Late Sequelae of Amputation

THE HEALTH OF FINNISH AMPUTATED WAR VETERANS

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"An unusual opportunity to study the late effects of amputation on a large sampling of World War II veterans in Finland was provided by a situation in which the amputees were available as subjects for a period of three weeks. By taking advantage of this opportunity, a team of investigators was able to conduct an extensive study and, subsequently, to report an impressive list of findings which contribute significantly to the store of knowledge in this area. The investigators apparently used every possible measure, including a large control series, to ensure the reliability of the findings.

"The authors discuss and compare their findings with others in this field, thus increasing the scope and value of the article. It is reassuring to note that the general physical condition of these amputees in their middle years compares favorably with that of uninjured individuals of the same average age."

INTRODUCTION

Of the disabled servicemen from the 1939 - 1945 wars on whom amputation of the upper arm, forearm, thigh and leg had been carried out, about 5,000 survived. Those who have had to do with our war veterans admire the sturdy perseverance which most of these seriously disabled men show as active members of the community, employed in even the heaviest occupations.

It is to be expected that because of the severe physical loss greater stress than usual will fall upon that part of the body which must compensate for the lost function or continue its earlier function despite the extensive change. Now, about twenty years after the wars, we can expect to gain an idea whether amputation of an extremity has any effect upon the general health of the amputee, *i.e.* of the late results of amputation. Similar studies based on more limited series of Finnish war veterans have already been carried out to some extent (Solonen and Aho 1958, 1959). As is well known, amputees themselves believe that many of the disorders from which they suffer after the loss of an extremity, pain in limbs or back pain, symptoms of fatigue, heart diseases, etc. are directly or indirectly attributable to the amputation. At variance with this belief is the opinion held by many doctors that amputation does not cause any noteworthy injury beyond that entailed by the loss of a limb in itself Some authors (Arens 1962, Belz 1962, Warmuth 1962) have drawn attention to the marked difference be-

tween the subjective symptoms and the clinical and radiological findings in the area of the motor-skeletal system in amputees. Such a difference is not confined to amputees, however, but is commonly met with, particularly in cases of arthrosis deformans. The fact that persons with lower limb amputations and good prostheses have as much back pain and deformities as those with poor prostheses has attracted attention. It should be remembered, however, that even though the artificial limb fits well, is of correct length and weighs little, the fact remains that when a person loses a large part of his lower limb, for instance, he also loses a large part of his active organism, which is replaced by a dead detachable substitute which lacks sensibility and which makes demands on the strength of the remaining organism. At the same time, the centre of gravity of the body changes and, furthermore, occupies different positions according to whether the artificial limb is being worn or has been removed, whilst it is always in a different position than before the amputation. Banfo (1960) found that after an extensive lower limb amputation, for instance, the centre of gravity may move from its original site to as far as the level of the twelfth thoracic vertebra. The centre of gravity, moreover, moves laterally from the central sagittal plane. It is understandable that to preserve the equilibrium of the body under such conditions both when moving and standing requires quite a changed position of the trunk, different effort and muscular function (Müller and Hettinger 1952, Bauer 1954). That deformities and degeneration of the spine arise or become exacerbated as a result of amputation is being more and more generally admitted (Lange 1952, Arens 1957, Borgmann 1959, Endert 1959, Mayr and Schoch 1959, Schöneberg 1960). However, as was already indicated, the radiological state of the spine does not always reveal the severity of the condition (Biström 1954, Solonen 1959). It must not be forgotten, on the other hand, that if certain pathological changes of the spine are radiologically demonstrable, the spine must be considered inferior to a healthy one and, at any rate potentially, diseased.

