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Surgery 4

Vascular Surgery

Edited by
P. R. F. Bell,
and
Nicholas L. Tilney

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Vascular Surgery

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Surgery

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Preface

Many books on vascular surgery have recently been published, as is perhaps inevitable in such a rapidly growing specialty. Although for many years vascular surgery has been part of general surgery, it is now emerging increasingly as a specialty in its own right, with appropriate fellowship programmes for which aspiring trainees must compete. Indeed, the subject is burgeoning as the population ages, peripheral arteriosclerosis becomes more prevalent, and as reconstructive procedures and techniques become more refined and approaches more bold.

In addition, while this branch of surgery becomes an increasingly demanding technical exercise, there are many associated areas of knowledge that must be understood by the modern vascular surgeon. In this volume we have tried to explore subjects of current interest and controversy, and to discuss areas of possible future expansion. The authors, all of whom have had considerable experience in each of their subjects, have set out their views in detail while comparing them with the methods of others. Each chapter is accompanied by a comprehensive and current list of references which can be used for more extensive study.

Although the volume is not meant to be all comprehensive, we have tried to cover a variety of topics which should be within the spectrum of knowledge of the vascular surgeon, including such subjects as the use of drug therapy in peripheral vascular disease and beginning specialties such as percutaneous angioplasty. We have included a final speculative chapter which tries to outline what we can expect from vascular surgery in the future.

We would like to thank our contributors for their efforts in producing this book and for making our task relatively easy and very interesting.

P. R. F. Bell
Nichols L. Tilney

1
Which vascular investigations are really necessary?

D. Charlesworth

My brief is to discuss those investigations which are necessary to good clinical practice in vascular surgery, and throughout I will try to make a clear distinction between those investigations which contribute to the management of a particular patient and those which are done for the purpose of research. Research is essential to good practice in surgery and good research involves precise measurement and careful analysis of the data. If we are to compare one treatment with another, or our own results with those of others, it is essential to define precisely what type of patients (claudicants, pregangrene) are to be compared and to eliminate or quantify all variables other than those under test. This involves clinical measurement, and the distinction between what is necessary to the proper management of the individual patient and what is desirable for the purpose of research is often blurred. It has become common practice in many places to measure non-invasively as many 'parameters' (variables) as possible in every patient in the hope that when the results are reviewed in retrospect the appropriate data will be available. Unfortunately, the roles of data collection and decision making have become reversed and it is not uncommon to find units in which patients are investigated in a 'vascular laboratory' before seeing a clinician. The clinician is then presented with a data sheet which purports to give the diagnosis and not infrequently indicates the treatment. This is neither good medicine nor good research.

A clinician faced with a patient whose symptoms suggest some dysfunction in the peripheral vascular system has several problems to solve and, in order to reach a balanced decision, he needs information. The information required to make the decisions can, in most instances, be elicited by a careful examination and a thorough enquiry into the history of the symptoms. Armed with this information the clinician must ask himself, 'Are the symptoms due to peripheral vascular disease and, if they are, Which arteries are affected?' In the majority of patients there is sufficient clinical evidence for him to answer these questions. The clinician must then choose the appropriate treatment. For some patients this may amount to nothing more than observation, whilst in others it may involve a complex and technically difficult reconstruction of the peripheral arteries. In either event the clinician needs precise objective information to check the patient's prógress. If he decides that the most appropriate treatment is surgery then he needs information, on the basis of which he can choose the most suitable operation. What information is necessary and the weight one can place on the evidence varies according to the site of the arterial obstruction and is probably best illustrated by various examples.

Consider the following examples of common clinical problems:

(1) Intermittent claudication
(2) Rest pain and pregangrene
(3) Abdominal aortic aneurysm
(4) Cerebrovascular disease.

INTERMITTENT CLAUDICATION

The majority of patients give a history of pain on exercise which is sufficiently typical in its distribution to make the diagnosis clear cut, but there are others in whom the symptoms are imprecise or confusing and the clinician needs additional information to make the diagnosis. In some patients the symptoms may be clear but physical examination is normal and at variance with the history. Further information is needed to make the diagnosis. One or a combination of the following may help.

