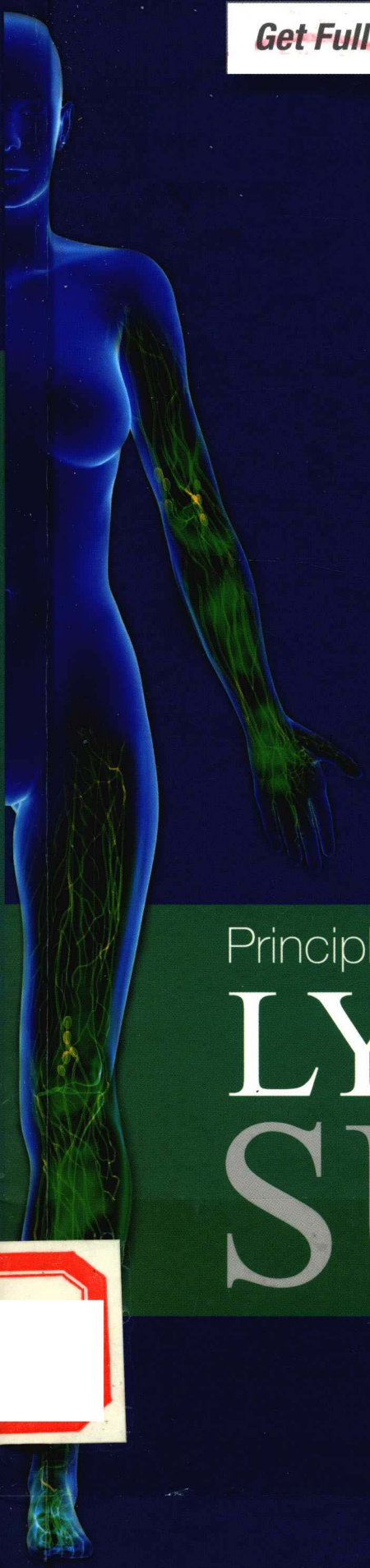

Principles and Practice of

LYMPHEDEMA SURGERY

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ELSEVIER

Principles and Practice of Lymphedema Surgery

FIRST EDITION

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Preface

The treatment of lymphedema is now at the forefront of medicine. Patients who otherwise may have had long-term disability and functional impairment now have surgical and non- surgical treatment options that are able to significantly impact their lives. Recently, surgeons, clinicians, and therapists alike have recognized the impact of this chronic condition and the need for a comprehensive treatment plan and a team approach to providing optimal outcomes. Modern lymphedema care is rapidly incorporating valuable surgical options to help provide symptomatic relief. These include microsurgical techniques such as lymphovenous bypass, lymphatic grafting, and vascularized lymph node transfers. An in-depth understanding of these complex procedures from the leading authorities in the field has contributed to the subsequent chapters in this book. In addition to microsurgical techniques, liposuction and excisional techniques are also discussed and explained in detail. Indications, outcomes, and technical details of these various surgical procedures will provide the reader with the knowledge-base to safely and efficiently execute them.

This unique and revolutionary textbook has been structured to provide the reader with a "start-to-finish" understanding of lymphology and lymphedema surgery, allowing one to incorporate the specialty into his/her own practice. From the foundation of lymphology to understanding how to assess treatment outcomes, readers will gain complete familiarity with managing a lymphedema patient. As lymphedema surgery continues to expand, it is imperative to have a comprehensive resource such as "Principles and Practice of Lymphedema Surgery" to ensure the successful promotion and support of this specialty in medicine worldwide.

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Ming-Huei Cheng

Dedications

I would like to extend my sincere gratitude to my family. My wife Hsiao-Fang and my daughters—Josephine, Christine, and Stephanie—are a constant source of warmth and love. Much of my spare time was devoted to this book, and they have always offered me their unfailing support. I can never thank them enough.

MING-HUEI CHENG

To my parents Paul and Esther Chang for all their sacrifices, my wife Mary and my children Matthew & Loren for their love and support.

DAVID W. CHANG

To my wife, Ashley, for her enduring love and for bringing balance to my life.
To my family, for their support and encouragement.
To my mentors and teachers, for their knowledge, education, and friendship.

