

Lymphovenous Microsurgical Shunts in Treatment of Lymphedema of Lower Limbs: A 45-year Experience of One Surgeon/One Center

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WHAT THIS PAPER ADDS

An operation involving microsurgical lymphovenous shunts was designed for decompressing the lymphedematous limb of the accumulated lymph by directing its flow to the venous system distally to the site of lymphatic obstruction. It is performed using a microsurgical technique, between the limb afferent lymphatics and superficial veins. This study presents the 45-year experience of one surgeon based on over 1100 lympho-venous shunts in the treatment of postinflammatory, postsurgical, hyperplastic and idiopathic types of lymphedema of the lower limbs. Improvement of between 30% and 80%, depending on the type of lymphedema, was achieved in the 5-year follow-up, measured by decrease in limb circumference and increase in joint flexing.

Rationale: The use of microsurgical lymphovenous shunts is one of the generally accepted treatments for limb lymphedema.

Aim: The 45-year personal experience of one surgeon in indications, technique and results of lymphovenous shunt operations in lower limb lymphedema of varying etiology is presented.

Material: One thousand three hundred patients were followed up in the period 1966–2011. Patients were classified into groups according to the etiology of lymphedema as postinflammatory/posttraumatic, postsurgical, idiopathic and hyperplastic. Decrease in limb circumference, heaviness and pain, and increase in joint flexing were evaluated.

Results: The most satisfactory results, reaching 80–100% improvement, were obtained in the congenital non-hereditary hyperplastic lymphedema group, with large lymphatics not previously damaged by infection. Results were also satisfactory in the group of cancer patients after iliac lymphadenectomy, reaching 80%. A less satisfactory outcome was observed in the postinflammatory group, not exceeding 30–40%. In idiopathic lymphedema results were satisfactory in only a few cases.

Conclusions: Patients with lymphedema with local segmental obstruction but still partly patent distal lymphatics and without an active inflammatory process in the skin, subcutaneous tissue and lymph vessels present satisfactory results.

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INTRODUCTION

The need for effective treatment of lymphedema of the limbs has become increasingly important, as the prevalence of this condition after soft tissue bacterial and parasitic infections, traumatic bone fractures and oncological surgery is steadily increasing. The statistics from WHO and other sources oscillate between 100 and 300 million of the world population, varying between different continents. The increasing longevity of patients treated for cancer with late

post-treatment development of lymphedema adds to these statistics. The contemporary therapy for lymphedema is based upon a combination of manual and pneumatic massage, elastic garments, prophylactic antibiotic administration for prevention of dermatolymphangioadenitis (DLA), and surgical procedures.¹

An operation involving microsurgical lymphovenous shunts was designed for decompressing the lymphedematous limb of the accumulated lymph and directing its flow to the venous system distally to the site of lymphatic obstruction. This operation mimicks the natural anastomosis of the thoracic duct with the subclavian vein, by the creation of microsurgical shunts between the lymphatics and veins. The other type of operation used is debulking surgery, but the microsurgical shunt procedure appears to have the advantage of creating a naturalistic lymph outflow

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pathway. Evaluation of the efficacy of this technique involving large numbers of patients was needed, with the indications adjusted to lymphedema of different etiologies and various stages of its advancement.

Lymphovenous shunts were experimentally attempted by us in 1966 and the first clinical operations were performed soon after.^{2–5} Since that time, various modifications of this operation have been tried at different centers.^{6–13} Herein, we present the 45-year experience of one surgeon/one center in the treatment of lymphedema of the lower limbs based on over 1100 patients operated upon in the period 1966–2011. The results obtained in patients with lymphedema of various etiological types are presented. Indications for the use of lymphovenous shunts and methods of assessment based on the evaluated material are described.

PATIENTS AND METHODS

Patients

A total of 1343 consecutive patients with unilateral lymphedema of lower limb were admitted to our center in the period 1966–2011. There were 986 females and 357 males, and of them 26 patients were aged 7–16 years and the remaining 24–68 years. Patients were classified into groups according to the etiology of lymphedema: postinflammatory and posttraumatic, postsurgical, idiopathic and hyperplastic.¹⁴ This classification was based on past history, clinical picture, and lipiodol and, more recently, isotope lymphograms. There were no cases of inherited lymphedema included as a lack of lymphatic collectors precludes performing the lymphovenous shunt. To exclude cases with venous thrombosis, contrast venography and more recently Doppler color venography was performed.

