

SECOND EDITION

RECONSTRUCTIVE PLASTIC SURGERY

VOLUME SEVEN

THE LOWER EXTREMITY
THE TRUNK
THE GENITOURINARY TRACT

SECOND EDITION

RECONSTRUCTIVE PLASTIC SURGERY

*Principles and Procedures
in Correction, Reconstruction
and Transplantation*

VOLUME SEVEN
THE LOWER EXTREMITY
THE TRUNK
THE GENITOURINARY TRACT

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Editor

JOHN MARQUIS CONVERSE, M.D.

Lawrence D. Bell Professor of Plastic Surgery,
New York University School of Medicine

Assistant Editor

JOSEPH G. McCARTHY, M.D.

Associate Professor of Surgery (Plastic Surgery),
New York University School of Medicine

Editor, section on The Hand

J. WILLIAM LITTLER, M.D.

Chief of Plastic and Reconstructive Surgery,
The Roosevelt Hospital, New York City

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Reconstructive Plastic Surgery

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CONTRIBUTORS

TO VOLUME SEVEN

VINKO ARNERI, M.D.

Professor of Plastic Surgery and Specialist in General Surgery, Military Medical Academy, Belgrade. Director, Klinika za Plasticku Hirurgiju, V.M.A., Belgrade, Yugoslavia.

SHERRELL J. ASTON, M.D.

Assistant Professor of Surgery (Plastic Surgery), New York University School of Medicine. Assistant Attending Surgeon, Institute of Reconstructive Plastic Surgery, New York University Medical Center. Chief, Plastic Surgery Service, Veterans Administration Hospital, New York; Associate Attending Surgeon, Manhattan Eye, Ear and Throat Hospital, New York.

EARL Z. BROWNE, JR., M.D.

Assistant Professor, Division of Plastic Surgery, University of Utah College of Medicine. Surgeon, University Medical Center, Salt Lake City, Utah.

ROSS M. CAMPBELL, M.D.

Formerly Associate Professor of Clinical Surgery (Plastic Surgery), New York University School of Medicine, and Attending Surgeon in Plastic Surgery, Institute of Reconstructive Plastic Surgery, New York University Medical Center, New York.

BRADFORD CANNON, M.D.

Clinical Professor of Surgery (Emeritus), Harvard Medical School. Senior Consulting Staff, Massachusetts General Hospital, Boston, Massachusetts.

JOHN MARQUIS CONVERSE, M.D.

Lawrence D. Bell Professor of Plastic Surgery, New York University School of Medicine; Director, Institute of Reconstructive Plastic Surgery, New York University Medical Center; Director of Plastic Surgery Service, Bellevue Hospital; Consultant in Plastic Surgery, Manhattan Eye, Ear and Throat Hospital and Veterans Administration Hospital, New York.

DOUGLAS S. DAHL, M.D.

Assistant Professor of Surgery, University of Utah College of Medicine. Active Staff, University Medical Center, Salt Lake City, Utah.

JOSÉ DELGADO, M.D.

Clinical Associate Professor of Surgery (Plastic Surgery), New York University School

of Medicine. Associate Attending Surgeon, Institute of Reconstructive Plastic Surgery, New York University Medical Center, Bellevue Hospital, and Manhattan Eye, Ear and Throat Hospital, New York.

WALLACE M. DENNISON, M.D., F.R.C.S.(Ed.), F.R.C.S.(Glasg.)

Formerly Barclay Lecturer in Surgery of Childhood, University of Glasgow; Senior Surgeon and Chairman of the Division of Surgery, Royal Hospital for Sick Children and Surgical Paediatric Unit, Stobhill Hospital, Glasgow; Paediatric Surgeon, Royal Maternity Hospital, Glasgow, Scotland.

CHARLES J. DEVINE, JR., M.D.

