 working at the same job as before the amputation, 5 with other jobs after the amputation, 3 housewives capable of doing light household chores, 2 institutional cases and 1 patient who could not be traced. The same workers reported that no patient with amputation age over 60 years was gainfully employed, and also that 88 of the 97 surviving patients were prosthesis-walkers and 9 were confined to bed or wheelchair. Felländer, Hallberg & Storck (1962) had no patients subjected to amputation after age 60 at work, while 11 of the 19 with amputation ages below 60 years were gainfully employed.

Classification

Six degrees of sociomedical function were used, namely "full restoration", "partial restoration", "self-care plus", "self-care minus", "domestic care" and "institutional care". The criteria for classification were as follows.

- Group I. "Full restoration" — the patient has a fulltime job with no more than normal absenteeism. He feels the amputation is no serious hindrance either at work or during leisure hours and does not prevent active participation in sports and games. To this group were assigned, among others, children who could attend school and take part in games and athletics.
- Group II. "Partial restoration" — the patient has a job but is not seldom forced to be absent owing to stump distress, implying that the amputation restricted both working and leisure activity. To this group were assigned housewives who continued to keep house except for heavy chores.
- Group III. "Self-care plus" — the patient is able to do part-time work or light work with special transport arrangements or minor modifications to ancillary equipment. If such favourable circumstances did not apply or the patient was too unintelligent to manage a light job, he would be unemployable. The patient is exhausted by appreciable leisure activity and has to arrange his whole life towards resting when not at work. The patient can unaided carry on all activities of daily living. To this group were assigned many elderly subjects who could care for themselves without outside help.
- Group IV. "Self-care minus" — the patient is to be regarded as a disability pensioner. No patient in this group was at work. They required assistance to apply and remove the prosthesis. They spent all their time doing the most essential household chores but had to have groceries and other purchases brought in by others.
- Group V. "Domestic care" — the patient is confined to his bed or wheelchair and cared for at home. These patients required considerable assistance and required a full time attendant.
- Group VI. "Institutional care" — the patient has been in hospital or other institutions since the amputation. The majority of patients in this group were bed-ridden.

No distinct lines of demarcation separate these groups. If, at the confrontation with an individual patient, there was doubt as to which group the patient belonged to, the principle was adopted of assigning him to the worse group. Considering that the sole aim of this classification was to provide a schematic picture of the amputee's situation, this rough estimation was deemed adequate.

The sociomedical function was assessed a year after amputation for patients in the 331-Series and at the time of the follow-up examination for patients in the 133-Series, apart from patients over statutory pensioning age whose sociomedical function during their working years was assessed retrospectively. A consequence of this was that very few of the older amputees in the 331-Series were assigned to sociomedical function groups I or II, where it was required that the patient should be employed. Hence assignment to group III must be considered a good result for such older patients in the 331-Series. The patients in groups I—III were all able to care for themselves, unlike those in groups IV—VI who could not cope unaided with the activities of daily living.

As the sociomedical function of the majority of older patients in the 331-Series assigned them to the groups of domestic or institutional care, it was deemed convenient to regard the patients in groups I and II as belonging to a single category called "Restoration", to combine groups III and IV into the single category "Self-care" and to combine the categories "Domestic care" and "Institutional care" into "Disabled".

In the 133-Series the patient's occupation or trade after amputation was related to his job before it. The patients were asked whether they had received vocational training or been reeducated. Their present work was evaluated as to the degree of labour involved and rated as light, moderate or heavy. The economic status of the patients in the 133-Series was judged from their gross annual income, averaged over the years 1960—1962, and from whether they had received or were receiving any form of monetary compensation for their disablement. The marital status and dwelling condition of these patients were also taken into consideration.

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Unilateral amputees younger than 60 years

The functional classifications of the 52 patients surviving at least a year after the last amputation are given in Table 9:1. The 5 patients, who required domestic or institutional care, had the same amputation cause: peripheral obliterative arteriosclerosis. One of them had been treated for several years preoperatively in various hospitals. All of them were disabled by additional handicaps, namely severe cardiac disease in 4 cases and mental retardation in one case. As the time of amputation 4 of the 5 disabled patients were in the 50—59 years age group.

Half the 12 "Self care" patients had additional handicaps. Two thirds had amputation ages of 50—59 years. Half were below-knee amputees.

Sociomedical function	No.	%
I 10 "Restoration" II 25	35	67.3
III 8 "Self care" IV 4	12	23.1
V 2 "Disabled" VI 3	5	9.6

Table 9:1. Distribution of sociomedical function in unilateral amputees below 60 years old in the 331-Series.

The amputation cause was peripheral obliterative arteriosclerosis in half the patients and tumours or accidents in the other half.

The "Restoration" group of 35 patients was characterized by a low frequency of additional handicaps, which were present in 3 patients only. Three fifths were below-knee amputees. The amputation causes comprised 22 accidents, 6 tumours, 3 Bürger's disease, 2 congenital pseudarthrosis of the tibia, 1 peripheral vascular disease, and 1 aneurysm.

As appears from Table 9:2. the proportion capable of working among these patients in the amputation age groups below 60 years decreased with rising amputation age. While 5 of 7 in the 40—49 years group were able to work, only 8 of 20 were working in the 50—59 years group.

Among the 16 patients subjected to amputation for peripheral vascular disturbances, 5 returned to work. The amputation cause was Bürger's disease in 3, unspecified vascular disease in 1 and aneurysm of the popliteal artery in 1 of the 5 who went back to work. None of the 3 diabetic-gangrene amputees were able to work.

Age group	No.	Restored or working
50—59	20	8
40—49	7	5
30—39	11	9
20—29	6	5
10—19	5	5
< 10	3	3

Table 9:2. Frequency of "restoration" among 35 unilateral amputees below 60 years of age and surviving at least 1 year after last amputation in the series of 331.

