

Peripheral Arterial Surgery in 1980

By

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After more than two decades of rapid growth, with one advancement following another, peripheral vascular surgery has emerged as a specialty. Demand for this has been created by the prevalence of arteriosclerosis in the western hemisphere. Along with cancer and trauma, arteriosclerosis related deaths are high on the list in the United States when one looks at the mortality statistic. Occlusive disease involving the peripheral arteries constitutes a major share of this morbidity and mortality associated with arteriosclerosis. Although the amelioration of the arteriosclerotic process is not possible at this time, prolongation and improvement in the quality of life is being clearly achieved. Ingenious surgical procedures aside, a plurality of technologic advances have made the evaluation, treatment and followup of these patients simpler, painless, and cost effective. This article will attempt to cover briefly the existing state of the art and scan future horizons in peripheral arterial surgery. (Table 1).

Peripheral Arterial Aneurysms

Indian healers described "swelling and pulsations" in blood vessels thousands of years ago. John Hunter in 1786 described an operation for a popliteal artery aneurysm. More than a century ago Sir Astley Cooper ligated the abdominal aorta of a patient with a leaking aneurysm. Within the last two decades, the surgical treatment by resection or bypass has changed the prognosis of aneurysms entirely. Aneurysms

Table I Summary of Progress

A. DIAGNOSTIC	B. THERAPEUTIC
<u>X-Rays</u> —B Mode	<u>Surgical</u> —Extra Anatomic Bypass
Ultrasound	—Newer Grafts
—CT Scan	—Better Suture
—Selective Angiography	—Microvascular
	—Perioperative Care
	—In-Lay Technique For Aneurysms
<u>Biomedical</u> —Swan Ganz Catheters	<u>X-Rays</u> (Intervention Radiology)
—Noninvasive Arterial, Venous, And Cerebrovascular Evaluation	—Transcatheter Embolization For Hemorrhage
—Electromagnetic Flowmeter	—Percutaneous Transluminal Angioplasty
—Intraoperative Doppler	
	<u>Biomedical</u> —Fogarty Catheter
	—Auto Transfusions
	Drugs—Preventive Role of Aspirin

result from weakening of the media of an artery with stretching of collagen tissue and dilatation. Wall tension increases with an increase in diameter (Laplace's Law) ultimately leading to rupture. Although most aneurysms are arteriosclerotic in origin, trauma, syphilis, infection, and collagen disorders can also lead to aneurysm formation. Abdominal aortic aneurysms are the most frequent. Thoracic aortic, visceral arteries, renal, iliac, femoral, popliteal, subclavian, carotid aneurysms also occur.

Arteriosclerotic abdominal aortic aneurysms are the most important of these. Most are fusiform, infrarenal in location and occur in males beyond the fifth decade. About half are asymptomatic whereas the remainder present with abdominal or back pain, rupture, vague gastrointestinal complaints, extremity ischemia, distal atheromatous embolization, ureteral or nerve compression, spontaneous aorto enteric or aorto venous fistulae.

The natural history has been adequately studied(1). Autopsy statistics indicate that the rupture rate is about 25-30%. Bernstein has indicated that the growth rate is 0.3-0.4 cms per year in aneurysms less than six centimeters in size(2). Aneurysmal size is the most significant factor in deciding for or against surgery. The rupture rate is 16-18% in aneurysms less than 6 cms in size compared to over 40% in those larger than 6 cms. Rupture is seven times more frequent in hypertensive patients. Any patient with an aortic aneurysm larger than 4.5-5 cms should be surgically treated unless there are overriding medical contraindications. Physiologic age rather than chronologic age should be taken into consideration in elderly but functionally adequate patients.