The assertion that amputation of one lower limb causes increased deformity and subjective symptoms in the remaining limb has been challenged, for one thing, on the grounds that even a healthy person when walking always places weight on one leg at a time and thus a single lower limb is designed to carry the whole of the body weight; there is thus no reason to believe that the capacity of the healthy lower limb of an amputee is less than that of the healthy leg of a non-amputated person (Schöneberg). This is a specious argument, however. In 24 hours an amputee applies more weight to his healthy limb than to his artificial one. In walking, weight is placed for a shorter period on the artificial than on the healthy limb and in standing more weight is borne by the intact limb than by the prosthesis (Bauer). It should also be remembered that in the morning and evening at home a person with a lower limb amputation ofter moves about without his artificial limb, jumping or walking on crutches and thus placing a particularly heavy strain on his only sound leg. Because of the normal weight-bearing involved when the patient walks both with and without a prosthesis, the position of the foot changes, thus provoking various disturbances.

Solely to maintain his balance an amputee uses considerably more energy than a healthy person. For movement, more than the normal amount of energy is likewise demanded from muscular resources that are smaller than normal. Even the loss of an upper limb disturbs movement and the maintenance of balance in the absence of auxiliary movements and the weight of the arm. When there is loss of large portions of some organic system it would not be surprising if this were also to affect the function of the interior organs. The correlation between amputation and hypertension,

obesity and disorders of the internal organs has, in fact, been investigated elsewhere.

As regards their primary aetiology or patho-anatomy the deformities and degenerative changes of the skeleton and joints, the reduced mobility or other secondary injuries of the body in amputees hardly differ from similar changes in non-amputated persons. However, an investigation of the frequency and the degree of severity of such findings is called for, particularly as it is unlikely that observations made in other countries are directly applicable to Finnish amputees. Since the results may also be of significance from the point of view of medical insurance, it would seem important to determine the correlation between the expected pathological changes and the primary injury. For this reason we have tried to render our investigation as reliable as possible by using a large control series.

MATERIAL

The amputees investigated were all disabled in the 1939 - 1945 wars.

The following abbreviations will be used to indicate the various groups: Upper arm amputations—AE, forearm amputations—BE, thigh amputations —AK, lower leg amputation—BK, amputation of two limbs—D and control series—C.

TABLE 1

INVESTIGATED AMPUTEES

Group	No. of cases	Age yrs.	Average age	Average time since amputation, yrs.
Upper arm amputations (AE)	48	36—54	45	19
Forearm amputations (BE)	24	37—58	45	19
Amputation of thigh (AK)	65	36—54	44	18
Amputation of lower leg (BK)	157	27—59	44	18
Two limbs amputated (D)	17	35—57	45	19
Total	311			

As a control series we used non-amputated persons of the same age groups who had fought during the war and who were otherwise chosen at random.[1]

TABLE 2

CONTROL SERIES (C)

No. of persons	Age	Average age
92	33—67	45

[1] Our thanks are due to the Helsingin Reserviupseeripiiri r.y. and the Helsingin Reservialiupseerit r.y. for the assistance they gave us in collecting the control series.

Occupation of the investigated war disabled men, who were chosen at random:

Heavy labour (farm labourers, lumberjacks, unskilled workers, builders, etc.)	42 per cent
Medium heavy (carpenters, painters, platers, drivers, etc.)	20 per cent
Light work (shopkeepers, tailors, shoemakers, etc.)	25 per cent
Intellectual workers	11 per cent
Persons who could not be referred to any particular profession	2 per cent

It should be mentioned that of the 17 persons with two limbs amputated, 7 had undertaken heavy labour. Reamputation had only been carried out in a few cases and in the present investigation no particular attention has been paid to this point.

METHODS OF INVESTIGATION

The team of investigators consisted of an orthopaedist, a specialist in internal medicine, a radiologist and a physiologist.

An orthopaedic examination was carried out on the amputees immediately upon their arrival at the Kaskisaari Rehabilitation Centre for a routine course of rehabilitation and on the use of a prosthesis arranged for the war disabled. It should be mentioned that the law provides the possibility for all war amputees to take part in these three-week courses in which about 300 persons participate yearly. The amputees of the present series represent an average sample of the amputated war disabled. The medical, radiological and physiological examinations were carried out during this course and it is our belief that at the time of the examination the treatment given at the institute had not yet had any significant effect upon the amputees investigated. To obtain as reliable case histories and examination results as possible we made it clear to the persons involved that the check-up examinations and tests were a routine check-up and that the results obtained would not be of any direct use for them. For the examinations the usual orthopaedic, medical and radiological methods were used. Each specialist carried out all the examinations in his particular field himself and the results are thus evaluated on a uniform basis. The following radiological examinations were carried out:

Upper limb amputations: Cervical spine, thoracic spine, lumbar spine, shoulder joints, elbow joints, wrist joints, stump and miniature radiogram of the chest.