Unilateral amputees older than 60 years

The functional results for the 108 unilateral amputees are given in Table 9:3. 53 received institutional care and 25 domestic care, altogether 78 patients or 72 per cent. Preoperatively 15 of the 78 had been treated in hospital for at least 6 months, the majority for several years, 6 in a hospital for chronics, 7 in mental hospital and 2 in a home for socio-medical cases. The amputation had not affected the care requirements of these preoperatively disabled. 17 of 78 were subjected to amputation in 1961, leaving 61 postoperative disabled with observation periods of at least five years. Of the latter 21 survived at least four years, receiving institutional care throughout this period, 5 died during the fourth postoperative year and the remaining 35 during the second and third years.

Table 9:3. Sociomedical function of 108 amputees from the 331-Series over 60 years old and surviving at least 1 year after last amputation.

Sociomedical function	Men	Women	Total	%
I 0 "Restoration"	2	0	2	1.9
II 2				
III 10 "Self care"	16	12	28	25.9
IV 6				
V 25 "Disabled"	42	36	78	72.2
VI 53				

The functional results after elimination of the preoperatively disabled were distributed as shown in Table 9:4. 30 patients or 32 per cent of these 93 elderly unilateral amputees were in functional groups I—IV. After the amputation the remaining 63 or 68 per cent were disabled, 38 of them spending the rest of their lives in hospital and 25 receiving domestic care most of the time.

The 2 patients who had returned to work both underwent above-knee amputation for non-diabetic obliterative arteriosclerosis. One of them, a bachelor, was 66 and the other, a married man, 60 years of age at the time of amputation. The former returned to a sedentary workshop job, the latter worked as a precision machinist.

Table 9:4. Sociomedical function of 93 amputees from the 331-Series over 60 years old and surviving at least 1 year after last amputation, prior to which they did not receive institutional care.

Sociomedical function	No.	%
"Restoration" I—II	2	2.2
"Self care" III—IV	28	30.1
"Disabled" V—VI	63	67.7

The 28 patients in the "Self care" category included 9 with additional handicaps. The majority were 60—69 years of age at the time of amputation. All but one were prosthesis-walkers.

Particulars about the 78 requiring institutional or domestic care are given in Table 9:5. This group was characterized by a high incidence of additional handicaps, predominantly circulatory disturbances in the intact leg. Many had multiple handicaps, although the table specifies only the most disabling disease. Additional handicaps were present in 63 patients or 81 per cent. The majority of the disabled were 70—79 years old at the time of amputation. 16 were able to walk with a prosthesis. There was a

Table 9:5. Distribution of amputation ages, causes and levels and of additional handicaps among 108 amputees over 60 years in the 331-Series.

	Amputation age group year No.	Amputation cause	Amputation level	Additional handicaps
"Restoration" I—II 2 patients	60—69 2	Peripheral vascular disease 2	Above knee 2	0
"Self care" III—IV 28 patients	60—69 15	Peripheral vascular disease 23	Above knee 11	Circulatory disturbance in intact leg 2
	70—79 10	Accidents 3	Below knee 17	"Strokes" 2
	80—89 3	Tumours 2		Cerebral arteriosclerosis 2
				Marked loss of vision 2
				Residual state after frac- ture of femoral neck 1
				9
"Disabled" V—VI 78 patients	60—69 28	Peripheral vascular disease 73	Above knee 46	Circulations disturbance in intact leg 23
	70—79 38	Tumours 3	Below knee 32	Cardiac distress 13
	80—89 12	Frost bite 1		Cerebral arteriosclerosis 9
		Accident 1		Hemiplegia 6
				Mental disease 6
				Joint disease 2
				Blindness 1
				Nephropathy 1
				Myelomatosis 1
				Oesophageal stenosis 1
				63

preponderance of single individuals, 56 patients as against 22 with a living spouse.

The proportion of disabled rose with advancing amputation ages. Not counting the preoperatively disabled, the distribution of disabled amputees within amputation age groups becomes 22 or 56 per cent of those ages 60—69 years, 31 or 76 per cent of those aged 70—79 years and 10 or 77 per cent of those aged 80—89 years.

Bilateral amputees

Table 9:6 presents data on the sociomedical function of 31 bilateral amputees. The two patients capable of working were bilateral below-knee amputees and in good health otherwise. The "Self care" group was composed solely of gangrene amputees. The disabled were characterized by a high incidence of additional handicaps, being present in 16 patients of 25. The amputation cause in this group was gangrene in all except one who underwent bilateral above-knee amputation for metastasizing sarcoma.

Table 9:6. Distribution of amputation ages, causes, levels and additional handicaps among 31 bilateral amputees in the 331-Series.

	Amputation age group years No.		Amputation cause		Amputation level	Additional handicaps	
"Restoration" I—II 2 patients or 7 %	50—59	2	Buergers		Below		0
	60—69	2	disease	1	knee	2	
			Accident	1			
"Self care" III—IV 4 patients or 13 %	50—59	2	Diabetes	2	Above	Cardiac distress	3
			Arterio-		knee		
			sclerosis	1	Above and		
			Embolism	1	below		
"Disabled" V—VI 25 patients or 81 %	10—19	1	Diabetes	18	Below	"Stroke"	4
	50—59	1	Arterio-		knee	Senile mental insuffi-	
	60—69	7	sclerosis	6	Above	ciency	4
	70—79	12	Tumour	1	knee	Cardiac distress	4
	80—89	4			Above and	Loss of vision	2
					below	Nephrosis	1
					knee	Rheumatoid arthritis	1
							16

Frequencies of institutional and domestic care in different years

Table 9:7 shows how the disabled patients over 60 years at the time of unilateral amputation were distributed in the years 1947—1956 and 1961. There was no change in the proportion disabled among the total number of new amputees in any of the periods.

Period	No.	“Disabled”	
		No.	%
1947—1948	10	8	80
1949—1950	15	12	80
1951—1952	17	10	59
1953—1954	18	13	72
1955—1956	25	19	76
1961	23	16	70

Table 9:7. Frequency of disabled during different periods among 108 amputees over 60 years of age of the 331-Series.

