Role of Subintimal Angioplasty in the Treatment of Chronic Lower Limb Ischaemia

P. V. Tisi, A. Mirnezami, S. Baker, J. Tawn, S. D. Parvin and S. G. Darke

Departments of Vascular Surgery and Radiology, Royal Bournemouth Hospital, U.K.

Objectives: to determine the clinical outcome of subintimal angioplasty (SA) and to assess impact on surgical workload.

Design: retrospective review of a single radiologist’s case series.

Materials: one hundred and twenty two patients with critical limb ischaemia and 26 with claudication.

Methods: one hundred and fifty eight limbs treated by SA. Main outcome measures: technical success and complications; cumulative patency, limb salvage and survival; affect of SA on vascular workload.

Results: the technical success rate was 85%. There were 26 procedural complications (16%) but no patient required emergency surgery; 30-day mortality was 3%. Primary and secondary 12-month patency rates were 27 and 33%. Limb salvage rate was 88% at 12 months. SA initially reduced the number of patients needing arterial surgery, although this then increased due to late failure of SA and an increase in de novo bypass.

Conclusions: SA carries a low risk of major complications and high immediate technical success. Poor long-term patency suggests that SA is not as durable as bypass surgery. However, failed SA did not compromise subsequent surgery, which only became necessary in a proportion of patients. Our data suggests that there is little to be lost by using SA as first-line treatment for patients with limb-threatening ischaemia who are poor operative risks or who have no autologous vein available.

Key Words: Angioplasty; Peripheral vascular diseases; Ischaemia.

Introduction

The role of percutaneous transluminal angioplasty (PTA) for intermittent claudication remains controversial despite 35 years’ clinical experience. A recent Cochrane review concluded that angioplasty confers no clinical benefit for mild to moderate claudication.1 This summarised results from two randomised-controlled trials comparing angioplasty to exercise training.2,3 However, angioplasty continues to be used in an ad hoc way, in spite of increasing evidence suggesting that claudicants are best treated conservatively with anti-platelet therapy, cardiovascular risk reduction and exercise training.4

Critical limb ischaemia (CLI) has an annual incidence of 400 per million population in the U.K.5 By definition, treatment is needed for limb salvage. Frequently, patients present with diffuse femoropopliteal or infra-popliteal disease: the recent Trans-Atlantic Inter-Society Consensus document (TASC) concludes that these are best treated by surgery, where possible.6 However, surgery represents a physiological challenge to this, often frail group of patients. Subintimal angioplasty (SA), pioneered by the Leicester group in the U.K.7 can treat more complex disease patterns than conventional PTA, broadening the indications for endovascular treatment. Computer modelling has shown that angioplasty for ischaemic rest pain can increase quality-adjusted life expectancy and decrease lifetime treatment cost compared to surgery.8

However, several retrospective studies have shown that despite increased use of PTA, the rate of surgery continues to rise while the major amputation rate is unchanged.9,10 No series has included the effect of SA on clinical practice. The aim of this study was therefore to determine the clinical outcome of SA in our unit and to determine the impact on surgical workload.

Method

SA was introduced into clinical practice in this hospital in 1997. Diagnostic angiograms were reviewed at
the multidisciplinary vascular meeting. All cases potentially treatable by SA underwent this procedure, including those suitable for bypass surgery, but excluding lesions treatable by PTA. Data was extracted from a consecutive series of 166 limbs (156 patients) treated by a single interventional radiologist, including the learning curve. Eight patients treated with iliac SA were excluded from further analysis. The procedure was carried out using a standardised technique. Indications for treatment were CLI or lifestyle-limiting claudication. Hospital notes were reviewed retrospectively and patients were invited to re-attend for outpatient follow-up. Grading of limb ischaemia and angioplasty patency rates were reported according to the revised SVS/ISCVS criteria and the TASC document. For purposes of this study, claudication grades 1 to 3 were defined according to patient-reported walking distances of >250 m, 50–200 m and <50 m respectively. Short-term patency required an angiographic improvement (<30% residual stenosis), an increase in ankle-brachial pressure index (ABPI) by >0.1 and an improvement in clinical category. For tissue loss, this required complete ulcer healing. Long-term patency was defined as maintenance of both the improvement in clinical category and the increased ABPI (<0.1 below maximum post-angioplasty value). Duplex ultrasound was used to confirm patency if there was a reduction in ABPI. However, any deterioration in clinical status was considered as a treatment failure. All results were reported as intention to treat. Data was analysed using the life-table method and patency curves compared with the Mantel–Haenszel test.

Corresponding data on surgical and radiological workload for CLI between 1996 and 1999 was extracted from a prospectively gathered departmental database.

### Results

#### Subintimal angioplasty

One hundred and forty eight patients (55% men, 45% women) underwent SA between 1997 and 1999. The median (interquartile range (IQR)) age was 77.5 (70–82) years. Demographic data are shown in Table 1. Sixty-four patients (43%) were taking low-dose aspirin while a further 13 (9%) were intolerant of aspirin. All patients were prescribed aspirin after the procedure unless intolerant. Fifty-four patients (36%) had previously undergone intervention for lower limb ischaemia, including ipsilateral angioplasty in 26 cases and surgery in three cases.

