Review Article

Angioplasty in peripheral vascular disease

J.F. Reidy

X-Ray Department, Guy's Hospital, St Thomas Street, London SE1 9RT, UK.

Development

Percutaneous revascularization as an alternative to surgery in the management of peripheral vascular disease was first described in 1964 but gained little acceptance.¹ In 1974 the development of a double-lumen balloon catheter by Grüntzig and others made the technique a much more practical and effective one that has subsequently gained widespread acceptance.² At first it was used in the peripheral arteries but soon extended to the renal and coronary arteries. In the 12 years since its introduction the technology of balloon catheters and the associated equipment has improved considerably. This in addition to the experience gained by radiologists has allowed the scope and range of angioplasty to be extended so that many more lesions can now be safely and effectively treated. Angioplasty techniques can be applied to such diverse lesions as branch stenoses of a renal artery or a distal tibial stenosis as well as to aortic and pulmonary valve stenosis. In this article the role of percutaneous transluminal angioplasty (PTA) in peripheral vascular disease only will be examined.

Pathology and mechanism of angioplasty

The original concept of angioplasty was that the atheromatous plaque was compressible and that with 'cold flow' it could be redistributed throughout the arterial lumen. Experimental and post-mortem work has shown a much more complex and disruptive effect.³ Longitudinal tears are produced in the intimal atheromatous plaque which may fragment. There is over-stretching and fragmentation of the media and elastic tissue that effectively increases the lumen of the artery by increasing the outer diameter of the artery. Subsequent to this localized and very disruptive trauma there is lysis and organization by macrophages and this is followed by neo-intimal formation and

collagen formation. This accords with the observation that the immediate post-angioplasty film may not look too impressive yet films at a later date demonstrate a good looking and tidy result.

Indications

The indications for PTA take into consideration both the clinical indications (which are the same as for surgery) as well as the technical consideration of whether the lesion is a suitable one for angioplasty. Clearly PTA is appropriate for a patient with severe claudication and a localized stenosis. Sometimes however angioplasty is less appropriate and associated with a lesser chance of success, e.g., when there is severe distal disease with a long femoral occlusion. If the patient is severely disabled by rest pain, and if surgery offers no reasonable alternative then angioplasty will be indicated even though it is less likely to be successful.

The ideal lesions for angioplasty are short localized stenoses particularly in the iliac arteries. Longer and diffuse stenoses, usually in the femoral arteries, are technically more difficult and the long term results will not be as good. With extensive and diffuse disease of the superficial femoral artery, bypass surgery would be the appropriate procedure. Occlusions, particularly in the femoral and popliteal arteries, can be recanalized and dilated but in general terms the primary success rate is lower with the longer occlusion. Ten cm has arbitrarily been taken as the upper limit for the length of occlusions that can be reasonably dilated but sometimes even longer occlusions can be successfully treated.

Limb-threatening ischaemia or intermittent claudication severe enough to limit the working ability or severely affecting a patient's lifestyle have been the clinical indications for surgery as well as for PTA. As patients become less tolerant of exercise restrictions and as angioplasty in early and localized disease is such a low risk procedure the indications are extending

Correspondence: J.F. Reidy, M.B., B.S., M.R.C.P., F.R.C.R.

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so that patients are tending to be investigated earlier. Whereas it makes little difference to the surgeon whether he bypasses a severe stenosis or an occlusion, the stenosis is a much more straightforward procedure for PTA compared with the occlusion that inevitably follows it.

The indications for angioplasty must always be weighed up against the severity of the clinical situation and the surgical alternative and contra-indications are often relative. An absolute contra-indication would be where there was recent occlusion perhaps on the basis of an underlying stenosis. In this situation either localized low-dosage thrombolysis or allowing the occlusion to become established and subsequently performing an angioplasty would be the appropriate procedure.

Advantages of angioplasty

A major advantage of PTA is that it is performed under local anaesthesia and thus no patient is unfit for the procedure. For most patients a short hospital admission of 24 to 48 hours is adequate and thus the whole procedure is extremely cost-effective compared with surgery.^{4,5} Particularly with iliac and femoral lesions the complication rate is very low and it would be very unusual for the patient to be worse following the procedure.⁶ If a femoro-popliteal bypass graft fails, it is very likely that the collaterals that existed around the stenosis or occlusion will have been disturbed by surgery doubly jeopardizing the limb. If PTA fails to recanalize such an occlusion then the collaterals will remain functional and undisturbed. A previous angioplasty procedure does not usually affect the consideration for subsequent surgery and if a patient has had previous surgery, provided there is an access point, usually the common femoral artery, there are no problems in performing subsequent angioplasty. If restenosis occurs following successful angioplasty, again provided there is no problem with the percutaneous access, the procedure can be repeated.

Technique

Investigation

Before arteriography it is not possible to predict definitely which patients will be suitable for angioplasty even with non-invasive techniques such as Doppler ultrasound. If arteriography demonstrates a lesion suitable for angioplasty, in many ways it is logistically much better to proceed to angioplasty. The advantages of this approach are that the patient only has one procedure and spends a shorter time in hospital at less overall cost. In addition a severe

stenosis shown on initial arteriography may sometimes progress in a short space of time to become an acute occlusion and thus be a much more difficult problem to deal with. A disadvantage of immediately going on to angioplasty is that it leaves little time for discussion with the referring physician or surgeon but this can be overcome by a good clinical understanding between the radiologist and the surgeon.