Ankle/arm pressure ratio

The ratio usually calculated is that of the systolic pressure at the ankle to that in the arm. Similar ratios can be calculated from measurements of systolic pressure in the thigh and below the knee. It is now recognized that the systolic pressure at the ankle alone is a useful indication of the severity of disease in the arteries of the leg. The ankle/arm pressure ratio exceeds 1 in normal people and a low score indicates disease in the great vessels of the leg.

Measurements made at intervals after a period of ischaemic exercise provide better information. The shape of the pressure ratio/time curve can be interpreted as typical of one block or two, but the information cannot be used to localize an occlusion with certainty. The method is particularly suited for use in a clinic when the problem is to discriminate between normal and abnormal.

Plethysmography

A variety of transducers may be used but the principal is the same: the change in volume of a limb when the veins are suddenly occluded is proportional to the arterial input. Originally the volume of the limb was measured, but changes in circumference, weight and electrical impedence have also been measured. The process can be automated to give a flow/time curve and, in all instances, flow is measured in ml/min/100 mg tissue. The information is useful for diagnosis but is insufficiently quantitative to make it a useful test of progress. Plethysmography has been used to estimate mean flow in the calf as a way of quantifying 'run off' but the information is of little help. In patients with an occlusion of the superficial femoral artery, mean flow in the calf when the subject is at rest is similar to that in normal people. Any change in mean flow is due to the proximal occlusion and hence the method cannot be used to measure 'run off'. It is only after exercise that differences which can be measured with certainty occur. The information is qualitative and does not always correlate with claudication distance.

Ultrasound velocity wave-form analysis

Analysis of ultrasound signals can provide a great deal of information about the major arteries in the legs. Essentially they are velocity vs. time wave-forms and can be obtained non-invasively. Changes in the shape of this wave-form caused by the damping effect of arteriosclerosis and by the reflection of pressure waves can be interpreted by pattern recognition. This is particularly applicable to the interpretation of the signals from the arteries of the lower leg because the wave-form has a reverse component which increases as more distal parts of the artery are insonated. The changes produced by arteriosclerosis are usually referred to as damping. The degree of damping can be assessed by calculating various indices from the outline of the wave-form. The correlation between the values of these indices and the degree of narrowing seen on arteriograms is not exact but a combination of wave-form analysis, comparison of the pulsatility at different points in the arterial tree (damping ratio), and a measure of the time taken for the pulse to travel a known distance (transit time), provide enough information for a clear distinction to be made between normal and abnormal.

How handicapped is the patient? This question can only be answered by the patient. There is little or no correlation between exercise tests and the patient's estimate of his exercise tolerance. What matters is that the patient finds his symptoms intolerable. There is a second related question, are the symptoms getting worse, better, or are they unchanged? Again the only information we have is the patient's history, exercise tests are unreliable and exercise tolerance has little to do with the extent of disease. The decision whether or not to advise operation is a purely clinical one.

However, if a surgeon advises his patient to have an operation he will need precise information to help him with his answers to subsequent questions.

(1) 'Which operation is most appropriate?'
(2) 'What are the chances of success?'

Success is difficult to define, but in this context it would mean complete cure of symptoms for 5 years or more, rather than the usual index of success, a patent bypass. The information is obtained from arteriograms. The technique of obtaining these is beyond the scope of this chapter but they are essential and there is as yet no reasonable alternative. However, interpretation is difficult and can be misleading. The surgeon needs to know three things:

(1) Where is the obstruction?
(2) What is the state of the arteries proximal to the obstruction, 'run in'?
(3) What is the state of the arteries distal to the obstruction, 'run off'?

Patients who complain of claudication may have a complete occlusion or a severe stenosis in the main artery of the leg:

(1) In the aorta or iliac arteries
(2) In the superficial femoral artery
(3) A combination of both.