Inclusion criteria were: a) edema developing after incidents of dermatitis with recurrent attacks of DLA referred to as cellulitis and erysipelas; b) edema after major trauma of soft tissues with hematoma and inflammation; c) edema after lymph node removal and/or irradiation (after hysterectomy, inguinal lymphadenectomy), or saphenous vein harvesting for aorto-coronary bypass; d) cases with slow symptomless development of edema — so-called primary or idiopathic edema; and e) congenital edema (non-genetic) with dilated actively contracting lymphatics — hyperplastic lymphedema. Exclusion criteria were: congenital genetically transferred lymphedema, lipedema, chronic venous stasis, cardiac and kidney edema, rheumatoid arthritis, and acute inflammatory soft tissue changes.

There were 850 patients in the postinflammatory and posttraumatic group. In the postsurgical group there were 302, including 136 after hysterectomy and radiotherapy due to uterine cancer and 66 after inguinal and iliac lymph node removal because of melanoma or seminoma. There were 165 patients in the idiopathic group and 26 in the hyperplastic group. Of the total number of admitted patients, 1176 gave signed consent for the lymphovenous shunt operation. They met the following criteria: gradually increasing uncontrolled edema of the limb, in stages I to IV,

with hyperkeratosis and fibrosis of the skin and lymphographic signs of lymph stasis. Of these, 960 patients were followed for at least 5 years, including 218 who showed up occasionally for check-ups over 10–40 years. None of the investigated patients consistently used additional types of edema therapy, which could affect the results. The purchase of elastic materials and more recently manual or pneumatic compression equipment is not reimbursed by the Polish insurance system and most patients could not afford to buy them. We monitored patients with respect to any additional therapy at each periodic check-up. The study was approved by the Warsaw Medical University ethics committee.

Study setting

Patients were divided into four groups according to the etiology of lymphedema. Each of these groups was stratified into stages based on the advancement of limb anatomical and lymphographic changes. With the exception of the hyperplastic lymphatics group who were all aged 7–16, there was an even distribution of age across all etiology groups and stages of the disease.

All patients had either lymphodeno-venous or lymphatico-venous shunt performed in the groin. Selection of the type of shunt depended on presence or absence (atrophy, fibrosis) of inguinal nodes. In both types of drainage operation, the lymph flow through the shunt should have been similar, as at least 3–5 afferent lymphatics carry lymph to the groin region.

The initial follow-up period after the operation was 5 years. There were also small groups followed for periods of 10, 20, 30 and 40 years. During the 5-year follow up patients were assessed every 6 or 12 months. Patient compliance was around 80%. Those with longer follow up of above 10 years appeared for assessment occasionally at different time intervals. Thirteen patients whose body mass index had increased at the end of follow up by 10% were excluded from evaluation. This low number could not skew the results.

Clinical staging

Staging was based on evaluation of the level of edema embracing the limb from foot to groin, and the advancement of skin keratosis and fibrosis. Briefly, in stage I pitting edema was limited to the foot, in stage II pitting edema affected the foot and lower half of the calf, in stage III foot and calf were involved with hard foot and ankle area skin, and in stage IV the whole limb was edematous with foot and calf skin hyperkeratosis and toe papillomatosis.^{14,15} Clinical staging was correlated with the lymphographic pictures of lymph stasis.

Preoperative imaging and staging

Visualization of the lymphatic system is indispensable before planning the lymphovenous shunt. All patients had lymphography carried out. In the period up to 1988, an oily contrast medium was injected into a cannulated lymphatic on the dorsum of the foot. Since 1988, with isotope lymphography available, Tc99m Nanocol® (aggregated

albumin) was injected between the toes (superficial system) and into the sole (deep system). Gamma camera pictures provided information on tracer absorption, afferent lymphatics' outline, and time for tracer to reach inguinal lymph nodes and their outline. According to our classification lymphoscintigraphy in stage I lymphedema reveals spread of tracer in the foot, a faint outline of superficial lymphatics and small inguinal lymph nodes visualized within 30 min of isotope injection. In stage II, there is spread of tracer in the foot and lower part of calf, interrupted outline of narrow lymphatics, and a few small inguinal nodes with irregular outline. In stage III there are no collecting but only minor lymphatics visible and inguinal nodes reveal irregular outline after more than 2 h following isotope injection. Stage IV is characterized by spread of tracer in minor lymphatics and tissue space of the foot and calf without visualization of collecting lymphatics and nodes. Lack of visualization of lymphatics did not preclude the shunt operation, as there are thigh lymphatics draining into the inguinal lymph nodes that are not shown after injection of tracer into the foot tissues.