As the number of elderly amputees is rising all the time we have to face the fact that the absolute number of diseased also will grow. Let this be illustrated by the sombre picture that emerges when we scrutinize the functional results achieved by the 74 patients subjected to amputation in 1961. At the end of February 1963, 43 of them were known to be dead and the 31 others or 42 per cent had been followed up and found alive. Up to two years after the amputation 19 of the survivors were still in hospital. The other 12 were living in their homes and 8 of these had to be regarded as chronic domestic-care cases. Only 1 of the remaining 4 was back at work thanks to large contributions from public funds to finance retraining for a more suitable job, part-payment for a car and the cost of driving lessons; another had great difficulties in locomotion owing to a poorly fitted prosthesis; another walked with his prosthesis despite a large wound on the stump; and the last, a female prosthesis-walker, was unable to work because of depression. In sum, only one of the 74 patients subjected to amputation in 1961 was back at work about two years postoperatively, and no less than 27 of the 31 then surviving were chronically disabled, 19 of the 27 requiring institutional care and 8 domestic care.

Case reports

The problems posed by and facing the elderly amputee with clinically and sociomedically impaired functional ability will now be exemplified

by reports of four cases in which the author visited the patient's home and made supplementary environmental observations.

Patient 185, a widow born November 6, 1878. The patient had senile diabetes since the mid-1950's, and in the autumn of 1955 the right great toe became gangrenous. She was treated at Ekmanska Sjukhuset 17/2—31/3, 1956. The great-toe amputation proved ineffective so on the 12th March, 1956, the right leg was amputated above the knee. She received a prosthesis but could not learn to use it owing to senile mental insufficiency. Since discharge from hospital she was given domestic care by the geriatric nursing service for two hours daily and by daughters taking turns watching over her day and night. She was visited December 30, 1962. Her home was a flat on the 2nd floor without modern conveniences or toilet. There was no central heating. The patient, sitting in a wheelchair without prosthesis, was completely disoriented as to time and place, talking incoherently. A daughter said she required constant attention. She was incontinent of urine and never left the flat.

Patient 405, male, born February 6, 1887, married. The patient, a former tramline worker, had a hemiplegia of the right side in 1957 and 1958. Towards the end of December 1960 gangrene of the right foot set in and on the 8th February, 1961, the patient was admitted to Surgical Department II, Sahlgrenska Sjukhuset, where the right leg was amputated above the knee for non-diabetic gangrene on the 9th March. He was transferred to a hospital for chronics the 29th March 1961 and treated there until the 16th November, 1962. The amputation wound healed secondarily; a prosthesis was fitted and he was given gait training for a considerable period. When visited on the 1st March 1963 he was found to live in a semi-modern flat on the second floor with a toilet on the landing. There was no elevator. He was cared for by his wife who was 70 years old and had a painful back. He was sitting in a chair with the prosthesis on. He managed to walk round a table with the greatest difficulty, supporting himself with one hand on the edge of the table. He suffered from total afasia and hemiplegia of the right side. His wife had to dress him and helped to apply and remove the prosthesis. He had moreover to be fed and needed assistance in using the toilet. His wife said he used to sit in his wheelchair most of the day. He never left the flat because he could not get down the stairs. The patient required constant attention.

Patient 410, male, born June 26, 1880, married. Had been operated on in 1956 for cancer of the anus. Dry gangrene of the 2nd and 3rd toes on the left foot developed in January 1961. He was treated in the Surgical Department, Sahlgrenska Sjukhuset 24/1—14/4, 1961, where the left leg was amputated above the knee because of the gangrene on the 23rd February, the wound healing by the second intention. He was admitted to the Orthopaedic Department and treated there 8/9—26/9, 1961, where he was fitted with a prosthesis and given gait training. The patient became able to take a few steps with the aid of crutches. For practical purposes, however, the patient had to be regarded as a wheelchair case. In December 1961 the right foot began to give trouble. Admitted to a hospital for chronics 4/11—8/2, 1963, he underwent below-knee amputation of the right leg on the 29th November, 1962. The patient, visited the 1st March, 1963, lived in a semi-modern 2nd floor flat with his sickly wife who was 79 years of age. A geriatric nurse helped the couple for two hours daily, but otherwise no one looked after them. The patient was dressed and sitting in a wheelchair with a badly fitting above-knee prosthesis on the left side and no prosthesis on the right side. He was well oriented and able to describe his case competently. He seemed well adjusted to his situation. His wife however had to dress and wash him every day. Had never left the flat since coming home from hospital.

Patient 429, a spinster, born December 29, 1873. She was admitted to Surgical Department II, Sahlgrenska Sjukhuset, 25/8—12/10, 1961, with onset of non-diabetic gangrene of right great toe in July 1961. A below-knee amputation was performed the 13th September. Extensive necrosis postoperatively necessitated above-knee reamputation the 20th September. Visited the 1st March, 1963. She was living with an elderly sister in a semi-modern detached house at the top of a steep hill and with a long flight of steps leading to the entrance. The patient, a large and obese woman with extensive oedema on the stump, was lying in bed with an indwelling catheter. She was completely disoriented as to time and place and had never been given a prosthesis. The sister said she could sit up in a wheelchair for short periods, but the sister had to be helped by a geriatric nurse.

The cases reported in the foregoing are all typical of patients classified as requiring domestic care. The patients in these four cases had in common the complete isolation in a dwelling and the need for attention practically round the clock. None could have lived at home were it not for the considerable efforts of the geriatric nursing staff and the great sacrifices of relatives who were obliged to discontinue or severely limit their income-producing activities. All were handicapped by two or more intercurrent diseases and each of these tended to inhibit function. The social status of the patient requiring domestic care not infrequently prevents his effective rehabilitation. The patient may be single or have an old and frail spouse who is too weak to assist the amputee even with the simplest tasks. Or, as often is the case, the amputee's dwelling may be without any modern conveniences and in bad repair, making it anything but suitable.

Factors influencing sociomedical function

The leg-amputee's sociomedical function is governed by his physical condition, mental status and social background.