Professor and Chairman, Department of Urology, Eastern Virginia Medical School. Chief, Department of Urology, Medical Center Hospitals, Inc. and DePaul Hospital; Active Staff, Children's Hospital of the King's Daughters, General Hospital of Virginia Beach, Bayside Hospital, and Chesapeake General Hospital, Norfolk, Virginia.

PATRICK C. DEVINE, M.D.

Professor, Department of Urology, Eastern Virginia Medical School. Director, Urology Residency Program, Medical Center Hospitals, Inc. and DePaul Hospital; Active Staff, Children's Hospital of the King's Daughters, Norfolk, Virginia; Consultant, U.S. Naval Hospital, Portsmouth, and Veterans Administration Center, Hampton, Virginia.

LEONARD T. FURLOW, M.D.

Clinical Associate Professor of Plastic Surgery, University of Florida School of Medicine. Attending Plastic Surgeon, Alachua General Hospital and North Florida Regional Hospital; Consultant in Plastic Surgery, Veterans Administration Hospital, Gainesville, Florida.

RALPH GER, M.D.

Professor of Surgery and Professor of Anatomy, Albert Einstein College of Medicine. Director of Surgery, Hospital of the Albert Einstein College of Medicine, Bronx, New York.

JOSEPH W. HAYHURST, M.D.

Clinical Assistant Professor of Plastic Surgery, University of Oklahoma College of Medicine. Director of the Microsurgery Unit, Presbyterian Hospital, Oklahoma City, Oklahoma.

HERBERT HÖHLER, M.D.

Chief of the Department of Plastic and Reconstructive Surgery, St. Markus Krankenhaus, Frankfurt am Main, Germany.

CHARLES E. HORTON, M.D.

Professor and Chairman, Department of Plastic Surgery, Eastern Virginia Medical School. Chief of Plastic Surgery, Medical Center Hospitals, Inc.; Consultant, DePaul Hospital and Children's Hospital of the King's Daughters, Norfolk, Virginia.

STEPHEN R. LEWIS, M.D.

Professor of Surgery and Chief, Division of Plastic Surgery, The University of Texas Medical Branch. Consultant, St. Mary's Infirmary and Galveston County Memorial Hospital, Galveston, Texas.

JOSEPH G. MCCARTHY, M.D.

Associate Professor of Surgery (Plastic Surgery), New York University School of Medicine. Associate Director, Institute of Reconstructive Plastic Surgery, New York

University Medical Center. Attending Surgeon, University Hospital, Bellevue Hospital, Manhattan Eye, Ear and Throat Hospital, and Veterans Administration Hospital, New York.

JOHN B. McCRAW, M.D.

Associate Clinical Professor of Plastic Surgery, Eastern Virginia Medical School. Attending Surgeon, Medical Center Hospitals, Inc., Norfolk, Virginia; Consultant to Public Health and U.S. Naval Hospitals, Portsmouth, Virginia, and Bethesda, Maryland.

FRED M. MASSEY, M.D.

Chief, Gynecologic Oncology, Wilford Hall U.S.A.F. Medical Center, Lackland Air Force Base, Texas.

JOHN CLARKE MUSTARDÉ, M.B., Ch.B., D.O.M.S., F.R.C.S., F.R.C.S.(Glasg.)

Clinical Lecturer in Plastic Surgery, University of Glasgow. Consultant Plastic Surgeon, West of Scotland Plastic Surgery Unit, Canniesburn Hospital, Glasgow; Royal Hospital for Sick Children, Glasgow; Ballochmyle Hospital, Ayrshire; and Seafeld Sick Children's Hospital, Ayr, Scotland.

KENNETH L. PICKRELL, M.D.

Professor of Plastic and Reconstructive Surgery, Duke University Medical Center. Consultant Plastic Surgeon, Veterans Administration Hospitals, Durham and Fayetteville, and Memorial Hospital, Greensboro, North Carolina.

IVO PITANGUY, M.D.