In peripheral vascular disease of the legs it is essential that all the arteries are adequately demonstrated.⁷ Sometimes tortuous and overlapping arteries may hide a localized iliac stenosis and oblique views and intra-arterial pressure recordings are needed to either confirm a significant stenosis or exclude it.⁸ Doppler ultrasound studies may give additional information and may save further arteriography. In addition, should the patient go on to a PTA procedure the initial Doppler study will serve as a baseline for the long-term evaluation of the angioplasty result. This may obviate the need for arteriography or alternatively may suggest at some future date restenosis and the need for further arteriography.

Angioplasty technique

In most instances the balloon catheter is introduced percutaneously over a guidewire in the femoral artery on the side of the lesion. In some circumstances the opposite femoral artery is used and the catheter is passed over the aortic bifurcation and down (the crossover technique). Rarely, an axillary or brachial artery approach is used. Before insertion of the balloon catheter it is essential to cross the stenosis or occlusion with a floppy tipped guidewire. Often with a stenosis this is straightforward whilst with a long occlusion it may be difficult or even impossible. Once the guidewire is safely across the lesion the deflated balloon catheter will follow but it is sometimes necessary to pre-dilate with a stiff and tapered catheter. The diameter and length of the balloon when inflated are chosen from measurements of the arteries on the arteriogram. The balloon is inflated by dilute contrast media so that the dilatation process can be monitored by X-ray screening and a pressure gauge is used so that the inflation pressure is controlled. Most stenoses and occlusions dilate easily with the pressure used (about 10 atmospheres). When the lesion has been satisfactorily dilated the improvement is sometimes confirmed by the abolition of a pressure gradient in proximal lesions or by taking post-angioplasty films. Most angiographers give some intra-arterial heparin (4,000–5,000 units) during the procedure. There is a tendency to use less heparin in the 24 to 48 hours post-angioplasty but when there is diffuse and severe disease it will usually be given (about 20,000 units/day). The use of long-term antiplatelet drugs such as aspirin and dipyridamole and

Figure 1 (a) This lumbar aortogram (via the left femoral approach) demonstrates bilateral iliac stenoses that are severe. Note the very marked collateral vessels that have developed. (b) The patient was restudied over 4 years later when he was found to have femoro-popliteal disease. Note that the common iliacs now show no evidence of disease.

their dosage is a confused subject and there are many different regimes.

Iliac angioplasty

Localized iliac stenoses are ideal lesions for angioplasty. Bilateral iliac stenoses are usually dilated at the same procedure and very proximal lesions at the bifurcation will be dilated simultaneously. Sometimes a significant iliac stenosis will be dilated prior to the surgery where there is a long femoral artery occlusion suitable for a bypass procedure.⁹ Occlusions are more difficult to safely cross with a guidewire and because of this the results are not as good as with stenoses.

Femoral and popliteal angioplasty

Usually an antegrade puncture of the common femoral artery on the same side as the lesion is employed. It may sometimes be very difficult to

catheterize selectively the superficial femoral artery rather than the profunda artery. Long stenotic segments and occlusions are more difficult to cross with a guidewire and on the whole occlusions longer than 10 cm have not been attempted. Early experience with the laser heat probe suggests that longer and more difficult lesions may be recanalized.¹⁰ Specialized small diameter balloons on smaller catheters are now available that allow angioplasty to be performed on small branch arteries below the knee.

Supra-aortic angioplasty

Only comparatively rarely is severe focal disease of the innominate, sub-clavian and axillary arteries associated with severe symptoms. Using the femoral approach these cases can be satisfactorily dilated. A very small number of carotid and vertebral artery stenoses have been dilated but most view such cases with great caution in view of the potential risk of small distal emboli.

Complications

Specific complications at the angioplasty site include dissection and perforation.¹¹ Even when these occur it is very unusual for the patient to be clinically any worse.⁶ Thrombosis and distal embolization are rare and rupture has only very occasionally been described. These latter complications may require surgical treatment. Localized stenoses show a very low incidence of complications whilst with extensive disease and occlusions they are more likely to occur. Stenoses in large arteries such as the iliacs will have a very low incidence of complications whilst with small branch stenoses below the knee there is a higher complication rate.¹¹

Invariably there is some haematoma at the femoral puncture site. This is sometimes quite large and very rarely will require a transfusion or some surgical repair. In addition the complications of any arteriographic procedure may occur at the puncture site.

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Results

With iliac stenoses primary success rates of around 95% have been described. Long term patency rates between 80–90% are described which are comparable with reconstructive surgery.¹² The initial success rate with iliac occlusions is less and in the region of 70%.¹³ Femoral stenoses that are localized show primary success rates comparable to iliac stenoses but with severe disease and occlusions this will be of the order of 80%. Long term patency rates of about 60–75% overall again make the results comparable with surgery.¹⁴

In the situation of very severe femoro-popliteal disease with severe ischaemic changes, success rates of only about 50% are to be expected. Often these patients with severe and limiting symptoms are unsuitable candidates for surgery and the only alternative to the salvage angioplasty is an amputation.