In the present context, the term "physical condition" includes general health, stump condition and, for the sake of simplicity, clinical function. Classification of the patients in the several groups of sociomedical function in regard to the distributions of amputation age, amputation cause, additional handicaps and clinical function discloses that patients less than 60 years of age returned to work with diminishing frequency the higher their amputation age. Among patients over 60 years of age rising amputation age increased the proportion requiring institutional or domestic care. Apparently, however, the rising frequency of additional handicaps in elderly amputees seems to be responsible for this result rather than rising amputation age. Among the younger patients those between 40 and 60 years of age had the worst sociomedical function. In this age group the dominant cause of amputation was peripheral vascular disease, a systemic condition involving not only the vessels in the lower extremities but also those in the brain, heart, etc. The rising frequency of additional handicaps with advancing age was probably responsible for the falling sociomedical function. The sociomedical function of traumatic amputees was good, for the majority of these patients were young and not otherwise handicapped. The sociomedical function was worse among gangrene amputees because diseases accompanied by gangrene also gave rise to additional handicaps. In all age groups, additional handicaps usually made the sociomedical function worse. Whereas good clinical function was a *sine qua non* for good sociomedical function, good sociomedical function was not necessarily a consequence of good clinical function, as bears witness the fact

that the group of amputees older than 60 years requiring institutional or domestic care included 16 prosthesis walkers.

Here attention was paid merely to one of the components of the patient's mental status, namely manifest mental disturbances in the form of senile mental insufficiencies and oligophrenia. Such conditions are included among so-called additional handicaps. Studies of the influence of mental status on the amputee's sociomedical function must take into account the patients morale. Analysis of this factor, however, was felt to fall outside the scope of the present investigation.

The marital status of the patient was the only component of the amputee's social environment considered in the present investigation, but his sociomedical function might be influenced by a variety of other social factors. Elderly amputees with a living relative had better sociomedical function than those with no one to help them. Among the 93 amputees not requiring institutional or domestic care preoperatively the frequency of those with no living spouse or other relative, differed significantly on the 2.5 per cent level from the lower frequency of those with such a person in their environment. The ratio of postoperative disablement to postoperative non-disablement among single amputees was about 4:1, while the corresponding ratio for amputees with a spouse or other relative was about 1:1. This appears from Table 9:8.

Table 9:8. Frequency of disabled among single and married unilateral amputees in the 331-Series over 60 years old and not receiving institutional care prior to amputation.

Sociomedical function	Marital status	
	Single	Married
"Restoration" + "Self care"	11	19
"Disabled"	42	21
Total	53	40
$\chi^2 = 5.02, \text{ d. f. } = 1, 0.01 < P < 0.025$		

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Information on the classification of these patients according to their sociomedical function is presented in Table 9:9. The "Full restoration" group included the highest proportion of these 133 patients. The majority of the 93 fully restored patients — 67 patients or 72 per cent — were under 30 years of age at the time of amputation. Accidents constituted the most common cause of amputation with 58 patients or 62 per cent. The

Sociomedical function	No.	%
"Full restoration" I	93	70
"Partial restoration" II	24	18
"Self care plus" III	13	10
"Self care minus" IV	3	2
Total	133	100

Table 9:9. Sociomedical function in the 133-Series.

amputation level was below the knee for the majority, namely 65 patients or 69 per cent. One or more additional handicaps were present in 12 patients or 13 per cent. While 65 patients or 70 per cent were married and had a living spouse, the remaining 28 patients were bachelors or spinsters.

The 24 patients in the "Partial restoration" group were also for the most part young, 16 of them being less than 30 years of age at the time of amputation. The dominant amputation cause was trauma with 19 patients. Above-knee amputees numbered 13. Additional handicaps were present in 12 patients, and lastly, 20 were married and had a living spouse.

The "Self care plus" group of 13 patients included 8 with an amputation age over 30 years, disproportionately few traumatic amputees, 6 above-knee and 7 below-knee amputees, 10 of 13 with additional handicaps, and 4 married and 9 single patients.

For the three patients in the "Self care minus" group fairly full data will be supplied in the form of case reports at the end of this chapter, page 91.

The incidence of additional handicaps tended to rise with decreasing sociomedical function. Conditions included among the additional handicaps in the 133-Series are set out in Table 9:10.

* * * * *

The sociomedical function as a whole was better in this series of 133 patients than in the series of 52 patients less than 60 years of age subjected to leg-amputation in Gothenburg in the years 1947—1956 and 1961. Whereas 88 per cent of the patients in the 133-Series were assigned to the "restoration" group, the corresponding figure for the sample of 52 patients from the 331-Series was 67 per cent. The difference was due to the fact that the 52 patients included a high proportion of gangrene amputees, and peripheral vascular disease is consistently associated with impaired sociomedical function. Conversely very few of the amputees in the 133-Series had vascular disease as the cause of amputation. This was

because those gangrene amputees had died who otherwise would have been included in this series. The patients in the 133-Series in the first place provide us with an impression of the traumatic amputee's sociomedical function once the difficulties of the first few years have been overcome. No patient required institutional or domestic care, while the aforementioned 52 patients from the 331-Series included 10 per cent such cases, all with peripheral vascular disease as the cause of amputation. The prognosis for gangrene amputees is discouraging, and that seems to be so whether the patient's amputation age is over or under 60 years. Gangrene amputees younger than 60 years had their ability to work destroyed or greatly impaired and gangrene amputees older than 60 years in most cases required institutional or domestic care.

Table 9:10. Additional handicaps in the 133-Series.

Additional handicaps	No.
Arteriosclerotic heart disease	8
Degenerative arthritis of hip and knee joints	7
Circulatory disturbance in intact leg	5
Back pain	4
Cerebral haemorrhage	2
Mental deficiency	2
Stump eczema	2
Marked loss of vision	2
Thyreotoxicosis, pulmonary insufficiency, rheumatoid arthritis, peptic ulcer, arm amputees one of each	5
Total	37

Distribution of occupations

Occupations represented among the patients in the 133-Series are specified in Table 9:11 together with an indication of the type of labour involved. The occupations of all the patients are included, for retired patients the occupation before retirement. The preoperative and postoperative distributions of heavy, moderate and light labour are shown in Table 9:12. A change to lighter work was made by 41 of the 51 who had heavy work preoperatively. The "No occupation" group comprised children and adolescents subjected to amputation before starting work or while attending school. All below working age at the time of amputation were trained for light or moderately heavy work.