KETAN M. PATEL

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1 An Introduction to Principles and Practice of Lymphedema Surgery

MING-HUEI CHENG, DAVID W. CHANG and KETAN M. PATEL

"Declare the past, diagnose the present, foretell the future."
HIPPOCRATES

Overview

The surgical treatment of lymphedema has evolved over the recent few decades. With the addition of microsurgical techniques, new options are available to patients suffering from the physical and emotional sequelae of symptomatic lymphedema. The development of lymphatic microsurgery occurred much later than parallel specialties in microvascular and peripheral nerve microsurgery. This is likely due to the advancements in basic science research in these respective fields, as well as crossover understanding of common principles shared by these similar specialties. The study of lymphedema has been plagued with difficulty in directly assessing physiologic changes and structural components, reproducing surgical outcomes, and differences in evaluating clinical conditions. Recently, new technology, techniques, and improved skill-sets have resulted in an improved understanding of the disease process, which has in turn guided the development of new surgical techniques.

Much of the recent increased interest in this field can be attributed to the immense population of people suffering from either primary or secondary lymphedema. In industrialized countries, secondary extremity lymphedema continues to be prevalent in patients receiving comprehensive treatment for either breast or gynecologic cancers. Once symptomatic lymphedema occurs, few options exist for this subpopulation of patients who, many times, have fought emotional and physical battles through the cancer treatment process. Being able to provide valuable surgical and nonsurgical treatment options to this patient population has significant implications for not only the individual patient, but also the health care system. Cost considerations are valued in the physical strain and lost opportunity in various activities related to patients' personal and professional lives.

Many controversies exist in the diagnosis and treatment of lymphedema including: universal diagnostic criteria, methods of limb measurements, and treatment options by variable medical specialties. The staging and treatment of lymphedema has no universal consensus among medical specialties, such as breast oncologists, gynecological oncologists, rehabilitation specialists, medical oncologists, radiologists/radiation oncologists, vascular surgeons, and reconstructive microsurgeons. Individualized clinical experiences lead to the disparate treatment options by various specialties, increasing the difficulties in choosing from the vast array of available alternatives for young surgeons.

Much of the interest related to lymphedema surgery among reconstructive microsurgeons has been garnered by the introduction of lymphovenous bypass and vascularized lymph node transfer techniques. Although these techniques have been described many decades ago, only recently has clinical interest surged in using these techniques. Using commonly learned microsurgical techniques, procedures resulting in lymphatic fluid shunting into the venous system can provide relief and decompression of a lymphedematous extremity. Furthermore, possibly re-establishing lymphatic connections can provide for an outflow of stagnant lymphatic fluid to flow centrally in the body. In addition to these techniques, reported clinical series have provided validation of these methods and have contributed further advances within the surgical community.

Born from these techniques and reinforced by enthusiastic surgeons, new surgical societies have been created, dedicated conferences have been held, and innovative techniques have been described. The compounding effects of these events have further strengthened the evolving and growing field of lymphedema surgery. The timely nature of this compilation of chapters cannot be underestimated. The rapid rise in interest in the surgical treatment of lymphedema necessitates a comprehensive understanding of not only the surgical treatment options available, but also the nonoperative and diagnostic modalities used in the care of this patient population. Many of the world's authorities in their respective areas of expertise have made contributions to this textbook. With the vast experience treating these clinical conditions, the collection of authors provides a pragmatic and thoughtful approach that can be understood by all readers across all relevant specialties.

Principles and Practice of Lymphedema Surgery is structured in such a way as to provide the reader with an in-depth, practical knowledge of the disease process, nonsurgical treatment options, surgical treatment options, and scientific outcomes assessment. The intent of this logical, stepwise chapter list is to allow for the incorporation of treating patients with lymphedema into the clinician's practice.

Section I

In order to understand the basis of lymphedema surgery, one must appreciate the history, controversies, triumphs, and pitfalls of the specialty over previous decades. As history has a curious way of repeating itself, outlining these aspects of the specialty is important for the clinician to understand prior to incorporating lymphedema surgery. These principles and theories set the stage for the current understanding of the

physiologic principles and pathologic changes in the lymphedematous condition. In addition, laboratory investigation of this disease entity is discussed in detail as having a foundation in animal and molecular studies, thus allowing progression of ideas and innovation within the specialty. The chronic and dynamic state of lymphedema development is a complex process requiring an appreciation for the dynamic physiologic changes of vascular systems and in particular an appreciation of the lymphatic system, where chronic outflow obstruction leads to characteristic changes to downstream lymphatic vessels as well as fibrosis of vascular vessel wall and adipose tissue.