There were 29 claudicant limbs in 26 patients (Rutherford grades 1 to 3) with a median (IQR) reported walking distance of 51 m (23–91). There were 129 limbs with CLI in 122 patients. One hundred and one limbs had tissue loss (Rutherford grade 5) with peripheral gangrene in six cases and ischaemic ulceration in the remainder. Twenty eight limbs had rest pain alone (Rutherford grade 4), while a further 51 had rest pain and tissue loss with a median (IQR) duration of 7 weeks (3 weeks to 4 months). The median (IQR) ABPI was 0.55 (0.40–0.66) with an absolute ankle systolic pressure of 80 mmHg (61–110).

Diagnostic angiography revealed 135 arterial occlusions and 12 stenoses, with no information available on 11 limbs. The median occlusion length was 10 cm (IQR 5–16, range 3–60). This was distributed in the femoro-popliteal segment in 122 (77%) and crural vessels in 36 (23%). According to TASC morphology lesions were graded as Type A in one limb, B in

<table>
<thead>
<tr>
<th>Smoking</th>
<th>Current</th>
<th>Ex-smoker &gt; 1 year</th>
<th>Non-smoker</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>37 (25%)</td>
<td>69 (47%)</td>
<td>34 (23%)</td>
<td>8 (5%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Insulin-dependent</td>
<td>Non-insulin dependent</td>
<td>Not diabetic</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>16 (11%)</td>
<td>27 (18%)</td>
<td>97 (66%)</td>
<td>8 (5%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Untreated &gt; 150/90</td>
<td>Treated</td>
<td>Normal blood pressure</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>18 (12%)</td>
<td>61 (41%)</td>
<td>60 (41%)</td>
<td>9 (6%)</td>
</tr>
<tr>
<td>Hyperlipidaemia</td>
<td>Untreated</td>
<td>Treated</td>
<td>Normal lipids</td>
<td>Not measured</td>
</tr>
<tr>
<td></td>
<td>8 (5%)</td>
<td>13 (9%)</td>
<td>42 (28%)</td>
<td>75 (51%)</td>
</tr>
<tr>
<td>Ischaemic heart disease</td>
<td>None</td>
<td>Unknown</td>
<td>Ischaemic heart disease</td>
<td>(Angina)</td>
</tr>
<tr>
<td></td>
<td>84 (57%)</td>
<td>8 (5%)</td>
<td>56 (38%)</td>
<td>33 (33)</td>
</tr>
<tr>
<td></td>
<td>6 (4%)</td>
<td>12 (9%)</td>
<td>(Myocardial infarction)</td>
<td>(Coronary artery bypass)</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>None</td>
<td>Unknown</td>
<td>Cerebrovascular disease</td>
<td>(Stroke)</td>
</tr>
<tr>
<td></td>
<td>108 (73%)</td>
<td>11 (7%)</td>
<td>29 (20%)</td>
<td>19 (19)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Carotid endarterectomy)</td>
<td></td>
</tr>
</tbody>
</table>

Figures shown are number (%) of patients (LVF, left ventricular failure; TIA, transient ischaemic attack).
36 limbs, C in 74 limbs and D in 41 limbs. There were three run-off vessels in 24 limbs (15%), two vessels in 49 limbs (31%), one vessel in 48 limbs (30%) and no run-off in 23 limbs (15%); there was missing run-off data in 14 limbs.

The site of entry into the subintimal plane and re-entry back into the vessel lumen is shown in Table 2. The technical success rate of the procedure was 85%. Of 23 technical failures, most were due to failed creation of a subintimal plane (n = 10) or failed re-entry back into the lumen (n = 7). The subintimal channel collapsed in four patients and immediately thrombosed in one patient. There was significant vessel perforation in three patients, leading to abandonment of the procedure. Nine technical failures required no further intervention while three proceeded to major amputation. Eleven patients subsequently underwent successful bypass surgery: one graft later occluded, requiring a below knee amputation at two months. The complication rate from the procedure was 0.18 (0.00 – 0.40). At 30 days, 21 limbs were normalised (asymptomatic with an ABPI > 1.0) and 43 limbs improved in both ABPI and clinical category. Twenty-six limbs showed either an improvement in ABPI or clinical category, and are therefore not strictly “patent” according to the SVS/ISCVS criteria.11

There was no change of clinical category in 47 limbs and a deterioration of ABPI or clinical category in 13 limbs. Overall, 30-day primary and secondary patency rates by strict criteria were 45 and 46% respectively.

Thirty-day mortality was 3% (four patients), all in technical successes. The cause of death was myocardial infarction (n = 1), cardiac failure (n = 1) and of uncertain aetiology (n = 2).