Table 9:11. Vocations and trades in the 133-Series classified by degree of labour required.

Light	Clerk, skilled engineer, cashier (female), park attendant, laboratory assistant, servant, tailor, technologist, civil servant, shoemaker, bookkeeper (bookkeeping machine operator), shopkeeper, designer, book-binder, instrument maker, upholsterer, photographer, primary school teacher, post office worker, draughtsman, inspector, engraver, salesman, journalist, glazier, artist, office executive, cutter-out (female), seamstress, manager, knitting machine operator (female).
Moderate	Turner, engineer, engine-room officer, cook, non-commissioned officer, crane operator, paper-hanger, cabinet maker, chauffer, welder, storeroom man, foreman, hoist operator, electrician, storeroom worker, grinder, metal worker, car mechanic, typesetter, housewife, waitress, steward, laundry worker, textilemill worker, shop assistant, plater, plumber, weaver, air-force officer, baker, errand boy.
Heavy	Woodcutter, prepared-meats worker, fisherman, points operator, farm labourer, fireman, construction worker, shipyard worker, heavy labourer, caretaker, stonecutter, stevedore, general worker, rock blaster, seaman, gardener.

Occupation	Preoperatively		Postoperatively	
	No.	%	No.	%
None	33	24.8	6	4.5
Heavy work	51	38.3	10	7.5
Moderate	35	26.3	49	36.8
Light	14	10.5	68	51.1
Total	133	99.9	133	99.9

Table 9:12. Occupational status preoperatively and postoperatively in the 133-Series.

The change in working conditions was analyzed within each class of sociomedical function.

Of the 93 patients in the "Full restoration" group, 36 were heavy labourers before and 9 after the amputation, while 11 had light work before and 36 after the amputation. In the "Partial restoration" group 5 of the 24 patients were heavy labourers before and 1 after the amputation, the corresponding figures for light labour being 2 and 14. All 5 patients in the "Self care plus" group were heavy labourers before the amputation and changed to lighter work after it.

The 58 persons whose amputation forced them to change jobs included 34 who were helped to do so by aid from the state, the local government or insurance companies. The Gothenburg Centre for cripples and disabled

provided vocational training for 14 but 10 of the latter were unable to make a living at their new trade. Before undergoing amputation many of the patients had jobs associated with considerable accident risk. For example, 12 able seamen sustained circular injuries of the lower extremities from wire ropes or cables. The second largest occupational group was railway and tram workers with 9 patients who were involved in accidents while at work.

Economic status

When the patients were followed up and asked whether the economic situation was disturbing them, 10 patients or 8 per cent answered in the affirmative, namely 8 men and 2 women all of whom were of working age. The annual income, averaged over the years 1960—1962, was less than 5000 kronor for all of these patients. Social service grants were paid to 2 and no less than 6 of these 10 patients had been re-educated at the State's expense. The latter 6 patients included 3 who were unable to find a job owing to structural changes in the employment market, and the other 3 were workshy. The last four with economic difficulties were unable to work for medical reasons: advanced arthrosis of the hip joint in 2 cases and heart disease in 2 cases.

Payments from public or private insurance companies were enjoyed by 60 patients or 43 per cent of the 133. The payments were made in the form of annuities payable quarterly or monthly to 44 patients. A lump sum had been given to 7 and a 100 per cent disability pension was paid to 9 patients. The 9 patients receiving such pension all had additional handicaps: heart disease in 2, arthrosis of the hip or knee joints in 3, hemiplegia in 1, oligophrenia in 1, circulatory disturbance in the intact leg in 1 and, lastly, one with an arm-amputation.

The households the 133 patients came from possessed a car in 42 cases or 32 per cent.

Men of working age suffer a loss of income from prolonged illness or disability. In an attempt to make an unbiased assessment of the leg-amputee's earning power, the gross income of 84 patients in the 133-Series was analyzed. These comprised all men of working age except 3 — a technologist, a chef and an electrician — about whom no satisfactory information was obtained. When interviewed all the 84 said they were working full-time and had no financial problems. Income specifications for the years 1960—1962 were supplied by the internal revenue office. Random fluctuations were eliminated by averaging the income over these 3 years. Table 9:13 presents the distribution by income of these 84 patients. The

Income 1.000 kronor	No.
< 4	14
4— 8	10
8—12	15
12—16	22
16—20	16
20—24	6
> 24	1
Total	84

Table 9:13. Mean annual income 1960—1962 of 84 male amputees between 16 and 67 years of age from the 133-Series.

median income, after taking the average for the years 1960—1962, was 12.200 kronor per year. In Gothenburg the median income of men aged 25—66 years averaged over the years 1960—1962 was 16.620 kronor. 10 of the patients had earned nothing in at least one of the three years, while 5 of them had earned nothing in any of the years. 4 of these 10 patients were included among the aforementioned patients with economic problems. The other 6 admittedly had a small income, in most cases solely a small pension, but were satisfied with their financial situation. Among those without income in 1960—1962, 5 could be described as vagrants, 1 was oligophrenic, 1 had grave thyreotoxicosis, 1 suffered from hemiplegia, and 2 had pronounced arthrosis of the hip joint, 3 of the 5 vagrant-like individuals claimed to have an entirely satisfactory life on their pension, and 2 of the 5 were suspected chronic drunkards. None of the 10 patients without income during at least one of the 3 years was in economic difficulties solely because of the amputation.

In studying the leg-amputee's social status, the distinction between cause and effect may sometimes be difficult to make. 2 patients in the 586-Series and 1 in the 133-Series actually were subjected to amputation as a direct result of their antisocial way of life. When drunk one of them fell asleep across the railway track and was run over by a train, his injuries necessitated traumatic amputation; another who used to sleep under tarpaulins in the harbour froze a foot so severely one cold night that amputation for frostbite became unavoidable; the third rode a stolen motorcycle at top speed right off the road and became a traumatic amputee. These three patients have remained sociopaths despite repeated medical and social attempts to rehabilitate them.