Complete surgical resection of the aneurysmal sac was practiced in earlier years. The recent, technical step of leaving the aneurysmal sac intact including the posterior wall and simply inserting an artificial prosthetic graft inside the opened aneurysm has simplified the procedure enormously. After a midline abdominal approach, exposure of the aneurysm is obtained and systemic heparin administered. The aorta above and below the aneurysm is clamped, and the aneurysm incised. It almost always contains thrombus. A knitted or woven dacron graft is sutured to the proximal and then the distal aortic ends with nonabsorbable monofilament suture. The capability to autotransfuse the blood lost during surgery by sophisticated autotransfusion machines has substantially reduced morbidity from massive transfusions. This is particularly helpful in large thoracoabdominal aneurysms requiring reimplantation of the visceral and renal arteries into the dacron graft. Aneurysmal rupture is a cataclysmic event with a mortality rate of 100% if untreated and operative mortality greater than 50%. Immediate operation is advisable. The newer woven grafts have reduced intraoperative blood loss impressively.

Operative mortality for elective aneurysm resection has declined to 2-5% due chiefly to surgical technique, improved instrumentation, better blood banking facilities, etc. Surgical treatment has been shown to prolong life. Seventy-five percent of patients with untreated aneurysms are dead at five years. Following aneurysmectomy, 50% are dead at five years mainly due to coronary artery and cerebrovascular disease. In poor risk elderly patients, a new approach to the aortic aneurysm has been reported. This involves subcutaneous, prosthetic grafts from the axillary to femoral artery to provide circulation to the

legs(3). Then, the iliac arteries are ligated to precipitate thrombosis inside the aneurysm. The latter can also be induced by deposition of thrombin or bucrylate (a tissue adhesive) in the aneurysm through an arterial catheter.

Diagnosis by physical examination is made in 80-85%, by plain x-rays in 50-80% when calcification of a widened aorta is noted, and by arteriography in 80-90% of patients. However, noninvasive diagnosis has finally come of age. Newer grey scale B-mode ultrasound techniques are 95-100% accurate in identifying aneurysms. Computerized axial tomography (CAT Scan) has also been refined to the point of 90-100% accuracy. These methods are safe, painless, non-invasive, and can be repeated as often as desired.

Arterial Embolism

Embolism to the peripheral arteries occurs fairly frequently due to the increasing longevity of the population and high prevalence of arteriosclerosis. The heart is the commonest source of emboli (75-90%). Arteriosclerotic heart disease with chronic artial fibrillation is the common underlying basis, and has replaced rheumatic heart disease. Recent myocardial infarction is also a source for emboli in addition to cardiomyopathies and iatrogenic sources such as cardiac operations. Currently, attention has been focused on a previously unrecognized etiology. This is the so called "blue toe syndrome" and results from embolization of platelet aggregations and atheromatous material from the inside of major vessels or aneurysms to small vessels in the periphery.

The procedure of embolectomy has been revolutionized by the introduction of the Fogarty

balloon catheter in 1963. Embolectomy can now be performed under local anesthesia through a femoral arteriotomy for emboli distal to the abdominal aorta and through a brachial arteriotomy for upper extremity emboli. Intraoperative completion arteriography is advised to check for residual thrombo emboli. Embolectomy is not withheld even in delayed cases unless there is established rigor or gangrene. Obviously, for atheromatous debris embolism be it from arterial ulcer or aneurysm, the proximal source is surgically treated. The mortality rate following embolectomy has ranged from 10 to 41%; the underlying cardiac pathology accounting for most of the fatalities(4). A diligent search for the source of the arterial embolism is made postoperatively and a correctible lesion i.e. heart valve, proximal aneurysm, is surgically treated. Limb salvage rates of up to 90% have been reported(5), the amputation rate being reduced from earlier reports of 30% to 10-20%.

Cerebrovascular Surgery

Cerebrovascular surgery has shared in the advances in diagnosis and treatment made in the field as a whole. Transient ischemic attacks (TIA's) related to extracranial carotid or vertebro basilar occlusive disease remain the primary indications for vascular surgery in this area. It is now recognized that carotid territory symptoms may result from vertebro basilar occlusive disease. The natural history of transient ischemic attacks has been well documented and has provided for further impetus to corrective carotid surgery. Stroke secondary to cerebral infarction occurs in about 35-40% of patients with TIA's, half of these in the first year. Also becoming clear is the fact that most TIA's are related to embolic phenomena rather than isolated stenosis.