Professor of Plastic and Reconstructive Surgery, Catholic University of Rio de Janeiro. Chief, Plastic Reconstructive Unit, Santa Casa do Rio de Janeiro General Hospital, Rio de Janeiro, Brazil.

THOMAS D. REES, M.D.

Clinical Professor of Surgery (Plastic Surgery), New York University School of Medicine. Attending Surgeon, Institute of Reconstructive Plastic Surgery, New York University Medical Center. Visiting Surgeon, Bellevue Hospital; Chairman, Department of Plastic Surgery, Manhattan Eye, Ear and Throat Hospital, New York.

CLIFFORD C. SNYDER, M.D.

Professor and Chairman, Division of Plastic Surgery, University of Utah College of Medicine. Chief, Surgical Services, Veterans Administration Hospital; Chief, Plastic Surgery Service, Shriners Hospital for Crippled Children, Salt Lake City, Utah.

RICHARD BOIES STARK, M.D.

Professor of Clinical Surgery, Columbia University College of Physicians and Surgeons. Attending Surgeon in Charge of Plastic Surgery, St. Luke's Hospital, New York.

DONALD WOOD-SMITH, M.B., F.R.C.S.E.

Associate Professor of Surgery (Plastic Surgery), New York University School of Medicine. Surgeon Director, Department of Plastic Surgery, Manhattan Eye, Ear and Throat Hospital; Attending Surgeon, Institute of Reconstructive Plastic Surgery, New York University Medical Center; Visiting Surgeon in Plastic Surgery, Bellevue Hospital; Attending Surgeon, Veterans Administration Hospital; Consultant, New York Eye and Ear Infirmary, New York.

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Part Four

THE LOWER
EXTREMITY

CHAPTER 86

RECONSTRUCTIVE SURGERY OF THE LOWER EXTREMITY

BRADFORD CANNON, M.D.,

JOHN D. CONSTABLE, M.D.,

LEONARD T. FURLOW, M.D.,

J. W. HAYHURST, M.D.,

JOSEPH G. MCCARTHY, M.D.,

AND JOHN B. MCCRAW, M.D.

Closure of Defects of the Lower
Extremity by Muscle Flaps

Ralph Ger, M.D.

Closure of Defects of the Lower
Extremity by Myocutaneous Flaps

John B. McCraw, M.D.

The methods and principles of reconstructive surgery of the lower extremity are similar to those of reconstructive procedures elsewhere in the body. There are, however, certain unique anatomical characteristics of the lower extremities which may alter the standard reconstructive techniques. The anterior aspect of the tibia is covered only by a layer of skin with minimal subcutaneous tissue. Consequently a cutaneous defect of the pretibial area usually involves bone and does not provide a suitable bed for skin grafting. Another anatomical

characteristic is the pattern of vascular anastomoses around the knee which makes possible the use of undelayed direct retrograde flaps in this area. However, the absence of such anastomoses below the knee endangers the vascularization of local flaps in this area. Furthermore, arteriosclerotic changes in the elderly and diabetic angiopathic changes complicate lower extremity reconstructive procedures in these patients.

The lack of readily accessible sources of flap donor tissue requires special methods of trans-

fer, such as cross-leg, muscle, or microvascular free flaps. Newer reconstructive techniques have decreased the need for cross-leg fixation.

Another unique anatomical characteristic is the irreplaceable weight-bearing skin of the sole of the foot, which calls for special consideration in choosing tissue for repair.

Because of the dependent position of the legs, they require a longer period of protection and support for the healing tissues, a period considerably longer than that required in other parts of the body. Adjunctive measures such as leg elevation and wraparound dressings promote venous and lymphatic return. These special characteristics are but a few of those which must be considered when one is undertaking reconstructive procedures in the lower extremity.

The chapter is divided into two major sections: (1) reconstructive problems of the lower extremity, and (2) reconstructive procedures used in resurfacing cutaneous defects of the lower extremity.

