Primary vascular access in diabetic patients: an audit

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Abstract

Background. The increasing proportion of diabetic patients in the haemodialysis population, mainly elderly patients with diabetes mellitus type 2, is a challenge to nephrologists and vascular surgeons. The aim of this study was to assess different strategies in an effort to improve the commonly disappointing results of arteriovenous (a–v) fistula surgery in this group of patients.

Strategies. Besides the availability of a suitable vein, special attention was paid to the quality of the artery, based on clinical and recently available ultrasonographic parameters. In the case of peripheral arterial narrowing and/or calcification, the elbow region was the preferred location for creation of the first a–v fistula, taking into consideration the reduced life expectancy of the majority of diabetic patients. Furthermore, a clinical surveillance programme was established to treat the failing, not the failed fistula. To this end, elective revisions were performed prior to the onset of thrombosis to correct stenoses, aneurysms, and other signs of fistula dysfunction. Absolute priority was given to the use of native vessels.

Results. During the period January 1993 to December 1995, 347 primary Brescia–Cimino fistulae were performed out a total of 799 access procedures. No graft material was used in these first operations. The patients were followed up until 31 July 1998. Of these 347 patients, 269 were non-diabetic and 78 were diabetic. Two hundred and two of all 347 first a–v fistulae were created in the forearm/wrist region, 182 in non-diabetic patients and 20 in diabetic patients, whereas the elbow region was used in 145 patients, 87 in non-diabetic and 58 in diabetic patients. Based on the carefully planned choice of location of the first operation and the strategy of elective revisions, virtually identical results for non-diabetic and diabetic patients could be obtained with regard to revision and patency rates. Some differences were observed with regard to the types of revision.

Conclusion. A strategy is presented that helps to reduce the vascular access problems in diabetic and elderly patients.

Introduction

During the late 1970s, diabetic patients with end-stage renal failure were increasingly accepted for maintenance chronic haemodialysis. This concerned mainly younger patients suffering from insulin-dependent diabetes mellitus type 1. At that time the strategies for creating vascular access in diabetic patients were not different from those in non-diabetic patients: absolute priority was given to an anastomosis located at the wrist, despite occasional technical problems in suturing the vein to a calcified artery. This strategy, well established and accepted in non-diabetic patients, caused a high failure rate, especially early thromboses and low arteriovenous (a–v) fistula blood flow.

In an effort to improve the results in diabetic patients, two clinical observations that had been made in non-diabetic patients gave new directions for interventional strategies in diabetic patients:

(i) during revision of arteriovenous fistulae, it was noted that the feeding radial artery had dilated from approximately 2 mm to 4 or 5 mm, and this was confirmed by angiographic findings (Figure 1);

(ii) intraoperative and native X-ray findings revealed that arterial calcification was less pronounced in the elbow than in the wrist region.

These observations shifted the focus of attention from the veins to the arteries, particularly to the quality of the arterial wall and the diameter of the arterial lumen. The conclusion was that an atherosclerotic and calcified radial artery narrowed at the level of the wrist will deliver only a limited blood flow rate and will not undergo adaptive flow-mediated dilatation to deliver sufficient fistula blood volume—the prerequisite for venous dilatation and satisfactory blood flow.

This consideration led us to the idea of using the proximal radial artery or the brachial artery in the region of the elbow or the upper arm when constructing a first a–v fistula in the diabetic patient. The same proposal was subsequently also made by Adams et al. [1].

The choice between either the wrist/forearm or the elbow region was made after assessment of a variety of clinical parameters:
(i) medical history with regard to diabetes mellitus, peripheral ischaemia, hypertension, stroke, amputation, and other factors;
(ii) blood pressure measurements in both arms;
(iii) careful search for a suitable vein;
(iv) quality of the arterial pulses along the radial, ulnar, and brachial arteries;
(v) phlebography in some obese patients;
(vi) native X-ray of the arms to detect arterial calcifications (Figure 2);
(vii) ultrasonographic evaluation of the arterial and venous system in both arms including arterial blood flow rates.

Doppler/duplex investigation has recently become an essential part of the preoperative diagnostic procedure, providing information on diameter and wall structure of the blood vessels as well as arterial blood flow rates.

This strategy had been adopted empirically. To provide information on outcome we performed an audit and compared the functional results of first a–v fistulae in non-diabetic and diabetic patients including a rising proportion of elderly, type-2 diabetic patients in recent years.

Patients and methods

From January 1993 until December 1995 the author performed 347 primary Brescia–Cimino fistulae out of a total of 799 access procedures (43%). These patients were followed up until 31 July 1998 (mean follow-up 31 ± 19.3 months). Neither PTFE nor other synthetic or biological graft material was used to establish first a–v fistulae.