Until now, arteriography has remained the sole method for detection of carotid artery disease. The last few years has seen a myriad of non-invasive techniques applied to the detection of cerebrovascular problems. Biomedical engineering technology has made it possible to assess carotid artery disease in a safe, accurate, noninvasive, painless, and relatively inexpensive way. Personal experience with carotid phonoangiography (CPA) and oculoplethysmography (OPG) combined has been extremely favorable(6). The former utilizes a special microphone held over the neck through which the sound is transmitted to an oscilloscope and the picture photographed with a polaroid camera. This is used to evaluate carotid bruits. The OPG obtains ocular pulse tracings through small eye cups placed over the cornea. Internal carotid blood flow tracings and external carotid tracings obtained by clips placed over the ear lobes are recorded. A delay in the ocular pulse arrival time indicates a hemodynamically significant ($> 20\%$) internal carotid flow reduction. The overall accuracy of the two tests is 86% correlated with angiography. It is an excellent diagnostic tool in patients with nonhemispheric symptoms, in evaluating asymptomatic carotid bruits, in screening potential stroke victims, and in followup of patients post carotid endarterectomy. These techniques are still imperfect and caution is advisable on relying on these as the sole method for recommending angiography and operative treatment in symptomatic patients. Newer methods undergoing trial include B-mode ultrasound and continuous wave or pulse doppler carotid imaging.

Considerable controversy exists over the management of asymptomatic carotid bruits.

Recent evidence suggests that the incidence of TIA's is 30-37% and future stroke 15-18%, if these patients are followed for three to five years(7). In patients with asymptomatic carotid bruits and abnormal noninvasive tests, arteriography may be advisable so that carotid surgery can be performed as a prophylactic measure.

Carotid endarterectomy for TIA's and in selected patients for stable strokes and asymptomatic lesions carries an operative mortality of 1-2%. Serious morbidity from perioperative stroke is in the 2-5% range. Intraoperative means to prevent this occurrence of stroke includes the use of electroencephalography, intraluminal plastic shunt to maintain cerebral blood flow, internal carotid stump pressure measurements etc. Technically, the carotid bulb is opened and removal of the diseased intima and some of the media is performed leaving a smooth surface. The artery is then sutured with fine 6-0 suture.

A variety of extra thoracic bypass procedures are being utilized to treat occlusive lesions at the origin of the major aortic arch branches. Intra thoracic and transmediastinal approach carries some morbidity and mortality. The established patency rates of extrathoracic, extra anatomic bypass grafts such as axillary to axillary artery subclavian bypass for occlusion of the innominate or subclavian arteries. Dacron grafts are usually utilized for this purpose. The graft is tunneled from one side to the other. Similarly, a carotid to subclavian artery bypass is performed to relieve the "subclavian steal" syndrome. (Fig. 1, Table 2).

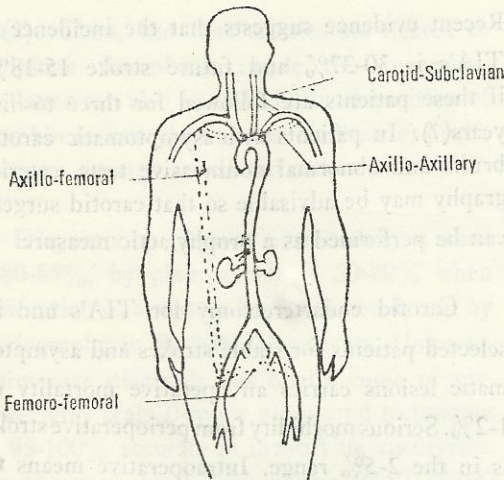


Fig. 1

The latest development is the application of microsurgery to cerebrovascular revascularization. In symptomatic patients with inaccessible intracranial lesions of the internal carotid or total occlusion, the ipsilateral superficial temporal artery is anastomosed to the middle cerebral artery to improve cerebral blood flow. The ultimate value and the indications for this procedure have not been clearly defined and randomized trials are now underway.