Section II

Crucial to the incorporation of lymphedema patients into one's clinical practice is a thorough understanding of the nonsurgical or conservative treatment options available. Nearly all patients will receive physiotherapy during the course of lymphedema treatment. What entails appropriate treatment for patients with various stages of disease? And, how do we ensure that maximal functional outcomes result from physiotherapy? Multiple forms and treatment protocols exist that can enhance the treatment process and the recovery of patients and these are outlined within this section.

Section III

A major contribution of this book is the detailed descriptions of the surgical treatment options for the treatment of lymphedema. In addition to lymphatic microsurgical techniques, excisional and debulking therapies are discussed in detail. Commonly employed techniques for later stage disease include the use of these excisional techniques to remove the lymphedematous tissue burden from the often overweight and bulky extremity. In addition, each vascularized lymph node flap commonly utilized today is discussed in a step-by-step method to allow for safe and effective flap harvest. Although many of these named flaps are used for various other reconstructive procedures, the composite nature and inclusion of vascularized lymph nodes require special consideration and dissection techniques to ensure successful and reproducible outcomes. Supermicrosurgical techniques are evaluated, including various methods for lymphovenous bypass and the technical aspects of these procedures. Also, important considerations for the evaluation of usable lymphatic vessels, appropriate surgical site selection, and choice of technique are reviewed to ensure consistent outcomes following lymphovenous bypass surgery. We are enthusiastic to have a vast collection of video contributions from various authors, which greatly enhances the overall quality of the textbook.

Section IV

Understanding how outcomes are assessed following lymphedema treatment is as important as the treatment itself. As lymphedema surgery continues to expand, a patient-centered approach to treatment planning will be instrumental to the growth and sustainability of the specialty. Although mastering surgical methods and nonsurgical treatment protocols are the foundation for ensuring successful outcomes, a systematic, standardized approach to outcomes assessment is crucial for a number of reasons. Objective conclusions are more easily determined, which can help to predict outcomes and generalize treatment protocols. In addition, standardized outcomes assessments are more easily reportable and valuable to the surgical community in order to further enhance the global development of lymphedema surgery. As knowledge and experience continues to expand, reported outcomes will be the benchmark used by others to justify the various treatment options available.

Summary

The surgical treatment options for lymphedema and worldwide clinical experiences are rapidly expanding. As this occurs, a comprehensive and structured compilation of focused chapters can provide clinicians with an organized and systematic approach to this group of patients. Descriptions of treatment options are greatly enhanced by detailed, step-by-step videos describing each procedure and many technical aspects surrounding each procedure. Altogether, each section can provide the clinician a thorough and comprehensive knowledge base to adopt lymphedema surgery into their practice.

SECTION 1

CONCEPTS AND PRINCIPLES

2 Clinical Surgery for Lymphedema: Historical Perspectives

WALDEMAR LECH OLSZEWSKI

KEY POINTS

- Lymphedema is caused by partial or total obstruction of lymphatic collectors.
- Lymphovenous shunts have their established position in therapy of lymphedema.
- Control of infection of lymphedematous tissues, innovations of optical devices, and improved design of fine surgical instruments and sutures contribute to maintaining patency of shunts.
- Debulking of lymphedema tissue mass with normal healing can be accounted for by control of infection with antibiotics, preoperative compression therapy and better knowledge of blood vascularization of skin at various limb levels.
- Postoperative therapy after lymphovenous shunting and debulking must be a combined modality of long-term penicillin, elastic support and intermittent pneumatic compression application.

Introduction

This chapter is taking us back to the historical period of the 1960s, when the first ever surgical lymphovenous shunts in humans for the treatment of obstructive lymphedema were performed by Olszewski and Nielubowicz in Poland. At that time, it was not easy to convince the vascular surgeons that this type of surgical procedure had a future. But dynamic lymphography delineating lymphatic pathways, new operating microscopes, and fine atraumatic sutures helped us to successfully perform the first five operations in patients with lymphedema of lower limbs after radiotherapy for uterine cancer. Our results allowed us to convince others. Today, lymphovenous shunts are carried out all over the world. In addition, studies of bacteriology and immunohistochemistry of lymphedematous tissues have allowed for improvements to debulking surgeries mitigating previously encountered complications such as skin necrosis and fluid leakage. Also, this chapter will discuss the latest trends in surgical treatments for lymph stasis, which are based on the current knowledge of anatomy and physiology.