RECONSTRUCTIVE PROBLEMS OF THE LOWER EXTREMITY

Reconstructive problems of the lower extremity can be divided into several categories which will be considered separately. Plastic surgical techniques frequently prove invaluable in dealing with many of the pathologic conditions involving the lower extremity.

1. Problems following *acute trauma* are the commonest and perhaps the most frequently overlooked. Trauma may produce damage or destruction to skin only (burn, avulsion, crush), may involve the skin and underlying soft tissues (deep burn, laceration, crush), or may involve soft tissues and bone with or without a break in the skin (deep burn, fracture, severe crush). *The restoration of an intact cutaneous covering is the primary surgical requisite following trauma of the lower extremity because deep healing can be no better than the surface covering.* Restoration of the surface as soon as possible after injury is essential to prevent further contamination, to avoid the development of infection and suppuration, and to lessen fibrosis and interference with local blood supply. Tension and hematoma formation jeopardize healing in a primarily closed wound. If an acceptable primary repair is impossible, delayed primary closure or skin transplantation by a graft or a flap may be required. Hueston and Gunther (1967) advocated the primary use of a cross-leg flap to achieve cutaneous coverage following trauma, especially when

there is associated major skeletal injury and loss of the tendo Achilles. Surgical methods of resurfacing traumatic defects are discussed later in the chapter.

2. Circulatory insufficiency (arterial, venous, and lymphatic) may result in chronic ulceration, edema, and other disabilities of the dependent lower extremities. These problems challenge the skills of the reconstructive surgeon.

3. Tumors of the lower extremities may be either benign or malignant. They present problems in reconstruction because of their location, because of associated involvement of osseous structures, and because of spread through the lymphatics to the regional lymph nodes. The types of tumors encountered include carcinoma, melanoma, lymphangioma, and hemangioma.

4. Osteomyelitis, either post-traumatic or hematogenous in origin, is often associated with extensive loss of the overlying soft tissue. Resurfacing the defect with a skin flap, in addition to curettage of the involved bone, is often required.

5. Congenital anomalies, such as supernumerary toes and syndactyly, require careful evaluation before reshaping of the foot in order to simplify the fitting of shoes and to prevent problems in walking. In patients with constricting bands, excision and revision of the scar are required to improve the circulation in the distal portion of the extremity.

6. Finally, there is a miscellaneous group of disabilities of the lower extremity which at one time or another require surgical reconstruction. These include the plantar wart, plantar callus, keratosis plantaris, neurotrophic ulcers, the ingrown toenail, and the sequelae of irradiation for benign or malignant disease.

Trauma

Trauma to the lower extremity may be of little consequence or may be of such magnitude that the healing of the deep tissues is temporarily or permanently impaired. The soft tissue repair must be constantly kept in mind and not treated lightly despite what may appear to be a minor injury. Failure of primary wound healing not only occurs in compound injuries with or without loss of skin but also complicates the open reduction of simple fractures if closure is attempted in the presence of significant subcutaneous or subfascial edema. Spontaneous rupture of the unbroken skin occurs occasionally if its circulation is impaired by tension.

Wounds of the lower extremity must be mar

aged like soft tissue wounds elsewhere on the body. There are no exceptions to the principles of debridement and closure of the wound.

A special type of lower extremity trauma is the avulsion injury in which a flap of skin and subcutaneous tissue is raised, usually in the pretibial region. The surgeon must resist the temptation to resuture the flap, as the major portion is destined to necrosis because of extensive soft tissue injury and intravascular sludging.

The safest course is to resect the major portion of the avulsed flap and apply split-thickness skin grafts to the defect (either immediately or after 24 to 72 hours), provided the recipient bed is suitable for skin grafting. Connelly (1973) proposed the following test to determine the viability of the avulsed flap:

1. Elevate the leg for one minute.
2. Inflate a tourniquet around the thigh.
3. Lower the leg.
4. Deflate the tourniquet.
5. The point to which the circulation (pink color) returns correlates with the future line of demarcation. The avulsed flap should be debrided to this line.