The role of aspirin in the prevention and treatment of patients with TIA's is being clarified. Multicenter trials are underway. Preliminary evidence suggests that it may reduce incidence of further TIA's and stroke in male patients.

Lower Extremity Arterial Disease

The arteriosclerotic process involving the infrarenal aorta and the distal vessels down to the tibial arteries is manifested by severe claudication, ischemic rest pain or tissue loss (ulceration/gangrene). Over half of the patients with

aortoiliac occlusive disease have femoropopliteal involvement as well. Objective evaluation in patients with lower extremity symptoms has been facilitated by doppler noninvasive pressure measurements. Similar to blood pressure in the arms, the pressure and waveforms over these arteries are recorded with a doppler and an EKG like strip chart recorded at various levels in the leg. These objective data are useful in the differential diagnosis of leg symptoms, quantitative assessment and correlation with symptoms, determining the level of arterial obstruction and in following patients on medical treatment or postoperatively. This has the advantage of being painless, noninvasive, avoids unnecessary arteriography and hospitalization.

Once a decision for surgical intervention has been made, arteriography is necessary to plan the type and extent of the procedure. In dealing with large vessels i.e. aortoiliac system, endarterectomy has declined in use and is only performed on patients with disease isolated to a small arterial segment. Usually an invested Y shaped graft made of dacron is inserted from

Table II Results of Common Vascular Procedures

Procedure	Operative Mortality	5-10 Yr. Patency
Elective Aortic Aneurysm	5%	> 95%
Ruptured Aortic Aneurysm	50%	> 90%
Aorto Femoral Bypass	3%	> 80%
Femoro Popliteal Bypass	2%	> 70%
Femoro Tibial Bypass	3%	> 50%
Aorto Renal Bypass	3%	> 80%
Carotid Endarterectomy	2%	> 90%
Axillo Femoral Bypass	2%	> 50%

the infrarenal aorta to common femoral and profunda arteries in both groins, effectively bypassing the diseased area. The operative mortality for this operation has decreased to 3% and longterm (five year) patency is in the range of 85-95%. With the increase in the number of poor risk patients being offered reconstruction for limb salvage, newer, less major procedures are now being performed. These are the so called "extra anatomical" bypasses, where grafts are placed in manmade locations. To bypass aortoiliac obstruction a graft from the axillary to the femoral artery is placed subcutaneously. If both iliacs are blocked then an extension graft is placed across the groin, deriving its blood flow indirectly from the axillary artery. If only one iliac artery is blocked in a poor risk patient, the other iliac is used as a donor vessel and a cross femoro-femoral bypass is constructed. There are many variations of the principle. These long, subcutaneous grafts have stood the test of time, although the patency rate is 50-70% in five years, which is somewhat less than the direct aortofemoral bypass. (Fig. 1, Table 2).

Insofar as femoropopliteal-tibial occlusive disease is concerned, bypass is performed for severe, disabling claudication or limb salvage. Sometimes, reconstruction of the profunda femoris artery alone is sufficient. Reversed autogenous saphenous vein is the undisputed material of choice, especially to the distal tibial vessels which are often no more than 2 mm in size. Bypasses can be performed from the femoral to the dorsalis pedis artery. About a third of patients will have unsuitable or previously stripped veins. Local breakthrough has been accomplished with grafting materials for this area. Dacron is not

used in this location. Human umbilical vein especially prepared with a dacron mesh covering is now being used. A further addition has been the availability of a new material, polytetrafluoroethylene (Goretex), a derivative of teflon. This is currently undergoing extensive use. Short term results are thus far satisfactory. The newer technique of percutaneous transluminal dilatation of narrowed arterial segments is being performed with good results. This exciting development promises to spare poor risk patients a major operation and longterm results are eagerly awaited.