In the case of patients with aorto-iliac disease no further information is needed but, if the superficial femoral artery is occluded, it is essential to know whether or not the aorto-iliac segment is functionally normal because impaired 'run in' reduces the chances of success. Arteriograms provide information about the topography of the vessels not about their function. No single test of the function of the aorto-iliac segment of the arterial tree is indisputably better than another, but it is generally agreed that arteriograms underestimate the degree of functional impairment in some patients. The question of which test is most reliable has been well reviewed and two tests provide useful information (de Morais and Johnston 1982; Aukland and Hurlow 1982).

(a) Measurement of the drop in pressure between the aorta and femoral artery and the response to an injection of papaverine
(b) Analysis of the velocity/time wave-forms obtained by insonating the common femoral artery by either (i) pulsatility index or (ii) Laplace transform analysis.

These tests supply useful information which, in conjunction with the arteriograms, helps the surgeon to identify impaired 'run in'.

'Run off' is difficult to quantitate. When the femoral arteries are blocked the constraint this imposes on flow in the lower leg is such that the influence of any disease in the tibial arteries is totally dominated by the block upstream. The problem of quantitating the 'run off' (i.e. the capacity of the downstream vessels to accept an increased rate of flow) is vital to the success of femorodistal bypass, but we can only make a rough estimate by counting the number of patent arteries distal to the site implantation of the bypass. It would be of inestimable value to a clinician if he could, on the basis of objective information, predict the outcome of the operation he contemplated. Systolic pressure at the ankle, the ankle/arm pressure ratio, and post-exercise pressure in the toe have all been tried. Results show that when aortofemoral reconstruction is carried out, patients with a high resistance in the leg fare worse than patients in whom the resistance in the leg is low (normal).

There is considerable overlap in the groups and it is difficult to be certain in individual patients. Of the various tests 'toe pulse reappearance time' is said to give the most reliable information.

PATIENTS WHO PRESENT WITH PREGANGRENE

The term pregangrene is difficult to define in scientific terms; whilst a strict definition is essential for purposes of research, clinical measurements are not essential to make the diagnosis in practice. For the purposes of research it is essential to define precisely what is meant by pregangrene or critical ischaemia (Bell *et al.*, 1982).

Essentially patients with pregangrene fall into one of two groups:

(1) Patients who have an occlusion in the superficial femoral and iliac arteries
(2) Patients who have an occlusion in the superficial femoral artery and its distal branches.

The site and extent of an arterial obstruction can be seen on arteriograms and appropriate treatment planned without further investigation, although some measure of the 'run off' into the foot would be helpful if a femorotibial bypass was contemplated.

ABDOMINAL AORTIC ANEURYSM

Patients who present with an aneurysm may pose several problems. The aneurysm may be small and confirmation of its presence is required, or one may be doubtful about its extent. Whether or not an abdominal aortic aneurysm extends above the renal arteries and into the chest is important because this type of aneurysm can now be resected by the Crawford technique.

Abdominal aortic aneurysms can be visualized by plain X-ray, angiograms, ultrasound and CAT scans but the vast majority can be easily felt and measurements of diameter provide little or no useful information other than for purposes of research.

CEREBROVASCULAR DISEASE

Patients who present with cerebrovascular disease present a particularly difficult set of problems. They may present with:

(1) A stroke
(2) A stuttering stroke/stroke in progress
(3) A prolonged but reversible neurological deficit
(4) A transient ischaemic attack
(5) An asymptomatic bruit heard over a carotid artery
(6) Symptoms which suggest the 'subclavian steal syndrome'.