Duplex ultrasound phlebography of limb superficial and deep venous systems and pelvic veins was performed in all cases to exclude recent or past thromboses.

Microsurgical lymphovenous shunt operations

A total of 1176 patients had lymph node-saphenous vein (LNSV) or lymphatic vessel-saphenous vein (LVSV) anastomosis performed (Table 1, Fig. 1). Details of the technique have been described previously,^{3–5} and are outlined as follows.

LNSV: The groin skin was incised. One of the inguinal lymph nodes was cut transversely across its long axis between the first distal and second third. After venotomy, the lumen of the vein was rinsed with heparin saline solution, and the distal and proximal segments of the vein were also be filled with heparin saline. Only the capsule of the node without parenchyma was stitched to the vein wall, interrupted 6-0 or 7-0 DEXON™ being the most suitable suturing material. An operating microscope with magnification $\times 8$ –12.5 was used during dissection and suturing. After the release of vascular clamps, light massage of the distal part of the limb was instituted to increase the lymph flow through the anastomosis.

Systemic heparinization was avoided because of the risk of bleeding from the suture line. Thrombotic complications have, so far, not been observed. Suction drainage of the wound was instituted for 48 h.

LVSV: Two types of operative technique were used. One was an end-to-end anastomosis of a dilated lymph vessel with a vein of the same caliber. To avoid a stricture at the site of anastomosis, a short length of tubing was inserted into the lymph vessel and vein at the time of suturing and removed immediately before completion of the anastomosis through an incision in the proximal part of the vein. Technically simpler was the procedure of invagination of the lymph vessel into the vein. In all types of LVSV special care was taken not to deprive the lymph vessel of its blood supply (!). The other operation was transmural implantation of a lymph vessel into the vein. In order to make an opening in the vein and to introduce the lymphatic vessel, needles of two different types, a straight one and an angled one, were used. They have a diameter of 12.15 or 18 mm, and a length of 140 mm. These needles have a groove 30 mm long. The lymphatic vessel was dissected carefully mostly by blunt separation with scissors. Each isolated lymphatic vessel (from 3 to 9 in number) was held by a traction loop of no. 1 or 2 black silk. A segment of the vein at an appropriate level was held by two traction loops of umbilical tape. A straight or angled grooved venous needle of adequate diameter was inserted into the great saphenous vein. The distal lymphatic stump was exposed. A 7-0 double arterial curved needle with prolene suture was used. One of the two needles was passed from outside, through the lymphatic wall, and into the lumen. The same needle was then inserted into the vein orifice through the grooved venous needle from inside to the outside of the wall, coming out at a distance of 2 mm from the orifice. The lymphatic vessel was carefully pulled into the vein. After completion of the first anastomosis other lymphatics were implanted.

Postoperative evaluation

Extremity measurements were taken preoperatively and were subsequently repeated at 6- and 12-month intervals. In some cases the 6-month measurements were omitted. Physical evaluation included: (a) leg circumference, (b)

Table 1. Number of patients undergoing lymph node-to-saphenous vein (LNSV) or lymph vessel-to-saphenous vein (LVSV) shunt operation in various types of lymphedema in the period 1966–2011 ($n = 1176$).

Type	Postinflammatory		Postsurgical		Idiopathic		Hyperplastic	
No. of patients	770		260		120		26	
Stage	LNSV	LVSV	LNSV	LVSV	LNSV	LVSV	LNSV	LVSV
I	230	22	92	38	22	20	—	—
II	218	78	62	21	48	2	—	—
III	112	20	34	13	—	—	24	2
IV	90	0	—	—	—	—	—	—