The treatment of acute thermal burns is discussed in Chapter 18. It should be reemphasized, however, that in circumferential full-thickness burns of the lower extremity, radical fasciotomy may be required to prevent circulatory embarrassment, and separate incisions of the individual compartments are necessary.

The management of frostbite is discussed in Chapter 19, and the techniques available for reconstruction of the cold-injured foot follow later in the chapter.

Bone Cavities. A deep cavity in bone is fortunately seen less commonly in civilian practice than in the military. The missile that penetrates the tibia below the knee joint and the bumper fracture, usually compounded in the upper portion of the tibia, are common causes. Throughout the full length of the tibia, however, there is a minimum of soft tissue available anteriorly for primary coverage, and if there is a loss of bone substance as well, additional tissue for filling the cavity may be difficult to secure. Many concave surfaces of the lower leg are temporarily closed by lining the bone cavity with skin grafts applied to the thinly granulating surfaces. The temporary skin dressing of the wound may suffice permanently if a sufficiently strong surrounding bony framework remains to ensure adequate bony strength for normal use. If minimal bone remains or if there is nonunion, bone grafting is indicated.

If an adequate local flap is available for the covering tissue, autogenous cancellous iliac bone chips may be used to fill the cavity. The temporary lining skin graft must be removed with care to eliminate every bit of epithelial tissue; residual epithelium may become a source of infection and destroy the transplanted tissue or may form a cyst, which becomes the site of recurring local infection. The completely denuded cavity is filled with the bone grafts and is finally covered with a skin flap as discussed later in the chapter.

Circulatory Disabilities

In the treatment of surface defects or cutaneous ulcers associated with venous, arterial, or lymphatic disease, correction of the underlying vascular disorder must be part of the therapeutic regimen.

Venous Disease. The commonest manifestation of circulatory disease with which the plastic surgeon is likely to be concerned is that of "varicose," "postphlebitic," "post-thrombotic," or "stasis" ulcers. These latter terms are used to distinguish more accurately the individual etiologies of similar lesions. Varicose ulcer is the oldest term, but it is incomplete, since only about 25 per cent of these lesions are due solely to the pathology of the varicose veins. Many ulcers have a definite history of antecedent deep thrombophlebitis and are therefore properly termed postphlebitic or post-thrombotic; this is not always the case, since ulceration may be due to incompetence of the deep veins or to varicose veins.

The essential factor in the development of these ulcers, regardless of whether the specific cause is varicose veins, deep thrombophlebitis, or silent venous thrombosis, is venous hypertension secondary to mechanical failure of the venous valves to support the venous blood returning from the extremity. It is now recognized that the critical factor in the return of venous blood to the heart from the legs, while dependent, is the pumping action of the muscles of the leg, which propels the blood of the deep venous system. The pumping action, however, is entirely dependent upon the integrity of the valves in the veins, and if these are destroyed, there is a retrograde backing up of blood in the superficial system, with relative local venous hypertension. If the incompetency of the valves is restricted to the superficial system (as in varicose veins), the deep veins will be unaffected. However, if there

is destruction in the perforating veins that connect the deep and superficial systems, there will be reversal of the usual flow in these vessels, and the "muscle pump" will add more blood to the already distended superficial veins rather than pushing it upward out of the limb.

Once the process of relative venous hypertension has been established, there are progressive secondary changes in the limb, including increased capillary permeability, local extravascular extravasation of red cells with consequent hemosiderin deposition, irritation of the subcutaneous tissues, and the formation of dense scar tissue over which the skin becomes at first atrophic, tender, and erythematous, then exceedingly thin and fragile, and finally ulcerated. The site of ulceration will be determined by the area of maximal venous insufficiency but is characteristically near or over the medial malleolus. As long as the basic venous abnormality is not corrected or controlled, the ulcers will usually persist, and even if they heal occasionally, they are subject to frequent recurrence.