Lower limb amputations: Thoracic spine, lumbar spine, hip joints, knee joints, ankle joints, foot, stump and miniature radiogram of the chest.

Control group: All the above (except the stump).

All radiograms were made in two planes perpendicular to one another. The miniature radiograms of the chest, 10 by 10 cm, were taken in an anteriorposterior and a lateral direction with contrast medium. To obtain as objective an evaluation of the results as possible, the radiograms of the stumps were laid aside and the rest of the radiograms were mixed, so that the radiologist evaluating them did not know to which group of amputees the patient in question belonged. In the evaluation of the radio-

grams we tried as thoroughly as possible to follow the radiopathoanatomical classification of the following authors: Köhler (1953), Schinz *et al.* (1953), Brocher (1957, 1959), Schmorl and Junghanns (1957).

No attention has been paid in the present investigation to the *prosthesis,* since a single artificial limb is always an aid of short duration and thus not of any particular significance so long after the amputation. Many of the amputees of the present series had had five or six or even more prostheses since their amputation.

RESULTS

General Condition

The general condition of the persons examined was, as a rule, good. In only a few cases, 3 per cent of the amputees and 2 per cent of the controls, was the general condition considered below normal.

TABLE 3

STATE OF NOURISHMENT

Amputees	Overweight %	Normal %	Underweight %
AE	12	81	6
BE	17	79	4
AK	37	60	3
BK	21	78	1
D	35	65	—
Total	24	74	3
C	12	84	4

In classifying the series into three weight groups (overweight, normal, underweight) the basis for the division was an excess or deficit of 15 per cent, the number of kilograms being compared with the number of centimetres exceeding one metre of the subject's height. The weight deficiency due to amputation was calculated according to Braune and Fischer's table (1893).

There was no clear difference in the weight distribution of the upper limb amputees and the controls. Among the lower limb amputees there were clearly more overweight persons than among the upper limb amputees who had both legs intact, or among the controls. The difference is statistically significant ($P < 0.01$). There was a relatively greater degree of overweight among the persons with thigh amputations. The group with two amputations is so small that statistical tests cannot be applied to it.

In a series of 1,100 thigh amputees, Meyeringh and Stefani (1956) did not find a greater tendency to overweight than in a normal population. According to Loos' (1957) investigation of 647 amputated persons, there were no differences worth mentioning between the percentages of overweight persons in the different groups. According to him, this would seem to indicate that the limited mobility of the lower limb amputees does not contribute to the devolpment of overweight.

A number of routine laboratory tests were carried out on all persons investigated, the results of which are given in table 4. These values are the mean values for all the amputees.

TABLE 4

SOME LABORATORY FINDINGS

Group	No. with ESR over 20 mm/hr.	Hgb mean value g	Cholesterol mean value	Pathological ECG
AE	2			3
BE	2			2
AK	7			7
BK	7			7
D	2			2
Total	20 (6%)	14.3	267.4	21 (7%)
C	5 (5%)	14.0	300.7	6 (6%)

Only conditions following thrombosis of the coronary artery and evident signs of deficiency in the function of the coronary artery, severe rhythmic and conductive disturbances and signs of hypertrophy of the right or left side of the heart were considered pathological electrocardiographic findings. There was no cases of angina pectoris in our series (though one subject in the control series had thrombosis of the coronary artery some weeks after the examination). There were 21 (7 per cent) pathological electrocardiograms among the amputees and the percentage did not significantly exceed the corresponding figure for the control group. Neither were clear differences observed between the groups in the other laboratory tests. No explanation can be advanced for the difference between the cholsterol values.