Lymphedema of the limbs is characterized by increases in the volume of the extremity caused by the accumulation of tissue fluid, proliferation of fibroblasts and adipocytes, and excessive production of collagen. There are also increases in infiltrating immune cell mass. Bacterial colonization ensues as the result of an inadequate lymphatic clearance of microbes that routinely penetrate the palmar skin of the foot and hand. Under physiological conditions, capillary filtrate-tissue fluid flows into the lymphatics and is transported via the collecting lymphatic trunks to the blood circulation. The transported fluid volume for one lower limb ranges from 20 to over 200 mL during a 24-hour period.[1] Obliteration of the transporting lymphatic channels and sinuses of regional lymph nodes cause stasis of intercellular water, proteins, and migrating immune cells. Contractility of the lymphatics eventually disappears.[2,3] These alterations lead to tissue changes, such as hyperkeratosis, fibrosis, accumulation of tissue fluid/lymph under the epidermis, and occasionally lymphorrhea.[4] The most common complication of tissue fluid stasis is bacterial dermato-lymphangio-adenitis (DLA) and affects over 50% of patients.[5] Early on, there was no awareness of the progressive tissue changes in lymphedema leading to the development of elephantiasis. The accumulation of mobile fluid was considered the primary process in lymphedematous tissues.

The Importance of Lymphatic Fluid Outflow

For centuries, lymphedema was considered as an accumulation of excess water with proteins that should be treated by total excision of the diseased tissue or drainage procedures comprising various types of tissue flaps bridging the lymphedematous and healthy regions. Operations designed by Charles,[6] Sistrunk,[7] Thompson,[8] and Goldsmith[9] were widely practiced with rather unsatisfactory results. Commonly occurring events included: delayed wound healing, leakage of tissue fluid from the denuded surfaces, and chronic inflammation of the tissues with continued penetrance by environmental microbes.

The actual understanding of the mechanism of the development of lymphedema, based on contemporary human studies, drastically changed the surgical approach to lymphedema. Modern imaging techniques of the lymphatic vascular system (X-ray contrast lymphography, lymphoscintigraphy, near-infrared lymphography, computed tomography angiography and magnetic resonance imaging (MRI)) allowed for the discovery of spontaneous lymphatic

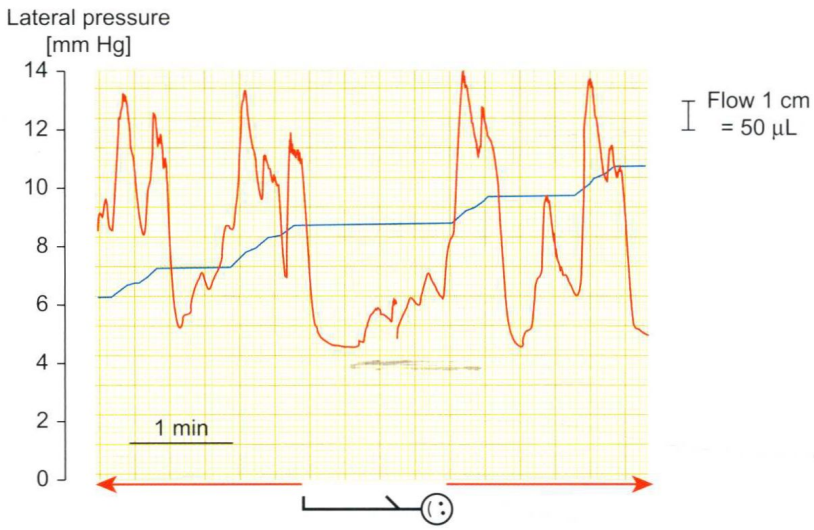

Figure 2.1 Lymphatic pulse in normal afferent lymphatics (red line) and lymph flow (blue line). One of the first-ever recordings in human leg lymphatics. Flow occurs only during spontaneous lymphatic contractions. This mechanism regulates fluid flow from tissues. Degeneration of muscle cells impairs contractility and subsequently lymph flow. Vessel patency and its contractility allow stagnant lymph to flow through newly constructed lymphatico-venous shunts. In the non-contracting lymphatics, flow can be generated by the intermittent pneumatic compression. Surgeons operating upon lymphatics often see lymphatic rhythmic contractility. (From Olszewski WL. Ann N Y Acad Sci 2002;979:52–63.)

contractility that is imperative for lymphatic flow (Figure 2.1),[2] visualization of stagnant tissue fluid, and evidence for the presence of bacterial flora in stagnant tissue fluid/lymph to be controlled by antibiotics (Figure 2.2).[5] These factors made it easier not only to re-design the old types of debulking surgery, but also to propose new procedures restoring lymph flow by microsurgical anastomoses.[10–13] Development of these techniques was further aided by improvements in the optics of operating microscopes and the production of ultra-thin atraumatic sutures. Additionally, long-term lymphangiographic observations highlighted the progressive and gradual obliteration of peripheral segments of collecting trunks after skin infections (erysipelas) and/or their proximal obliteration after lymphadenectomy, termed the 'die-back' phenomenon.[14] This prompted surgeons to surgically intervene earlier and perform anastomoses of patent fragments of collectors with the neighboring veins.