TREATMENT OF THE CUTANEOUS DEFECT. Since the skin ulcers are the most obvious and distressing evidence of venous disease, therapy must be aimed at closure of these lesions. In most cases treatment of the venous insufficiency will result in a rapid spontaneous healing of the ulcers. External support in the form of elastic bandages or elastic stockings is generally sufficient to promote healing of the ulcer. Although surgical treatment of the incompetent veins can be accomplished in the presence of open ulcerations, it is preferable to delay definitive vein surgery until the ulcers are healed. The location of the ulcers, as well as the scarring and induration around them, usually prevents the successful treatment by excision and direct closure.

A split-thickness skin graft is the treatment of choice, in some cases, for a large unhealed ulcer after the area has been sufficiently prepared. Frequent dressing changes will generally provide sufficient preparation, and local chemotherapy, antibiotics, or enzymatic debriding agents are unnecessary.

If skin grafting is feasible, healing will be of a better quality than when the wound is allowed to heal spontaneously; the graft heals with a cushion of underlying dermis, in contrast to the thin, atrophic, and unstable scar epithelium that grows in from the edges of the wound and is always vulnerable to minimal trauma.

A thin skin graft is preferable, since the ulcer bed tends to be densely scarred and the potential for vascularization of the graft is often less than

ideal. Local or distant skin flaps are rarely indicated in venous disease of the leg, since satisfactory healing can usually be obtained without these more complicated methods.

Thompson and Ell (1974) have advocated the dermal overgrafting technique in covering venous ulcers (Fig. 86-1). They have stated that serial application of skin grafts on a venous ulcer bed will yield a firm and resilient cover (see Chapter 6).

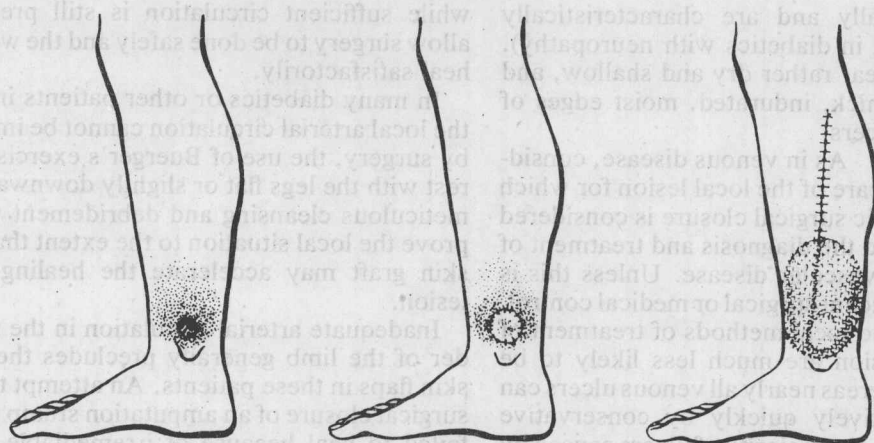
Any form of skin grafting requires complete bed rest for at least two weeks, with continuous elevation of the leg, and may eliminate the possibility of treating the ulcer on an ambulatory basis with adequate support.

Nearly all venous ulcers heal spontaneously if the underlying venous insufficiency is corrected by elevation or external elastic support or both. If the underlying venous insufficiency is not corrected, vascularized grafts fail to heal or break down as soon as the patient starts to ambulate.

DEFINITIVE SURGERY. In the very aged or poor risk patient, the healing of the ulcer with subsequent careful elastic support may represent the definitive treatment of the venous disease. In the majority of patients, however, closure of the ulcer—whether by elevation and bed rest, ambulatory treatment with firm support, or grafting—is only a preparation to more definitive surgery to correct the venous hypertension.