Meyeringh *et al.* (1960) compared the ECG findings of more than 1,000 amputees with those of other war disabled men who had not lost a limb. They concluded that cardiac disorders are not caused by factors related to the condition following amputation. Neither did they find among the amputees any tendency towards sclerosis of the coronary artery. On the other hand, these authors mention cardiac disorders arising from the inflammatory conditions that occasionally occur as sequelae of amputation.

The connection of the condition following amputation of the left arm with subsequent angina pectoris has also been discussed in the literature (Delius 1953 and Sturm 1957).

The results of measurement of arterial pressure are given in table 5.

TABLE 5

INCREASED ARTERIAL PRESSURE

Group	Arterial pressure 150/90	Systolic pressure 160 mm. Hg	No.	Total %
AE	2	4	6	13
BE	2	1	3	13
AK	4	5	9	14
BK	12	6	18	11
D	2	1	3	18
Total	22	17	39	average 14%
C	5	4	9	10%

The increased arterial pressure was confirmed by repeated measurements. The highest value, 240/150, occurred in the group of thigh amputees.

In order to avoid errors of measurement, particular attention was paid to the technique used.

The percentages of hypertonics in the various groups were more or less the same. Neither were they any higher than the frequency of hypertonia reported in the literature for a population of the same age (Master *et al.* 1943, 1950, Bøe *et al.* 1957).

Some authors considered increased arterial pressure to be a late result of amputation (Schneider 1940, Veil and Sturm 1946). It has been assumed that irritative processes in the stump may affect the midbrain by way of the nerves. Inflamation may also increase contraction of the arteries and in the case of hypertension impair the condition of those who already have a tendency to this disease (Bommes 1940). Other authors have not found higher blood pressure values in amputees than in other population groups (Schulze 1942, Bodechtel 1948 and Meyeringh and Stefani). Rausche (1939) and Loos (1957) have demonstrated a greater frequency of high blood pressure than is commonly met with only in amputees who are overweight.

The commonest diseases observed in the amputees are given in table 6.

TABLE 6

DISEASES

Group	Pulmonary Emphysema %	Chronic gastritis %	Condition following gastric operation %	Chronic inflammation of the large intestine %	Neurocirculatory asthenia %
AE	8	4	2	—	2
BE	8	8	—	4	8
AK	8	6	3	—	6
BK	6	10	2	1	6
D	6	6	—	—	6
Total	7	8	2	1	6
C	1	6	—	—	3

The emphysema was diagnosed clinically. It was slightly commoner in the amputees than in the controls. The incidence, however, presumably lies within the normal range. The same applies to the other diseases mentioned. Some of the amputees had chronic bronchitis with severe symptoms at the time of the investigation. The amputees referred to the group gastritis had, as a rule, had their symptoms for several years; in some of these cases there was radiologically verified ulcer, while some had not been previously diagnosed. Those operated on for ulcer are not included in the group of gastric catarrh. The history mentioned inflammation of the large intestine in two cases. In neither of them had the inflammation been ulcerative.

The group of neurocirculatory asthenia included those patients who for a number of years and independently of stress had had chest pain, lability of the pulse, dizziness or other symptoms of the vegetative nervous system. Within the range of the present investigation it was not possible to penetrate deeper into these disturbances. Other diseases established in the amputees included 3 cases of diabetes, 2 of which were diagnosed for the first time, 2 of gall-stones, 1 of urinary calculus and 1 of hiatal hernia.

In the control group 4 cases of gall-stone and 2 of urinary calculus were found.

TABLE 7

RESULTS OF MINIATURE RADIOGRAPHY OF THE CHEST

Group	Pulmonary emphysema %	Inveterate pulmonary tuberculosis %	Adhesions of the pleura %	Myopathia cordis %
AE	8	10	—	10
BE	12	4	—	8
AK	8	5	—	23
BK	8	4	4	15
D	6	—	6	18
C	4	3	6	9

There are no clear differences between the miniature radiographic findings in the amputees and the controls. The higher incidence of myopathy of the heart in amputees was not statistically significant. Neither is the difference in this respect between thigh amputees and other amputees statistically significant. Signs of inveterate pulmonary tuberculosis were observed to an extent that agreed with the figures reported, for instance, by Virtama (1962) and Härö (1963).