Marital status and dwelling standards

Of the 133 patients 90 were married and 72 couples had children. 37 of the rest were unmarried and the last 6 were divorced or widowed. As mentioned, the "Full restoration" group comprised 65 married and 28 single patients. Conversely the "Self care plus" group included 9 single and 4 married patients, while the "Self care minus" group was composed of 2 single and 1 married patient.

Data on dwelling standards was supplied by the patients or local officials in their part of the city, while corresponding information for Gothenburg as a whole was obtained from official Swedish statistics. By way of comparison it may be mentioned that in 1960 81 per cent of all Gothenburg flats or dwelling units had central heating and 75 per cent had a private toilet. Modern dwellings, defined as flats or detached houses with central heating as well as toilet and bath, were available to 81 patients or 61 per cent, semi-modern dwellings with shared bath and toilet to 26 patients or 20 per cent, and unmodern dwellings with dry toilets and not central heating to the remaining 26 patients or 20 per cent. This suggests that the dwelling standards of the 133 leg-amputees did not deviate appreciably from the average for Gothenburg. The complaint made about dwellings were due to such things as absence of modern conveniences or dissatisfaction with the neighbourhood etc. The majority of the blocks of flats had no lift. No patient thought that his state of being an amputee gave rise to any problems in his current dwelling.

Case reports

The three patients in the "Self care minus" group had the following histories.

Patient 79, a married man born May 31, 1897. His diabetes controlled by insulin commenced in 1929. He worked as a points operator with the Swedish Railways until 1951, when he was subjected to amputation of the right leg below the knee for diabetic gangrene. He was granted a disability pension in the same year as the amputation. He suffered from cardiac disease and nephroretinopathy. He was blind on one eye. During the follow-up examination the patient was able to walk with a moderate limp of the right leg and a cane in the left hand. Since the year of the amputation the patient had the last few years the right hand had become paralyzed. This couple was childless. Lived in a modern flat with no financial problems.

Patient 112, a bachelor born February 8, 1916, who grew up in a Children's Home. He was declared legally not accountable for a criminal offence on psychiatric grounds. Was involved in a motorcycle accident in 1950, which necessitated amputation above the knee of the right leg. He worked in a laundry at the time, and was postoperatively re-educated as a mechanic. Repeated attempts to find the patient suitable employment were unsuccessful owing to the patient's ingrained distaste for work of all kinds. When the patient was seen on the 16th May, 1962, he could walk with a moderate limp on the right and required no cane. His above-knee prosthesis with suction socket fitted well, and he was living in an unmodern flat, he did no work as he was financed by the social services.

Patient 121, a bachelor born March 28, 1912, was treated at the age of 1 year for congenital dislocation of the hip. Femoral osteomyelitis during childhood considerably shortened the left leg. Hence an arthrodesis of the knee and below-knee amputation were carried out at the age of 17 years. The stump measured from the sciatic tuberosity, was 31 centimetres long, so he was fitted with a normal above-knee prosthesis with triangular socket and suspension braces. Trained, with state grants, he became a tailor. At the follow-up examination on the 16th March, 1962, it was found that the patient had been receiving a disability pension for some years. He had considerable difficulties in walking. Aided by a cane he could walk with a rolling gait a maximum of 100 yards. Then movements and weight-bearing in the hip joints became unendurably painful and forced him to rest. Obesity and an incisional hernia were additional handicaps. He lived alone in a modern flat and did about 2 hours work daily, but was in strained financial circumstances. A geriatric nurse came to help him twice weekly.

The amputation was a contributory factor to difficult situation of these patients although additional handicaps were mainly responsible for the reduced sociomedical function. Quite apart from the amputation, these additional handicaps would by themselves impose major restrictions on the patient's ability to work. Indeed, the second patient's psychopathy had prevented him from doing much work even before the amputation.

CHAPTER 10

Discussion

Any conclusions that may be drawn from the foregoing in regard to the frequencies of leg-amputees of different types and at different times are valid, speaking strictly, only for the population of Gothenburg and its immediate neighbourhood. Yet it seems probable that this population is representative of a modern urban population in Sweden or a comparable country. A series of amputees collected at a rural hospital would perhaps have yielded somewhat deviating results with respect to the type and incidence of accidents leading to amputation; farming not infrequently gives rise to severe fractures and soft tissue injuries that necessitate amputation.

The surgeon's criteria for amputation will unavoidably to some extent be a product of the local and secular environment of the hospital in which he is working at the time of the operation. Hence any far-reaching conclusions drawn from the results presented here must not be taken too literally. The rate of amputation will be affected by changes in the age distribution of the population, by altered morbidity of conditions requiring amputation and by revisions of the indications for amputation.

Most of the demonstrated increase in the amputation rate among subjects older than 60 years at the time of amputation can presumably be accounted for by a shift towards higher ages in the population during the years considered here. There was a large difference in amputation rate between consecutive age groups over 60 years. For example, an octogenarian runs five times as great a risk of being subjected to amputation as a person in his 60's.

A further contribution to the amputation rate increment could come from a rise in the incidence of those peripheral vascular diseases which actually make amputation imperative. This is suggested not only by the demonstrated rise in amputation rate over the period studied in the age groups 70—79 and 80—89 years but also by the growing number of gangrene amputees. Perhaps one could say that currently a higher pro-

portion of senior citizens become potential victims of amputation-causing peripheral vascular diseases than their forefathers did. Changes in the age distribution of the population over 70 years of age might be responsible even for the observed amputation rate increase within the 70—89 years age group. The risk of becoming an amputee must rise appreciably between the ages of 71 and 79 years, considering that the risk of having a leg amputated was twice as high over 80 years of age as at 70—79. Another possibility that suggests itself is that in the “good old days” more people never reached the amputation risk zone because they died of their generalized vascular disease before it had advanced to that stage. As the years go by the longevity of elderly people with severe vascular disturbances is probably rising steadily, which of course brings with it an increase in the number of persons whose feet become gangrenous and have to undergo amputation.