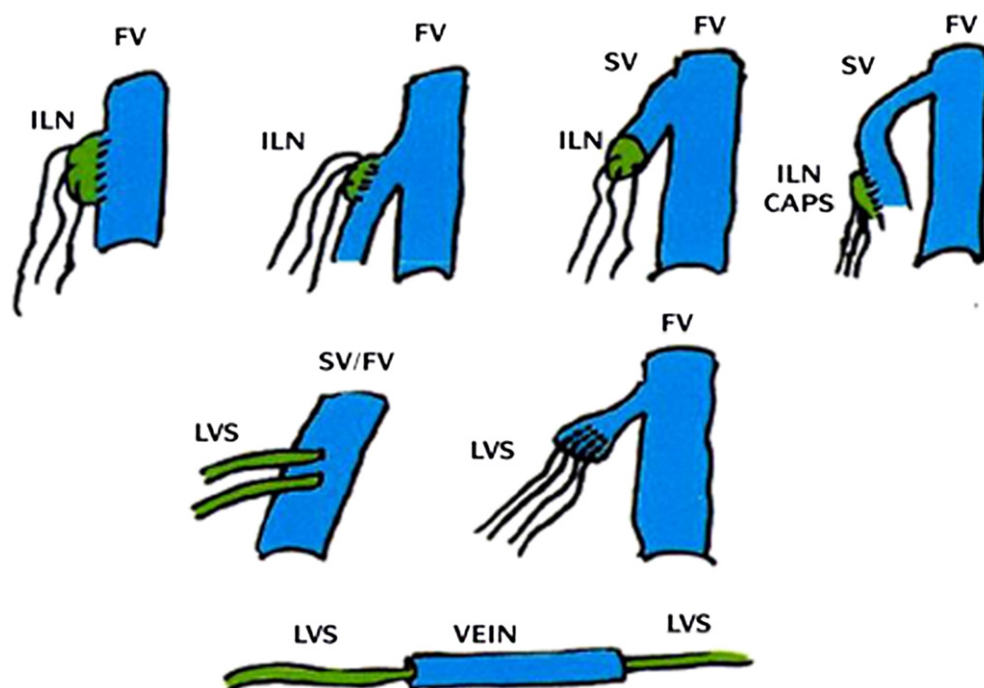


Figure 1. Lympho-nodo-venous and lymphatico-venous microsurgical shunts. Various types of anastomosis can be performed. FV-femoral vein, ILN-inguinal lymph node, SV-saphenous vein, CAPS-capsule, LVS-lymphatic vessels. Data on ILN to SV and LVS invaginated to SV shunts are presented in this article.

flexing angle in the ankle and knee joints, and (c) limb pain sensation after day-long upright position.

- Standardized circumferential measurements were made during morning hours at three locations on the edematous and contralateral normal limb: dorsum of foot, mid-calf and mid-thigh. The circumference ratio edema:normal was calculated. The post-treatment measurements were compared to the initial baseline circumference values. Decrease by at least 2 cm at all levels of the edematous limb was considered to be significant. The body mass index was estimated at the start of the study and at the end of follow up to adjust the circumference changes.
- Flexing and extension at the ankle and knee joints were measured using an angle gauge. Increase in foot flexing by 15° and knee by 30° was considered significant.
- In order to specify the kind of abnormal feeling (heaviness, pain) in the limb, the McGill Pain Questionnaire was applied, with dull, sore, hurting, aching, heavy rated 1–5.¹⁶ To assess the intensity of limb pain the routine numeric rating scale of 1–10 was used: 0 represented no pain at all, 1–5 moderate, 6–9 worse, while 10 was the worst imaginable pain.

The postoperative limb evaluation criteria were as follows: circumference decrease by 2 cm = 1 point, increase in flexing limb joints by 30° = 1 point, change from heavy to dull feeling = 1 point, and decrease of pain at day end to 1–3 = 1 point. Improvement ranged from 2 to 4 points.

To evaluate directly the function of the lymphovenous shunt, postoperative lymphoscintigraphic imaging of

lymphatics with manual venous occlusion above the shunt for prevention of fast dragging by the blood stream was done in 20 cases of each group within 90–360 days of the operation.

Statistics

Data are presented as percentages of improvement of clinical parameters. To assess individual results, the Student *t*-test for pairs was applied. Differences between results in the lymphedema groups, and between the LNSV and LVSV shunts, were evaluated with use of the Mann–Whitney test. The differences were considered significant at the level of <0.05 .