The commonest presentation is with transient ischaemic attacks and because the symptoms are not always typical, the essential question is, Has the patient had a transient ischaemic attack or not? Small areas of cerebral ischaemia can be recognized on CAT scans but the diagnosis is essentially a clinical one. Transient ischaemic attacks in the cerebral hemispheres produce lateralizing signs which are readily recognizable but the symptoms and signs of cerebellar ischaemia are more protean. The next question a clinician must ask himself when confronted with a patient who has transient ischaemic attacks is, 'Is there any arteriosclerosis at the carotid bifurcation?' Most of the non-invasive tests distinguish normal from abnormal but have a grey zone between. The methods in question, usually referred to as the indirect tests, are based on measurements of intraocular pressure, the direction of flow in the supraorbital artery, damping of the velocity wave-forms in the internal carotid artery, and the time taken for flow waves to pass along the carotid arteries (transit time). They are relatively inexpensive and easily done and can be used to distinguish arteries which are stenosed (75% area) from those which are not, but they do not indicate the presence of minor degrees of stenosis or ulceration and they do not distinguish between stenosis and occlusion. Because half of the patients who have transient ischaemic attacks have a less than 50% stenosis in the carotid artery, these methods fail to identify many patients who are at risk. The clinician must now ask himself, 'What is the probability of this patient having a stroke?' Information about the degree of stenosis does not help to answer this question because the relationship between degree of stenosis and likelihood of stroke is not known.

The alternative is to employ a test which will identify perturbations within the flow on the assumption that such disturbances in flow are created by atheromatous plaques and ulcers which constitute strictures of less than 50% (area).

PHONOANGIOGRAPHY

Perturbations in flow within the carotid arteries cause vibrations in the wall of the artery which can be detected as sounds. The duration, amplitude and characteristic frequency of these sounds can be measured, but a stenosis of less than 50% (area) causes little, if any, turbulance (and hence vibration in the wall). The sounds are influenced by the degree of stenosis, velocity of flow and the compliance of the artery wall (Chapman and Charlesworth, 1981). In patients who have an audible bruit the approximate size of the stenosis can be calculated from frequency analysis of the sounds (break frequency) (Lees and Dewey, 1970).

Direct methods of interrogation by ultrasound are relatively simple. B mode scans of the arteries can be combined with spectral analysis of pulsed ultrasound signals recorded from discrete points within the lumen of the arteries but the apparatus has become extortionately expensive and the techniques of data analysis are very complex.

The direct tests have two advantages over the indirect tests: severe stenoses can be distinguished from occlusions, and perturbations in flow associated with minor degree of stenosis or ulcers can be detected. The addition of a computer to an ultrasound system makes it possible, using a fast Fourier transform, to carry out an analysis of the frequency spectra. Extremely sophisticated ways of doing these analyses are being developed and it is now possible to detect small disturbances of flow associated with irregularities on the walls of the carotid arteries. The changes in the ultrasound spectrum associated with disease at the carotid bifurcation are elevation of the peak systolic frequency and broadening of the frequency envelope, ('spectral broadening') (Breslau *et al.*, 1983). Computerized pattern recognition programmes have been designed, taking into account changes in velocity, frequency and spectral broadening, which allow quantitative analysis of the ultrasound signals. The aim, using these programmes allied to scanners which interrogate small discrete areas of flow, is to detect reliably ulcers in the walls which may be the source of emboli. If multichannel pulsed Doppler devices are used it is possible to plot mean velocity as an instantaneous function of time at sites within the carotid arteries. Asymmetry of these velocity profiles may prove to be a useful means of detecting irregularities in the walls of the arteries. As yet these methods are experimental.