In table 8 the number of cases in each group is given in which no disease referable to internal medicine, no mental disorder nor any pathological miniature radiographic or laboratory findings were established, apart from the original injury, either at the examination or in the previous history.

TABLE 8

HEALTHY PERSONS IN THE DIFFERENT GROUPS

Group	No. of persons	Per cent
AE	13	27
BE	6	25
AK	15	23
BK	53	34
D	4	24
C	37	40

According to these observations, those with a lower leg amputation seem to form an intermediary group between the other amputees and the control group, the difference in either direction not being statistically significant. The difference between all other amputees compared as one group with the controls was statistically almost significant ($P < 0.05$).

The Stumps

The evaluation of the stumps must to a large extent be based on anamnestic information. The classification cannot, therefore, be very exact. The stump was considered good if the amputee has been continuously able to use a prosthesis. In other words, the stump was not particularly tender, there was no pain worth mentioning and on inspection the stump was faultless. A stump was considered satisfactory if its condition only prevented the use of a prosthesis to a small extent, or if there was periodic pain and tenderness, if there was excessive sweating or coldness of the stump, or if

the scar was to some extent painful while the stump was still fit for a prosthesis most of the time. A stump was considered poor if it was clearly inferior to that described above as satisfactory, if, for instance, wearing a prosthesis was often and continuously impossible owing to the condition of the stump (too short, great tenderness, poor shape, etc.) or if there was persistent pain or marked coldness. Also troublesome joint contracture caused the stump to be referred to the group of poor stumps.

Table 9 shows the distribution of the stumps in these groups in per cent of the number of persons of each group. Amputees with two stumps are not included in this table. In evaluating the stumps, damage to the stump of acute character and short duration was not taken into consideration.

TABLE 9

STUMPS

Group	Good or satisfactory %	Poor %
AE	69	31
BE	75	25
AK	71	29
BK	77	23

In the present series, lower extremities with a prosthesis were not so often too short as they were observed to be in a previous investigation on Finnish war amputees (Solonen and Aho 1958), evidently as a result of better servicing and checking of the prostheses. The length of an upper extremity prosthesis is not so important as that of a lower limb.

Table 10 shows to what extent the amputees of the different groups use a prosthesis.

TABLE 10

USE OF PROSTHESIS

Group	Always %	As a rule %	Seldom %	Not at all %
AE	44	31	17	8
BE	46	38	12	4
AK	98	2	—	—
BK	96	4	—	—
D [1]	65	6	6	24

[1] Prosthesis on one or two extremities.

In table 10 the prosthesis has been marked as used *always* when it is used every day during work, *as a rule* when used more or less regularly although not always even at work. *Seldom* indicates that the prosthesis is being used less frequently than in the former group, for instance on Sundays only or on some special occasion.

So-called Fatigue Pain

"Fatigue pain" occurs comparatively often in the joints of the intact leg and the stump. The anamnestic frequency of fatigue pain in the present

series is seen from table 11. (Fatigue pain in the same person has in some cases been referred to different anatomical areas).

TABLE 11

ANAMNESTIC FATIGUE PAIN IN JOINTS OF THE LOWER EXTREMITIES

Group	Intact leg				Amputated leg	
	hip %	knee %	ankle %	foot %	hip %	knee %
AK	11	39	27	5	9	.
BK	6	27	10	3	5	9
C	2	1	3	—	.	.

With regard to the fatigue pain in the knee joint the difference as compared with the control group is statistically highly significant. This is not the case, however, if amputations of thigh and leg are compared. The rate of ankle pain is also highly significantly higher in lower limb amputees than in the control group but here the difference between thigh and leg amputations is also significant.

It should be mentioned that 11 (17 per cent) of the thigh amputees and 95 (65 per cent) of the lower leg amputees had no fatigue pain at all in the intact leg. 60 (92 per cent) of the thigh amputees and 138 (88 per cent) of the lower leg amputees did not complain of fatigue pain in the amputated leg.