RESULTS

Clinical results of 5-year follow up

(a) Postinflammatory lymphedema

Improvement in stages I and II was observed in 29%–42% within rating 2–4 (Table 2). In patients with improvement the circumference of the limb decreased at all levels by a minimum of 2 cm. The circumference ratio (CR) of the edematous to normal limb decreased at foot level from 1.5 ± 0.5 to 1.3 ± 0.4 ($p < 0.05$), at mid-calf from 2.8 ± 1.4 to 2.5 ± 1.4 ($p < 0.05$) and at mid-thigh from 1.8 ± 0.8 to 1.6 ± 0.8 ($p < 0.05$) (Fig. 2). In patients rated 0–1 (no improvement) there was no increase in CR and in most cases alleviation of subjective symptoms was observed. Joint mobility increased in ankle from $25 \pm 10^\circ$ and knee $60 \pm 30^\circ$ before operation to $35 \pm 10^\circ$ and

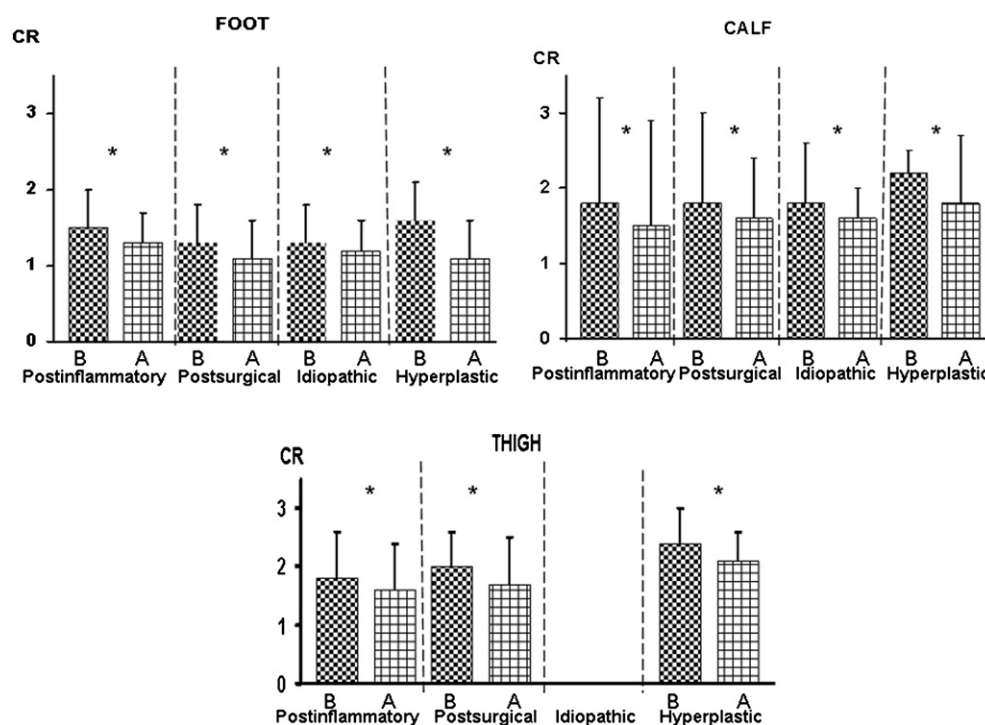


Figure 2. Changes in ankle and knee joint flexion after lymphovenous shunt operation in patients with clinical improvement rating 2–4 in the 5-year follow up. Values are means \pm SD. * $p < 0.05$.

limb.⁵ In the so-called idiopathic type of lymphedema, lymph flow impairment is located in small lymphatics, and even minor obstruction in collecting lymphatics or nodes causes lymph stasis.

In each of these groups, the prognosis is very different. The common denominator for all forms of lymphedema is tissue fluid and lymph stasis. There are several conservative methods for evacuation of stagnant tissue fluid and lymph;

however, what is basically needed is the restoration of anatomical lymph outflow pathways. Lymph node-to-vein and lymphatic-to-vein microsurgical shunts^{2–5} have been considered as one of the solutions. We designed the microsurgical lymphovenous shunts in the 1960s and have performed this operation in over 1100 cases since. In contrast to other authors, we have assessed the results in lymphedema stratified according to the cause of lymph