It has been shown that the amputation rate remained constant from 1947 to 1954 and only then began to rise. That changes in morbidity and in the age distribution of the population could be the whole explanation for this abrupt rise in amputation rate seems most unlikely. It is not improbable that changed indications for amputation may have contributed to the greater amputation rate. Surgeons have also acquired a more active interest recently as to the role of surgery in the geriatric sector. This means that amputations are performed on elderly persons who formerly might have been treated conservatively. It could be that the person who died of gangrene in the past nowadays is subjected to amputation and before long dies of its sequels. The art of vascular surgery — a speciality among other things dealing with peripheral reconstructive surgery designed to prevent or limit amputation — has done much and will probably do more to keep the amputation rate from rising by means of procedures like embolectomy, transplantation of vessels, etc. But technical problems tend to beset most new activities, so one should not be surprised in the future to see that refinements in technique and stricter delimitation of diagnostic entities may eliminate some patients who now come to amputation and perhaps include others. The spreading use of transmetatarsal amputation for diabetic gangrene has probably reduced the number of more proximal amputations for this disease. Anticoagulant therapy as a prophylactic measure also seems to promise a reduction of the number of amputations for thromboembolism.

No increase was demonstrated in the frequency of leg-amputations among persons less than 60 years of age nor among the victims of accidents. The frequencies of young leg-amputees and of traumatic amputees have probably been prevented from rising by the trend away from the motor-

cycle, the improvements in industrial accident prevention and the advances in reconstructive surgery.

The age at amputation has shown a tendency to rise in the period 1955—1962. This rise seems likely to be accentuated by the changing age distribution of the population. At present all age group of leg amputees below 80 years are comprised of a majority of men. During the period 1947—1960 the amputation rate tended to rise more for men than for women, and the rise for men significantly exceeded that for women in 1961—1962. The excess amputation rate for men could be caused by the increased morbidity of, or a growing male predilection for, peripheral vascular diseases of the type requiring amputation. However, population changes might also be a factor in this difference in amputation rate increase; the number of men in the population is slowly rising, and if this trend continues the present preponderance of women over the age of 60 years will diminish and vanish.

Among elderly subjects amputation should be regarded as merely one sign of a systemic disease which in the majority of cases ultimately is fatal. In such patients amputation is an ill omen for the prognosis, and the gangrene should be interpreted as a late or delayed manifestation of the patient's vascular disorder. This is borne out by the high incidence of multiple manifestations of vascular disease at the time of the amputation, the preponderance of above-knee amputees, the difficulty of getting the amputation wound to heal, the prolonged postoperative convalescence, and the high incidence of amputees requiring institutional and domestic care among the elderly.

The manifestations of the vascular disease are just as frequent regardless of whether amputation is carried out for peripheral obliterative arteriosclerosis with or without diabetes, although the amputation age was found to be slightly lower for diabetics than for non-diabetics, perhaps because diabetes mellitus may be and probably is a summation effect of arteriosclerosis of the major vessels and microangiopathy. Apparently subjects with early onset of clinical diabetes, as a rule patients below 30 years of age, less often develop gangrene. Probably this is merely because such patients die of other vascular complications before gangrene supervenes.

The discouraging functional attainments of elderly amputees must be considered in the light of the high frequency of vascular disease, often serious and systemic, in this segment of the population. The elderly amputee has used up much of his reserve capacity of physical and mental power and to work at a job or merely to cope with the activities of daily living he is forced to tax his powers to the utmost. Rarely, however, was the amputation *per se* the cause of total inability to work among leg-amputees

younger than 60 years nor of self-care failure among leg-amputees older than 60 years. For such patients minor additional handicaps often have profound consequences. Additional handicaps often make the young amputee unable to work and the old amputee unable to do without institutional or domestic care. Cardiac disease and senile mental insufficiency, both secondary to vascular disease, constituted the most common additional handicaps among old amputees. The young amputee, being more adaptable than the old, is less liable to be seriously affected by additional handicaps.

Those amputees who learn to walk with a prosthesis have a functionally good prognosis, for they generally make lifelong use of their prosthesis. Those amputees in the present investigation who had not learned to walk with a prosthesis within the first postoperative year never did manage to walk with a prosthesis. They remained chronically disabled till they died. The rarity of prosthesis walking among old amputees must in part be ascribed to the fact that the types of prosthesis available today are unsuitable for the aged.

The number of living amputees older than 60 years in the population predictably will rise over the rest of the present decade, provided the indications for amputation remain what they are now. The increase will be due to the rising proportion of elderly persons in the population at large. Hence, and in view of the poor clinical and sociomedical function of the elderly amputee evident today, new and better facilities will be required in order to improve the functional attainments of the elderly amputee.

Some day we may learn how to prevent or cure the damaging effects of vascular diseases and thereby reduce the number of leg-amputees. Probably vascular surgery will develop along lines enabling it to render even more assistance in the reduction of the amputee frequency. The leg-amputee must more often than currently is the case be given systemic therapy; not only the yet unamputated leg requires treatment. Efforts should be made to amputate as little and seldom as possible within specific criteria. More partial-foot and below-knee amputations at the expense of above-knee amputations might become possible by a careful preoperative analysis of the anatomy and function of the vascular tree by means of angiography and physiological tests of vascular function. It would also be desirable to have an efficient therapeutic organization with the resources to give, without delay, the aid required to promote effective rehabilitation of the amputee. Gait-training centres should be set up so as soon as possible to make the amputee an out-patient, and thereby set free urgently needed hospital beds. Furthermore, society should make available suitable dwellings for disabled persons, enabling the amputee to better care for himself and move about

easier. Something needs to be done to make it easier for the amputee to get from his dwelling to various establishments he has to or would like to visit. Orthopaedic workshops must be equipped to be able to use the fruits of technological advances. The country should have an adequate number of Orthopaedic and Prosthetic centres where research is carried on into the medical, technological and social problems associated with an amputation.

Summary

Information gathered about all the 586 residents of Gothenburg subjected to primary above-ankle amputation at Gothenburg clinics in the years 1947—1962 was used for studying the annual frequencies of new leg amputees and the age and sex distributions of the patients.