Portal Hypertension

Alcohol related hepatic cirrhosis remains the chief cause of portal hypertension and bleeding esophageal varices in this country, followed by post necrotic and biliary cirrhosis. Hemodynamic evaluation of wedged hepatic and vena caval pressures and angiography of the superior mesenteric artery to visualize the portal circulation is helpful in determining the type of surgical procedure needed. Non-surgical treatment of bleeding esophageal varices is still preferred. Intravenous pitressin infusion and Sengstaken-Blakemore balloon tamponade are used initially. Sclerotherapy has experienced a rebirth and prospective trials are in progress to assess the longterm value of this technique. For bleeding varices unresponsive to these measures, various shunting procedures are available. The ports caval shunt has been replaced by the Distal Splenorenal (Warren) Shunt(8). This shunt is more physiologic, decompresses varices effectively and in randomized trials has shown to have a much lower incidence of encephalopathy, which was the achilles heel of the earlier shunts. In this procedure, the splenic vein is disconnected

from the portal vein and anastomosed to the left renal vein end to side. This decompresses the varices through the intact spleen via the short gastric vessels. Partial gastric devascularization is also carried out. Recent data by Warren indicate a less than 5% incidence of encephalopathy and a shunt patency rate of over 90%. For poor risk patients, those with ascites and where retrograde portal vein flow exists, a choice of shunts exists. Commonly performed is the superior mesenteric vein to inferior vena caval interposition dacron or autogenous jugular vein shunt. The earlier esophageal transection procedure for bleeding varices has been revived but in a much simpler form. Through a laparotomy, a stapling device is used to completely transect and automatically reconstruct the gastro-esophageal area. The longterm value of this procedure is still in question. The ultimate longterm prognosis of patients who continue to abuse alcohol after any shunt remains dismal.

Renovascular Hypertension (RVH)

The true incidence and pathophysiology of diseases of the renal vessels has only been appreciated in the last two decades, after the use of renal arteriography. RVH exists in approximately 5% of persons with high blood pressure. Absence of a family history of hypertension, onset of hypertension below 35 or over the age of 50 years, accelerated hypertension and an abdominal bruit are all suggestive of RVH. The two main causes of RVH remain atherosclerotic lesions and fibromuscular hyperplasia. An intravenous pyelogram remains the standard screening test and may show decreased renal size, delayed appearance of contrast, hyperconcentration, delayed washout and ureteral notching. Renal arteriography with newer image intensifiers remains the mainstay

in diagnosis and operative planning. Venous samples from both renal veins and the vena cava are analyzed for renin. A stenosis is functionally significant if the renal vein renin ratio is over 1.5 times as compared to the normal side.

For atherosclerotic obstruction of the renal artery, surgical procedures include endarterectomy, reimplantation, bypass or nephrectomy. Longterm results after endarterectomy or bypass of the offending lesion show a cured or improved state in about 80% of patients. Autogenous saphenous vein, dacron, or the newer grafts are used to bypass the stenosis, being attached to the aorta at one end and the renal artery beyond the stenosis at the other end. In obstructions involving a renal artery branch, microvascular work is being increasingly performed with or without autotransplanting the kidney lower down in the pelvis. Transluminal dilation with round metal dilators at surgery is used to dilate the multiple concentric narrowings associated with fibromuscular disease. Progress in radiologic techniques has made available transluminal dilatation of these stenoses by a percutaneously inserted balloon catheter through the femoral artery. This avoids a major surgical procedure. However, this method is new and longterm results are not yet available.

Hemodialysis

With an increasing pool of patients on hemodialysis for chronic renal failure, the vascular surgeon has had to devise innovative surgical techniques to deal with the problem. The primary standby remains the Brescia-Cimino radial artery to cephalic vein fistula at the wrist, performed with fine 7-0 suture. Where this is not possible or has failed, arteriovenous shunts,

shunts artificially created between arteries such as the axillary, brachial, radial, femoral, and adjacent veins have been constructed. These artificial conduits are then punctured with needles for chronic hemodialysis. Aside from autogenous saphenous veins, dacron, human umbilical vein, bovine carotid artery and other materials are being used. Complications in these artificial grafts still pose a formidable problem for the vascular surgeon.

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