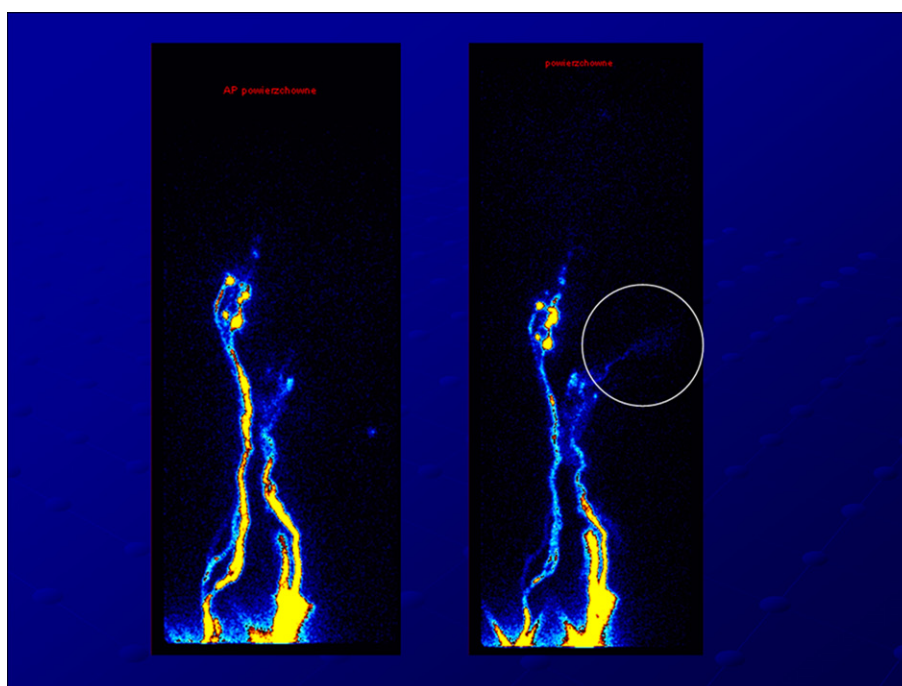


Figure 3. Lymphoscintigraphy in a patient with posttraumatic lymphedema of the left lower limb 6 months after a microsurgical lymph vessel to small subcutaneous vein was performed. Slow blood flow allowed to visualize isotope flowing into the vein (circle).

Table 3. The 10–40-year follow-up results of LNSV and LVSV shunt operations in patients with lymphedema of various etiologies in the period 1966–2011 ($n = 218$, % of improvement).

Type	Postinflammatory				Postsurgical				Idiopathic				Hyperplastic			
No. of patients	137				72				6				3			
Years of follow up	LNSV	%	LVSV	%	LNSV	%	LVSV	%	LNSV	%	LVSV	%	LNSV	%	LVSV	%
10	66	15	25	20	26	77	12	66	6	33	—	—	—	—	—	—
20	21	24	11	45	12	50	8	50	—	—	—	—	—	—	—	—
30	8	50	4	50	6	66	6	50	—	—	—	—	—	—	—	—
40	2	50	—	—	2	50	—	—	—	—	—	—	3	100	0	—

stasis. Patients were divided into four groups according to the etiology of lymphedema: postinflammatory/post-traumatic, postsurgical, idiopathic or hyperplastic. The old type of classification into primary (aplasia, hypoplasia, precox and tarda) and secondary is no longer considered tenable. It was based only on oily contrast lymphographic pictures from the 1960s. Contemporary imaging and immunohistological pictures show that in so-called primary lymphedema the lymphatics are damaged by invasive factors destroying endothelial and muscle cells. They reveal a normal developmental structure of the vessel; however, with secondary pathological changes in the wall and lumen.²¹ The idiopathic group is restricted to the cases of unknown etiology. The frequency rate of this condition is decreasing with progress in visualization and immunohistochemical techniques. We did not include in the study congenital lymphedema cases such as Milroy's disease, as lack of lymphatic collectors precludes performing a shunt in such cases.

The most satisfactory results were obtained in young patients with congenital non-hereditary hyperplastic lymphedema, with large lymphatics not previously damaged by infection. The improvement rate reached 80–100% according to the clinical evaluation criteria. There was a decrease in the limb volume after operation and the proportions of the swollen to the healthy limb in the still growing patients were preserved. Results were also satisfactory in the group with tumors requiring iliac and inguinal lymphadenectomy, with improvement in 80% of cases. In these patients the afferent lymphatics were not damaged by infection and their contractility was preserved. In contrast to these two groups, results in the post-inflammatory group with previous infections were less satisfactory, not exceeding 30–40%. Lymphograms revealed in this type of lymphedema fragmentation of the lymphatic outline and destruction of the lymph node architecture. This was mostly seen in advanced stages. In the idiopathic lymphedema group, obstruction to the lymph flow was located in the minor peripheral lymphatics. This is why the results were the least satisfactory, although improvement was observed in some cases.