The annual frequency of new leg amputees remained substantially constant in the years 1947—1954 and then rose. When allowance was made for changes in the age distribution of the population, it turned out that the amputation rate per 100.000 inhabitants showed a significant increase as from 1955 for subjects over 60 years of age. The male amputation rate was greater than the female (males: 62 in 1955, 129 in 1962; females: 46 in 1955, 66 in 1962). The amputation rate rose markedly with age for subjects over 60 (1962: 43 aged 60—69, 158 aged 70—79, 171 aged 80—89). Over the years 1950, 1955, 1958, 1960—62, moreover, the amputation rate rose significantly among subjects in the 70's and 80's. No increase in amputation rate was demonstrated for subjects below 60 years of age. A cautious prognosis suggests that the number of living leg amputees over 60 years of age in 1970 will have risen by 69 per cent for males and 80 per cent for females.

Analysis of the cumulative amputation age distribution in 4-year periods disclosed that the age at amputation remained fairly constant up to and including the year 1954 and then began to rise. The median age at the time of the amputation was thus 69 years in 1955 and 73 years in 1962. And while 68 per cent of those subjected to above-ankle amputation in the period 1947—1950 were over 60 years of age, the corresponding proportion in 1959—1962 was 88 per cent.

Apart from the 80—89 years age group, men were in the majority in all age groups.

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The series of 331 leg amputees for the years 1947—1956 and 1961 was studied in greater detail, and 84 of the 85 surviving at the end of 1962 were followed up and examined by the author. The fate of 246 deceased patients was followed from the day of the operation to the day of death.

The data thus obtained made it possible to chart the causes of leg amputation, the postoperative course, survival time, clinical function and socio-medical function after leg amputation.

Vascular disease had caused 273, accidents 35, tumours 17 and miscellaneous causes produced 6 of these amputees. The most common vascular disease was diabetic peripheral obliterative arteriosclerosis, affecting 143 of the patients, followed by non-diabetic peripheral obliterative arteriosclerosis with 93 patients.

At the time of amputation the median age of the diabetics was 69 years and that of the non-diabetics 72 years. The majority of gangrene amputees suffered from additional handicaps. Only 20 of the 143 diabetics had no additional handicap at the time of amputation. The annual frequency of gangrene amputees rose significantly, the increase being greatest for non-diabetics. Among the 35 traumatic amputees 24 had been involved in traffic accidents and 8 had been injured in industrial accidents.

The amputation wound healed primarily in 82 of the 225 unilateral amputees who survived more than one month after the operation. In 51 of the latter patients the above-ankle amputation had been preceded by unsuccessful toe and foot amputations. Reamputation from below to above the knee was performed on 18 of the 225 unilateral amputees.

The majority of patients under 30 or over 60 years of age at the time of amputation were above-knee amputees. Among the 331 patients 53 or 16 per cent were bilateral amputees.

Of the 278 unilateral amputees, 11 per cent had to be regarded as chronic cases preoperatively. They had all been treated in homes for chronics or similar institutions for at least 6 months, in most cases much longer, prior to the amputation. Postoperatively 45 per cent required long-term treatment, and no less than 21 per cent spent more than a year in a chronic ward.

Among patients younger than 60 years at the time of amputation in 1952—1956 42 of 67 patients or 63 per cent were still alive 5 years postoperatively. The corresponding figure for those older than 60 years was 35 of 190 patients or 18 per cent. The 5-year life expectancy in the Gothenburg population was 74 per cent for persons over 60 with a similar age distribution as the leg amputees. Two years postoperatively 79 of 190 patients or 42 per cent of the amputees older than 60 years remained alive. When the one-year mortality of gangrene amputees older than 60 years was related to the patient's sex and age, amputation level above or below the knee, and intercurrent usually fatal disease, it appeared that these factors exerted interacting effects on the one-year mortality. The highest one-year mortality was exhibited by below-knee gangrene amputees older

than 74 years at the time of amputation who had an intercurrent usually fatal disease. Of the 16 patients in this category 12 died within the first postoperative year.

In the series of 331 leg amputees 103 or 31 per cent succeeded in learning to walk with a prosthesis. Among the 52 unilateral amputees younger than 60 years with a survival time of at least one year 49 or 94 per cent learned to walk with a prosthesis, the corresponding figures being 45 of 108 or 42 per cent for unilateral amputees older than 60 years and 9 of 31 or 29 per cent for bilateral amputees. Gangrene amputees older than 60 years without additional handicaps became prosthesis walkers in 69 per cent of the cases but only 22 per cent of those with additional handicaps did so.

The sociomedical function of the 52 unilateral amputees younger than 60 years surviving one year postoperatively was classified as "Restoration" in 67 per cent, "Self care" in 23 per cent and "Domestic or institutional care" in 10 per cent of the cases. One of the patients in the last group was a chronic case before the amputation. Among the 108 unilateral amputees older than 60 years with a survival time of at least one year the classification by sociomedical function was 2 per cent "Restoration", 26 per cent "Self care" and 72 per cent "Domestic or institutional care". Preoperatively 14 per cent of the last group had been chronic cases. The disability incurred by the amputation itself was not alone responsible for making the younger patient unable to work and the older a chronic case. The reduced sociomedical function was instead usually due to one or more other handicaps in addition to the amputation.

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The writer followed up and examined 133 patients who had been equipped with prostheses at the Orthopaedic Department, Gothenburg, were younger than 60 years at the time of amputation before 1957 and were domiciled in Greater Gothenburg in 1961. The information obtained illustrated the sociomedical function of the younger leg amputee who had survived at least 5 years postoperatively and overcome the difficulties of the first years.

All but one of these patients used prostheses, 42 per cent walking with a mild, 46 per cent with a moderate and 11 per cent with a marked limp.

Sociomedically 88 per cent were in the "Restoration" group and the rest in the "Self care" group.

Preoperatively 38 per cent had heavy work and 11 per cent light work; postoperatively the corresponding figures were 8 per cent and 51 per cent.

Ten patients said they had economic difficulties, but the amputation alone was not responsible. Insurance companies assisted 45 per cent of the patients. Nine patients, all with additional handicaps, received 100 per cent disability pensions.

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