Among the 347 patients with primary Brescia-Cimino fistulae, 78 (22.5%) were diabetic patients, mainly type 2. In retrospect it was impossible to differentiate reliably between types 1 and 2. Table 1 shows the underlying renal diseases.

Mean age at placement was 57.8 ± 15.1 years in the non-diabetic and 62.3 ± 12.5 years in the diabetic group. The youngest patient was 10, the oldest was 93 years of age. The majority of patients were male. One hundred and twelve patients (41.6%) were female in the non-diabetic and 36
Table 1. Primary renal diseases

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes mellitus</td>
<td>78</td>
</tr>
<tr>
<td>Primary glomerular disease</td>
<td>78</td>
</tr>
<tr>
<td>Urological disease</td>
<td>35</td>
</tr>
<tr>
<td>Analgesic nephropathy</td>
<td>18</td>
</tr>
<tr>
<td>POLycystic kidney disease</td>
<td>30</td>
</tr>
<tr>
<td>Hereditary nephropathy</td>
<td>2</td>
</tr>
<tr>
<td>Congenital nephropathy</td>
<td>1</td>
</tr>
<tr>
<td>Vascular nephropathy</td>
<td>42</td>
</tr>
<tr>
<td>Systemic diseases</td>
<td>15</td>
</tr>
<tr>
<td>Miscellaneous and unknown</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td>347</td>
</tr>
</tbody>
</table>

Table 2. Age and gender of patients at the time of placement of the primary a–v fistula

<table>
<thead>
<tr>
<th>All patients</th>
<th>n = 347</th>
<th>Non-diabetics</th>
<th>n = 269</th>
<th>Diabetics</th>
<th>n = 78</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (years)</td>
<td>56.8</td>
<td>56.3</td>
<td>58.9</td>
<td>n = 199</td>
<td>n = 157</td>
</tr>
<tr>
<td>Female (years)</td>
<td>61.4</td>
<td>59.8</td>
<td>66.3</td>
<td>n = 148</td>
<td>n = 112</td>
</tr>
</tbody>
</table>

Patients (46.2%) were female in the diabetic population. Details are given in Table 2.

For analysis we compared diabetic and non-diabetic patients according to age, gender, access location, death, complication-free interval after the first operation (primary patency rate), thrombotic and non-thrombotic complications, rate and type of revisions, and use of PTFE graft material in case of revision.

Data were collected in a computer database and analysed with a professional statistical software package (SPSS 8.0; SPSS Inc.). Subgroups of patients were compared using the log-rank test. A P value of <0.05 was considered significant.

Primary patency rates were evaluated by life table analysis using the Kaplan–Meier method and calculated on the basis of the ‘first event’ after creation of the primary a–v fistula: first, the group of patients still living with functioning a–v fistula without revision at the end-point of 31 July 1998, and second, the date of the first revision due to any cause and the date when the patients were ‘lost’ due to death, renal transplantation, active closure of the a–v fistula in case of severe heart failure or steal syndrome, change to CAPD in some cases of fistula failure or according to the patient’s preference, change to an atrial catheter in case of unsatisfactory a–v fistula function or recovery of renal function with resultant cessation of maintenance haemodialysis. Patients lost to observation were considered as ‘censored’.

Perioperative aspects

The majority of access procedures were performed under local anaesthesia. Regional anaesthesia was chosen for more difficult and time-consuming access operations. General anaesthesia was required in a progressively rising proportion of severely ill and elderly patients with comorbidity.

Antibiotics were not used routinely. Only in high-risk patients, e.g. diabetic and elderly patients or those on immunosuppressive therapy, a single dose of an antibiotic was administered when a time-consuming revision or the insertion of graft material was planned.

We did not administer anticoagulants or antiplatelet agents on a routine basis. We believe that surgical errors cannot be corrected by pharmacotherapy.

Results

Site of primary a–v fistula

Two-hundred-and-two (58.2%) of the total of 347 primary a–v fistulae were created in the forearm/wrist region, i.e. in 182 (67.7%) of the 269 non-diabetic and in 20 (25.6%) of the 78 diabetic patients.

In 145 patients (41.8%) the elbow region was the primary choice, i.e. in 87 (32.3%) of the 269 non-diabetic and in 58 (74.4%) of the 78 diabetic patients. Amongst the patients receiving an elbow fistula, a Gracz fistula, i.e. an anastomosis using the perforating vein, was established in 38/87 (43.7%) of the non-diabetic and in 29/58 (50%) of the diabetic patients (Table 3).