Debulking surgery, still indicated for millions of patients, has become more effective due to pretreatment with antibiotics suppressing colonizing microbes, which results in faster wound healing.[5] Moreover, antibiotic prophylaxis can protect distal limb tissues, deprived of lymphatic drainage from chronic inflammation.[5] High-efficiency diathermy scalpels facilitate tissue resection without using ligatures, which are frequently expulsed from the debulking wounds for months following surgery. Various types of external compression (bandages, stockings and intermittent pneumatic compression devices) have improved the long-term results of surgery, forcing tissue fluid to flow through newly formed pathways, either to veins or to non-swollen parts of the body.

Figure 2.2 Bacterial colonies of *Staphylococcus epidermidis* and *aureus* from a drop of lymph placed on hemoline plate. Stagnant lymph contains bacteria in most patients who suffered from dermato-lymphangio-adenitis (DLA) (cellulitis). These microbes might damage the microsurgical anastomosis. Long-term penicillin administration prevents outburst of DLA. Awareness of presence of bacteria in lymph is still limited.

Progress of Lymphedema Therapy in the Twentieth Century

The modern era of clinical lymphology and the development of treatment methods based on new knowledge of physiology of the lymphatic system dates from the introduction of oil-contrast X-ray lymphography in the 1960s. This imaging modality has set the stage for improved technologies leading to better imaging. There are several types of lymphedema including postinflammatory (postinfective), post-traumatic, and postsurgical oncologic. The indications and outcome of surgical procedures may differ with variable types of lymphedema.

LYMPH NODO- AND/OR LYMPHATICO-VENOUS MICROSURGICAL SHUNTS

The development of vascular microsurgery in the 1960s created a basis for designing lymphovenous shunts (LVS), mimicking the natural communications between lymphatics and veins.[10–13] The physiological principles of the operation