In patients with varicose veins alone, careful ligation and stripping of the long and short saphenous venous systems is generally sufficient. However, in those patients with incompetent perforating veins between the deep and superficial venous systems, it is also essential that these be divided (Linton, 1953; Cockett, 1955), if necessary, by designing a large skin flap and elevating the fascia over the muscles of the medial half of the lower leg to identify and ligate the connecting perforating veins. Occasionally such an extensive flap heals with some areas of necrosis. If the venous disease has been controlled, the skin flap heals satisfactorily, even if preoperatively it looks incapable of survival. It is important that the perforating vein or veins located characteristically directly under the site of ulceration be divided, and the surgeon should not hesitate to incise or dissect below the newly healed graft if necessary; otherwise, recurrence of the ulceration is almost certain.

Skin grafts placed over the dense scar of an old ulcer without further vein surgery do not remain healed; they do remain healed if the ulcer and scar are initially excised widely. Presumably, this is because incompetent veins are interrupted during the excision. Skin grafts placed

**VENOUS STASIS ULCER****STAGE 1. Operation**

Skin graft to ulcer.

STAGE 2. Operation 3 weeks later

Strip varicose veins.

Dermal overlay graft (extensive).

Ligation venous perforators of gaiter area.

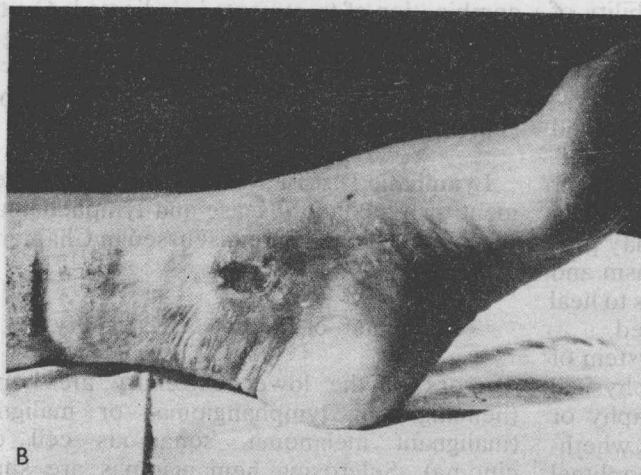


FIGURE 86-1. A, Technique of dermal overgrafting of a venous ulcer. B, Preoperative appearance of a varicose ulcer present for seven years. C, Appearance ten years after two dermal overgrafts, stripping of the varicose veins, and ligation of the perforating veins of the lower leg. (From Thompson, N., and Ell, P. J.: Dermal overgrafting in the treatment of venous stasis ulcers. *Plast. Reconstr. Surg.*, 54:290, 1974. Copyright © 1974, The Williams & Wilkins Company, Baltimore.)

over densely scarred ulcers survive indefinitely, provided that the underlying venous disease is controlled.

Arterial Disease. The causes of inadequate arterial circulation to the skin or to the extremities may be neurologic (exemplified by Raynaud's disease), obliterative, or obstructive. In most cases the sequelae of arterial insufficiency are not as well localized as in peripheral venous disease. Arterial disease is characterized by a progression from functional limitation of the extremity without pain (intermittent claudication) to pain at rest, atrophic skin changes, and finally superficial ulceration and gangrene.

These changes generally progress most rapidly at the most distant portion of the extremities. Diabetic arterial disease is peculiar in that there is extensive obliterative disease of the small end arteries without obligatory involvement of the major peripheral vessels. Consequently, gangrenous changes may be apparent in the presence of adequate pulses.

The distinction between ulcers due to venous insufficiency and those due to arterial inadequacy can usually be easily made, but both may occasionally be present at the same time. Ulcers caused by arterial insufficiency are usually accompanied by changes in the arterial supply elsewhere in the limb. They are generally lo-

cated peripherally and are characteristically painful (but not in diabetics with neuropathy). They often appear rather dry and shallow, and they lack the thick, indurated, moist edges of most venous ulcers.