Patient outcome

At the end of follow-up period as of 31 July 1998, 16 of the 78 diabetic patients (20.5%) were still haemodialysed with a primary or revised a–v fistula located in the same extremity, as were 120 of the 269 non-diabetic patients (44.6%). The course of the remaining 149 non-diabetic and 62 diabetic patients is shown in Table 4.

More diabetic patients had died, had been switched to CAPD, had undergone active surgical closure of the a–v fistula, or had received a permanent atrial single-lumen silastic catheter. More non-diabetic patients had received a renal transplant and more frequently a new vascular access had been created in the opposite arm. The highest mortality and the highest number of active closures of vascular access was found in diabetic patients with elbow fistulae (Table 5) presumably as a result of their high comorbidity.

Cumulative survival rates are shown in Figure 3. The median survival time was 33.9 months in diabetic patients, and actuarial survival was lower than in non-diabetic patients throughout the follow-up period of 67 months. Follow-up covered 895.5 patient-years at risk (mean per patient 2.6 years), i.e. 738 years for

Table 3. Site of primary a–v fistula

<table>
<thead>
<tr>
<th>All patients</th>
<th>Non-diabetics</th>
<th>Diabetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 347</td>
<td>n = 269</td>
<td>n = 78</td>
</tr>
<tr>
<td>Wrist/forearm</td>
<td>202 (58.2)</td>
<td>182 (67.7)</td>
</tr>
<tr>
<td>Elbow</td>
<td>145 (41.8)</td>
<td>87 (32.2)</td>
</tr>
<tr>
<td>Gracz a–v fistula (% of elbow a–v fistulae)</td>
<td>67 (46.2)</td>
<td>38 (43.7)</td>
</tr>
</tbody>
</table>

Percentages are shown in parentheses.
Table 4. Outcome at the end of the follow-up period

<table>
<thead>
<tr>
<th>Outcome</th>
<th>All patients</th>
<th>Non-diabetics</th>
<th>Diabetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living with a functioning access</td>
<td>136 (39.2)</td>
<td>120 (44.6)</td>
<td>16 (20.5)</td>
</tr>
<tr>
<td>Dead</td>
<td>121 (34.9)</td>
<td>79 (29.4)</td>
<td>42 (53.8)</td>
</tr>
<tr>
<td>Switch to CAPD</td>
<td>4 (1.2)</td>
<td>2 (0.7)</td>
<td>2 (2.6)</td>
</tr>
<tr>
<td>Renal transplantation</td>
<td>42 (12.1)</td>
<td>38 (14.1)</td>
<td>4 (5.1)</td>
</tr>
<tr>
<td>Active closure of vascular access</td>
<td>9 (2.6)</td>
<td>2 (0.7)</td>
<td>7 (9.0)</td>
</tr>
<tr>
<td>Change to permanent atrial catheter</td>
<td>11 (3.2)</td>
<td>7 (2.6)</td>
<td>4 (5.1)</td>
</tr>
<tr>
<td>Lost to follow-up</td>
<td>9 (2.6)</td>
<td>8 (3.0)</td>
<td>1 (1.3)</td>
</tr>
<tr>
<td>Recovery of renal function</td>
<td>1 (0.3)</td>
<td>1 (0.4)</td>
<td></td>
</tr>
<tr>
<td>New access contralateral arm</td>
<td>14 (4.0)</td>
<td>12 (4.5)</td>
<td>2 (2.6)</td>
</tr>
<tr>
<td>Total</td>
<td>347 (100)</td>
<td>269 (100)</td>
<td>78 (100)</td>
</tr>
</tbody>
</table>

Percentages are shown in parentheses.

Table 5. Outcome at the end of the follow-up period according to site of primary access