The presented statistics prove the efficacy of microsurgical lymphovenous shunts in a significantly large group of patients. The value of our data has been strengthened by the fact that patients were not treated by other means such as massages and elastic materials. Moreover, we controlled attacks of DLA with antibiotics, preventing further damage to lymphatics and increase in lymph stasis.

Why the most satisfactory results were limited to the postsurgical and hyperplastic groups can be explained by analysis of the primary pathological factors causing lymphedema. The peripheral lymphatic system is exposed to infections and drains away microorganisms as well as antigens from traumatized tissue. Dermatitis (erysipelas, staphylococcal infections) and trauma to limb soft tissues destroy the peripheral lymphatics.¹⁴ Moreover, microbes remain in the affected tissues and evoke recurrent inflammatory reactions.²⁰ Despite the decompression of lymphatics by lymphovenous shunts, the destructive process is proceeding. This is why in the postinflammatory/posttraumatic group less satisfactory results were to be expected.

The overall statistics in the pertinent literature point to good and sometimes even excellent results for the lymphovenous shunts.^{22–37,39–47} The number of performed operations around the world has reached hundreds of thousands. The main concern raised by several authors is the limited time of function of the newly created anastomoses.³⁸ As mentioned before, we observed this mainly in the post-inflammatory group operated upon shortly after an inflammation episode or in those with a chronic skin inflammation. Unfortunately, in most reports there was no stratification of the operated cases into groups according to the etiology of lymphedema. Our experience points to the necessity of detailed analysis of the causative factors, as the latent inflammation following erysipelas, non-healing wounds and cellulitis may have an effect upon the long-term results of lymphovenous shunts.

Evaluation of the clinical results of lymphovenous shunts is difficult because of: a) low show-up rate of patients for periodic follow up because of stabilization of the state of the limb; b) subjective assessments by patients of limb heaviness/pain carried out over years; c) lack of visualization methods due to fast venous blood flow diluting the lymph tracer; (d) supplementary multimodal therapy such as massaging, elastic support, long-term antibiotic prophylaxis used in most centers. We were able to avoid this last problem by prospectively planning a follow up without additional therapeutical modalities. With respect to limb measurement, we found that the most consistent evaluation parameters were leg circumference using self-adhering tape, increased flexing in the ankle and knee joints, and subsidence or decrease of limb pain during long-lasting upright position. Additional parameters such as time of appearance of radioactivity over liver after Nanocoll toe web injection before and after shunt operation did not correlate with the clinical evaluation. Postoperative

lymphoscintigraphic imaging of lymphatics with venous occlusion above the shunt showed occasional presence of radioactive tracer in the draining vein (Fig. 3).

Based on the long-term follow up of the lymphovenous shunt operation in the lower limbs, we suggest the following indication for further practice: lymphedema at an early stage (I and II) of postinflammatory, postsurgical or hyperplastic type, with at least one thigh lymphatic and a single inguinal or iliac lymph node visible on the stress lymphoscintigraphy (performed during limb pneumatic massage or after standard time walking). Limited indications include: stages III and IV with no lymphatics or nodes on lymphoscintigraphy but presumably patent thigh lymphatics. No indication is given in the case of idiopathic lymphedema with soft skin, pitting edema and lack of lymphatic structures on lymphoscintigraphy. Contraindications for operation are recent attacks of DLA and skin ulcers.

Taken together, the microsurgical lymph node or lymphatic vessel to vein shunts have their established position among the therapeutic modalities for lymphedema of lower limbs; however, the indications should be restricted to lymphedema with local segmental obstruction but still partly patent distal lymphatics and without active inflammatory processes in skin, subcutaneous tissue and lymph vessels. Satisfactory clinical results such as decrease in limb girth and easy flexing in limb joints were observed in 30%–80%, depending on the etiology of lymphedema.

CONFLICT OF INTEREST/FUNDING

None.

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