TREATMENT. As in venous disease, considerations of the care of the local lesion for which grafting or plastic surgical closure is considered are secondary to the diagnosis and treatment of the underlying vascular disease. Unless this is subject to significant surgical or medical control, conservative and local methods of treatment of an ischemic lesion are much less likely to be successful. Whereas nearly all venous ulcers can be healed relatively quickly by conservative measures alone, the majority of ulcers caused by arterial insufficiency do not respond similarly. While venous hypertension can be eliminated by elevation of the limb, there is no equally good way of increasing local arterial circulation; in most cases in which the arterial blood supply has become insufficient to maintain the viability of the skin or of a digit, it will also not be adequate to support the healing of an incision or the vascularization of a skin graft.

Therapy aimed at improving arterial blood supply depends upon the etiology of the insufficiency. In cases of neurovascular disease or Raynaud's disease, medical treatment with a sympathetic block or sympathectomy may provide temporary relief of the arterial spasm and allow the skin lesions or amputation sites to heal spontaneously or be satisfactorily grafted.

In occlusive disease of the arterial system of the lower extremity, appropriate physical examination with or without arteriography or the Doppler flow meter generally shows whether the obstruction is proximal to the popliteal bifurcation. If the obstruction is in the small vessels of the arterial "runoff," surgical improvement of the arterial blood supply is more difficult. The latter situation is characteristic of diabetic arterial disease, in which the toes may become gangrenous in the presence of a palpable pedal pulse.

Depending on the site of the block in the arterial tree, various vascular reconstructive techniques, such as vein grafts or plastic prostheses and endarterectomy are available. When arterial circulation to the area showing insufficiency, gangrene, or ulceration is restored, healing will commence spontaneously and may be accelerated by split-thickness skin grafting of the ulcers. In many cases surgical improvement in circulation can be considered only as temporary. It may be important to lose no time in closing extensive ulcers with a graft or in performing a transmetatarsal or even higher amputation

while sufficient circulation is still present to allow surgery to be done safely and the wound to heal satisfactorily.

In many diabetics or other patients in whom the local arterial circulation cannot be improved by surgery, the use of Buerger's exercises, bed rest with the legs flat or slightly downward, and meticulous cleansing and debridement will improve the local situation to the extent that a thin skin graft may accelerate the healing of the lesion.

Inadequate arterial circulation in the remainder of the limb generally precludes the use of skin flaps in these patients. An attempt to effect surgical closure of an amputation stump that has failed to heal because of irremediable arterial insufficiency generally results only in further necrosis of previously viable tissue, and a higher level of amputation is usually required.

In patients in whom concomitant severe venous and arterial disease is present in a limb, a combination of treatments is indicated. Caution must be exercised in surgery of the lower leg for the control of venous disease if there is, concomitantly, inadequate arterial blood supply to support adequate wound healing.

Lymphatic Disease. The etiology and treatment of lymphatic disease and lymphedema of the lower extremity are discussed in Chapter 87.

Tumors of the Lower Extremity

Tumors of the lower extremity are benign (hemangioma, lymphangioma) or malignant (malignant melanoma, squamous cell carcinoma). Sclerosing hemangiomas are small, firm, subcutaneous nodules which are peculiar to the pretibial area. Lymphangiomas may involve the lower extremity and have been associated with constricting bands (Kitlowski, 1957). The treatment of hemangiomas and lymphangiomas is discussed in Chapter 65.

While wide and deep excision of melanomas has become the accepted therapy, the role of regional node dissection has generated considerable controversy (see Chapter 65). The bed of the resulting cutaneous defect is usually a muscle, which provides a suitable site for the application of a split-thickness skin graft.

Osteomyelitis

Osteomyelitis may be either acute or chronic and either post-traumatic or hematogenous in origin.