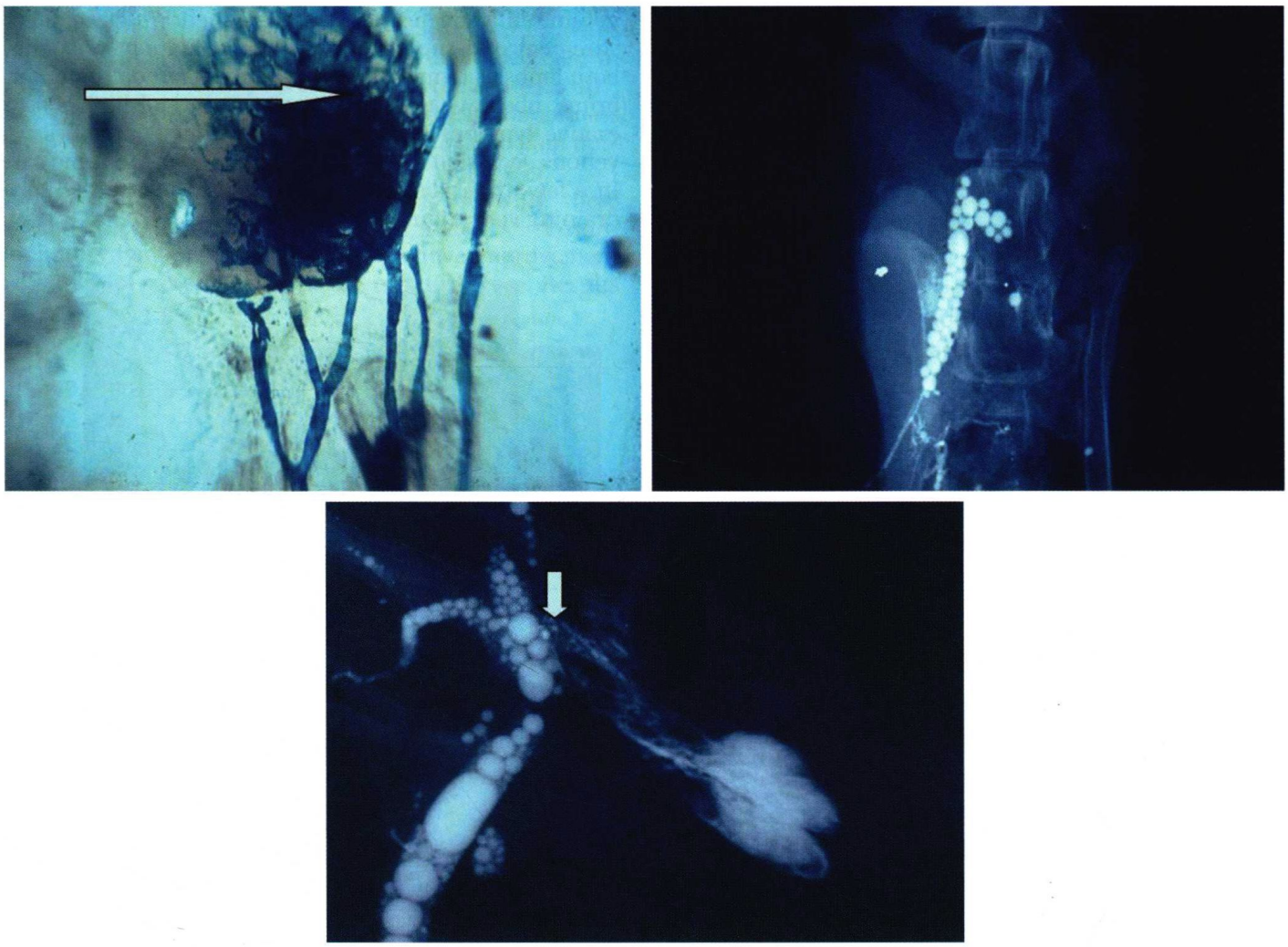

Figure 2.3 Canine mesenteric lymph node implanted into the interior vena cava. Oily contrast medium in the vein.[12] Such surgical shunts work in dogs for years. (From Nielubowicz J, Olszewski W, Machowski Z, et al. Pol Med J 1968;7:671–6.)

were based on observations of natural anatomical lymphovenous communications in the retroperitoneal space in animals and in humans in cases of obstruction of the thoracic duct. We observed that when the lymph node was cut transversely, lymph started oozing from the cortical sinuses (Figure 2.3). Such a node was implanted end-to-side into a window in the neighboring vein. The first operations were performed on dogs (Figure 2.3). The mesenteric lymph node was transected and its distal part with afferent lymphatics was implanted into the inferior vena cava. Lymph flowed freely into the vein because blood pressure in the vena cava was slightly negative at inspiration. These shunts, created in dogs, remained patent throughout their life.

In 1966, we carried out the first five operations of microsurgical lymphovenous shunts in humans, directing the stream of stagnant lymph of the lymphedematous lower limbs to the femoral vein.[10,11,13] The patients were women who developed obstructive lymphedema of the lower limbs after iliac dissection and radiotherapy of the pelvic region for cervical cancer. Surprisingly good results prompted us to carry out this type of operation in patients with other types of lymphedema of the lower limbs such as postinflammatory, posttraumatic and other "idiopathic" cases. Over time, various modifications of the lymphovenous shunt operations have been introduced and tried by us and other authors. Although difficult to accurately estimate, the numbers of these types of procedures are many thousands around the world. The worldwide experience in indications, technique, and results has been described abundantly in the literature.[15–40]

MICROSURGICAL INGUINAL LYMPHOVENOUS SHUNTS

Two types of shunts were primarily performed, the lymph node–saphenous vein (LNSV) and afferent lymphatics–saphenous vein (i.e., lymph vessel–saphenous vein, LVSV) (Figures 2.4–2.10).[10–13,15,32] The technique has been described previously in detail.[11–13,32] The most important factor remains the objective evaluation of results following these procedures.

POSTOPERATIVE EVALUATION AND RESULTS

In some patients, the following tests were done as a part of a research protocol: (a) time of appearance of radioactivity in the liver after Nanocoll webspace injection (less than 30 mins in a horizontal position), (b) decreased tissue fluid pressure in leg subcutaneous tissue measured with the use of the wick-in-needle method, (c) decreased volume of the interstitial space (postoperative intrasubcutaneous fluid