Muscular pain in the lower limbs was common. The amputees as a rule call this pain cramp. 4 per cent of the lower leg amputees and 3 per cent of the thigh amputees stated that such muscular pain constituted a marked symptom in their intact leg and 2 per cent of the thigh amputees had this pain in the stump as well. One subject of the control group had had similar pain.

The upper limb amputees, particularly the labourers, stated that they often had fatigue pain in the uninjured arm. 38 per cent of the upper arm amputees and 29 per cent of the forearm amputees said that they often suffered from fatigue pain in the upper or lower part of the intact arm. Such a history was not given in the control group.

11 (45 per cent) of the forearm amputees had no fatigue pain in the amputated upper limb. Likewise all upper arm amputees were free from such symptoms, evidently because the stump was little used.

Anamnestic pain clearly localized to the joints of the upper limb occurred in both the intact and amputated upper limb. The information obtained on the clinical and radiological symptoms in the area of the shoulder joint has been collected in tables 12 and 13.

Findings in the Upper Limbs

As usual, symptoms due to degeneration are much commoner in the area of the shoulder than in that of the elbow joint. The frequency of so-called periarthrosis appears from table 12. Only those cases were included in which there was clear limitation of movement. In all cases the abduction of the upper limb was a minimum of 90 degrees.

TABLE 12

PERIARTHROSIS OF THE SHOULDER JOINT

Group	Frequency in per cent	
	Intact side	Side of amputation
AE	38	27
BE	13	29
AK	—	—
BK	—	3
C	.	1

There was quite frequently periarthrosis of the shoulder joint of both the amputated and the uninjured arm. The higher frequency of periarthrosis in persons with upper limb amputations than with lower limb amputations is highly significant. On the amputated side, the symptom is relatively less common in the forearm amputees than in upper arm amputees. The difference is not statistically significant, however, because the chance of randomly existing difference is 6 per cent (the highest level for an "almost significant" result is usually 5 per cent).

On the whole, the number of positive findings is very small in all groups. Reckoned in per cent, however, they are more frequent in the amputees. There are no significant differences. Neither could any difference be observed with regard to the severity of the changes.

TABLE 13

RADIOGRAPHIC FINDINGS IN THE AREA OF THE SHOULDER JOINT

Group	Periarthrosis		Acromioclavicular arthrosis		Humeroscapular arthrosis	
	Intact side %	Side of amputation %	Intact side %	Side of amputation %	Intact side %	Side of amputation %
AE	2	—	2	6	2	2
BE	4	4	—	4	2	6
	right	left	right	left	right	left
C	2	2	1	1	1	.

TABLE 14

PAIN ON MOVEMENT OR LIMITATION OF MOTILITY IN THE ELBOW JOINT OF UPPER LIMB AMPUTEES

Group	Intact arm		Amputated arm
	Pain %	Limited motility %	Limited motility %
AE	4	4	—
BE	12	—	21
C	—	—	—

TABLE 15

RADIOGRAPHICALLY DEMONSTRABLE DEGENERATIVE CHANGES IN THE ELBOW JOINTS

Group	Arthrosis		
	Intact arm %		Amputated arm %
AE	15		—
BE	21		17
D	6		—
	right	left	
C	7	3	

Arthrosis was most commonly observed in the elbow joint of the intact arm of forearm amputees. Arthrosis was commoner in amputees than in the control group, in which arthrosis was commoner in the right, *i.e.* the more stressed elbow.

Neither the history nor the clinical status of the wrist and hand of the intact upper limb in the AE and BE group revealed anything noteworthy except that arthrosis was clinically diagnosed in the wrist of one AE amputee. Radiologically, arthrosis of the wrist joint was diagnosed in one forearm amputee and four upper arm amputees but not in the control group. The arthrotic changes were slight in all cases.

Part II of "Late Sequelae of Amputation" will appear in the next issue of the *Journal.* The material included will be:

Results (continued)

- Findings in the back and spine
- Findings in the lower limbs
- Flat-foot
- Circulatory disturbances
- Miscellaneous
- Phantom

Physiological Examination

- Method
- Results

Discussion and Conclusions

Summary

References