Follow-up

Patients were assessed by clinical and haemodynamic criteria. Those with an improved clinical category but a decrease > 0.1 in post-angioplasty ABPI were further investigated with Duplex ultrasound (n = 26) or angiography (n = 3). Cumulative primary and secondary patency rates according to the life-table method are shown in Fig. 1. Six patients were excluded from the life-tables because of missing data. There was an obvious attrition rate from 1 month onwards, with primary and secondary patency rates of 27 and 33% at 12 months. Patency rates in claudicants and those with CLI were not statistically different: primary patency 48% vs 24% at 12 months (Mantel-Haenszel, chi-squared = 3.60, p < 0.10) (Fig. 2); secondary patency 58% vs 28% at 12 months (chi-squared = 3.07, p < 0.10). There was no statistical difference in primary patency at 12 months in limbs with crural vessel disease (16%) vs femoro-popliteal segment disease (30%) (chi-squared = 1.74, p > 0.10). Run-off had no significant effect on patency rates. Primary patency at 12 months was 32, 21, 28 and 40% with zero, one, two and three run-off vessels respectively (Mantel-Haenszel chi-squared = 2.91, p > 0.10). Did the learning curve affect patency rates? The series was analysed according to “early” (1997–1998, 83 cases)

### Table 2. Site of entry into subintimal plane and re-entry back into vessel lumen (SFA, superficial femoral artery).

<table>
<thead>
<tr>
<th>Subintimal plane</th>
<th>Re-entry to lumen</th>
<th>Number of cases (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFA</td>
<td>SFA</td>
<td>18 (11)</td>
</tr>
<tr>
<td>SFA</td>
<td>Popliteal</td>
<td>76 (48)</td>
</tr>
<tr>
<td>SFA</td>
<td>Crural</td>
<td>13 (8)</td>
</tr>
<tr>
<td>Popliteal</td>
<td>Popliteal</td>
<td>7 (4)</td>
</tr>
<tr>
<td>Popliteal</td>
<td>Crural</td>
<td>26 (16)</td>
</tr>
<tr>
<td>Crural</td>
<td>Crural</td>
<td>18 (11)</td>
</tr>
</tbody>
</table>

![Fig. 1. Cumulative primary and secondary patency rates for subintimal angioplasty according to the revised SVS/ISCVS criteria. Numbers of limbs at risk at the beginning of each time interval are shown above the x-axis.](image-url)
and “late” (1999, 69 cases) sub-groups. Primary patency at 12 months was 20% in the “late” group and 32% in the “early” (i.e. learning curve) group (Mantel–Haenszel chi-squared $= 1.58$, $p = 0.10$). Seventeen patients (11%) underwent further late radiological intervention following failed SA, while 34 (23%) proceeded to elective surgery. There were no amputations in the claudicants. Despite poor patency in those with CLI, the cumulative limb salvage rate was 86 and 84% at one and two years (Fig. 3). Twelve month limb salvage was similar in both femoro-popliteal and crural segments (89% vs 85%) and “early” and “late” cases respectively (87% vs 89%). Fifteen patients (10%) required a major amputation during the study period. Seven patients underwent primary amputation, three in technical failures and four following reocclusion of a previously dilated segment. The remaining eight patients underwent surgical ($n = 7$ femoro-popliteal/distal bypass) or radiological intervention (repeat SA) before undergoing major amputation at a median 6 months following initial SA. Cumulative 2-year survival was 97% in claudicants and 60% in those with CLI. The single death in the claudicant group was due to a myocardial infarction at 30 days.

**Clinical workload**

Workload patterns for SA, PTA, bypass surgery and major amputation for chronic lower limb ischaemia are shown in Figure 4. Introduction of SA led to a slight decline in numbers of PTA and major amputations. There was a fall in surgical bypass procedures in the year after SA was introduced (1998) although in the following year numbers increased above baseline. This is a reflection of secondary reconstruction following failed SA ($n = 22$, 1999) but also an increase in de novo bypass i.e. patients who had not undergone previous SA ($n = 92$, 1999). This represents an increase in overall workload for chronic lower limb ischaemia, i.e. 114 cases in 1997, 151 cases in 1998 and 189 cases in 1999.

**Discussion**

Subintimal angioplasty attempts to overcome the problems of PTA by creating a smooth neo-lumen. The
In terms of workload, SA can reduce the need for early bypass surgery, although later surgery may be required to deal with late reocclusion of the dilated segment. The Leicester group have shown that 42.3% of patients with CLI can be treated with angioplasty alone, with a further 6.3% treated by a combination of bypass and angioplasty.21

In attempting to hone our own indications for SA, we now consider claudication to be a relative contraindication. Although our morbidity from intervention in claudicants was low, there were three technical failures, of whom two required elective bypass surgery.

In our experience, SA can be performed with good initial technical success and a low risk of major complications. It does not prejudice the success of surgery in the event of a technical failure or a subsequent occlusion. Despite poor patency, excellent limb salvage rates were achieved in patients with CLI, which supports the findings of several studies showing limb salvage despite unreconstructable disease or failed revascularisation.6 Some patients undoubtedly choose to persist with stable chronic ischaemic ulcers or rest pain rather than undergoing amputation.

In conclusion, fit patients with limb-threatening ischaemia can be offered either surgery or SA, as our results show that there is “nothing to lose” by using SA as first-line treatment. In the absence of a suitable venous conduit and in patients unfit for anaesthesia or with a limited life expectancy, SA may offer the best chance of avoiding a major amputation. In all cases, careful clinical judgement is required.

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References