If the symptoms and signs are unequivocal and indicate a lesion in the territory of the internal carotid artery, it is usual to proceed to an angiogram. Arch aortography has the advantage that all the branches of the aortic arch are visualized, but the disadvantage that definition is inferior to that which is obtainable by direct puncture of the carotid artery. A further disadvantage is that an image of the intracerebral circulation is not obtained. Neither method is infallible, particularly in those patients in whom there is an atheromatous ulcer rather than a stenosis. In patients with minimal disease up to one third of the angiograms may be misinterpreted, even when they are of good quality. It is possible to enhance the clarity of angiograms if the images of the bones and soft tissues are subtracted. This subtraction can now be done electronically and digital enhancement is so good that adequate images of the arteries can be produced after an intravenous injection of contrast medium. Digital subtraction angiography has been evaluated in several centres in the USA and has received enthusiastic reports (Turnipseed, Sackett and Strother, 1981; Little *et al.*, 1982; Eikelboom *et al.*, 1983). It compares well with other non-invasive methods used to interrogate the extracranial carotid artery and this seems to be its most useful application. It is, however, subject to the same drawbacks as conventional arteriograms and the overall accuracy of diagnosis is said to be about 90% for carotid artery examinations (Kempczinski *et al.*, 1983). Other non-invasive tests for carotid artery stenoses, Duplex scanning, periorbital ultrasound, oculoplethysmography, are equally accurate, particularly when used in combination, and the place of digital subtraction angiography is uncertain.

Ultrasound scans are as yet less reliable than angiograms and, in consequence, are used for screening rather than as an alternative to angiography.

In summary, patients who present with symptoms which are typical of transient ischaemia in the cerebral hemispheres usually go on to an angiogram. Patients who present with atypical symptoms or a bruit may have non-invasive screening tests. If the tests reveal a severe (75% area) stenosis, angiograms are done and a decision is made when all the evidence is reviewed.

WILL THE OPERATION WORK?

Quite apart from the evidence one can or would like to obtain about 'run in' and 'run off', other facts need to be taken into consideration, such as the results reported by other surgeons who have done a series of similar operations, but again there are problems.

Consider those associated with femorotibial bypass; it is not a recent innovation but interest in it has been revised recently. Most survival curves for this operation take the general form seen in *Figure 1.1*. There is an initial fall off followed by a more gradual decrease. The initial rate of failure represents errors of selection, i.e.

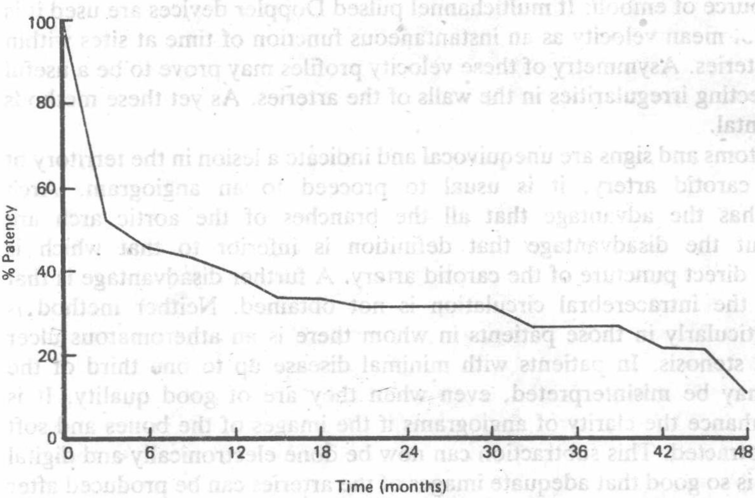

Figure 1.1 Cumulative patency rate for femorotibial bypass, the general form of the curve is shown without error bars or numbers. (Flattening off with time is commonly seen in graphs of cumulative patency and may be due to inadequate numbers)

the hydraulics of the bypass were such that the velocity of flow through the bypass was too low to prevent thrombosis. This is clearly a situation in which clinical measurements should be made with a view to reducing or eliminating these failures. In femorotibial bypasses, 'run off' into the foot is a primary determinant of success (*see Figure 1.2*) and in femoropopliteal bypass the same can be said of 'run off' into the leg. Some attempt should be made to quantitate 'run off' and, if it is inadequate, the surgeon may consider measures to improve it (arteriovenous fistula, or sequentitial bypasses).

It is obvious, when one considers these examples, how easy it is to stray from what is usually done, to what it is necessary to do (in an ideal world), to what can be done. The arguments in favour of the pursuit of a vigorously scientific approach to vascular surgery are undeniable, but it is equally certain that an experienced surgeon with an open and critical mind can achieve excellent results with little or no