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Non-diabetics wrist/forearm</th>
<th>Non-diabetics elbow</th>
<th>Diabetics wrist/forearm</th>
<th>Diabetics elbow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living with a functioning access</td>
<td>77 (42.3)</td>
<td>43 (49.4)</td>
<td>8 (40.0)</td>
<td>8 (13.8)</td>
</tr>
<tr>
<td>Dead</td>
<td>59 (32.4)</td>
<td>20 (23.0)</td>
<td>7 (35.0)</td>
<td>35 (60.3)</td>
</tr>
<tr>
<td>Switch to CAPD</td>
<td>1 (0.5)</td>
<td>1 (1.1)</td>
<td>2 (10.0)</td>
<td>2 (3.4)</td>
</tr>
<tr>
<td>Renal transplantation</td>
<td>30 (16.5)</td>
<td>8 (9.2)</td>
<td>2 (10.0)</td>
<td>7 (12.1)</td>
</tr>
<tr>
<td>Active closure of vascular access</td>
<td>2 (1.1)</td>
<td>5 (5.7)</td>
<td>1 (1.7)</td>
<td>4 (6.9)</td>
</tr>
<tr>
<td>Change to permanent atrial catheter</td>
<td>2 (1.1)</td>
<td>1 (1.1)</td>
<td>1 (1.7)</td>
<td></td>
</tr>
<tr>
<td>Lost to follow-up</td>
<td>7 (3.8)</td>
<td>1 (1.1)</td>
<td>1 (1.7)</td>
<td></td>
</tr>
<tr>
<td>Recovery of renal function</td>
<td>1 (0.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New access contralateral arm</td>
<td>5 (2.7)</td>
<td>7 (8.0)</td>
<td>1 (5.0)</td>
<td>1 (1.7)</td>
</tr>
<tr>
<td>Total</td>
<td>182 (100)</td>
<td>87 (100)</td>
<td>20 (100)</td>
<td>58 (100)</td>
</tr>
</tbody>
</table>

Percentages are shown in parentheses.

Fig. 3. Cumulative survival rates comparing non-diabetic and diabetic patients.

Fig. 4. Primary patency rates comparing non-diabetic and diabetic patients.

non-diabetic (mean 2.7) and 157.5 years for diabetic patients (mean 2.0).

Primary patency rates were not significantly different between non-diabetic and diabetic patients (Figure 4). The median time to first event was 45.8 months for non-diabetic and 42.3 months for diabetic patients.

The primary patency rates of wrist/forearm and elbow fistulae were not significantly different in the

combined group of non-diabetic and diabetic patients and in diabetic patients (Figure 5).

Revisions

Incidence

In total, 146 revisions were performed in the 347 patients, i.e. an average of 0.46 revision per patient.
At the end of the observation period 237/347 patients (68.3%) still had a functioning a-v fistula without any revision. In the remaining 110 patients (88 non-diabetic and 22 diabetic patients), 146 revisions were necessary (117 and 29 respectively). In these patients, the rate of revisions per patient was 1.3 in non-diabetic and diabetic patients respectively (Table 6). The rate of revision for the total number of patients per group was

Table 6. Comparison of non-diabetic and diabetic patients according to need for access revision

<table>
<thead>
<tr>
<th></th>
<th>All patients (n=347)</th>
<th>Non-diabetes (n=269)</th>
<th>Diabetics (n=78)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without revision</td>
<td>237 (68.3)</td>
<td>181 (67.3)</td>
<td>56 (71.8)</td>
</tr>
<tr>
<td>With revision</td>
<td>110 (31.7)</td>
<td>88 (32.7)</td>
<td>22 (28.2)</td>
</tr>
<tr>
<td>Revisions (n)</td>
<td>146</td>
<td>117</td>
<td>29</td>
</tr>
<tr>
<td>Revisions per patient</td>
<td>1.33</td>
<td>1.32</td>
<td>1.33</td>
</tr>
</tbody>
</table>

Table 7. Revisions of all types of vascular access, wrist/forearm and elbow a-v fistulae; data given as revisions per patient-year at risk

<table>
<thead>
<tr>
<th>All types of vascular access</th>
<th>All patients</th>
<th>Non-diabetics</th>
<th>Diabetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient-years at risk</td>
<td>895.5</td>
<td>738</td>
<td>157.5</td>
</tr>
<tr>
<td>Revisions (n)</td>
<td>146</td>
<td>117</td>
<td>29</td>
</tr>
<tr>
<td>Revision per patient-year at risk</td>
<td>0.163</td>
<td>0.158</td>
<td>0.184</td>
</tr>
<tr>
<td>One revision during n patient-years at risk</td>
<td>6.1</td>
<td>6.3</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Wrist/forearm a-v fistulae

| Patient-years at risk        | 557.9        | 507.2         | 50.7      |
| Revisions (n)                | 79           | 75            | 4         |
| Revision per patient-year at risk | 0.142     | 0.148         | 0.078     |
| One revision during n patient-years at risk | 7.0       | 6.7           | 12.8      |

Elbow a-v fistulae

| Patient-years at risk        | 337.6        | 230.7         | 106.9     |
| Revisions (n)                | 67           | 42            | 25        |
| Revision per patient-year at risk | 0.198     | 0.182         | 0.234     |
| One revision during n patient-years at risk | 5.0       | 5.5           | 4.3       |
Table 8. Outcome at the end of the follow-up period. Comparison of non-diabetic vs diabetic patients and wrist/forearm vs elbow location of primary access

<table>
<thead>
<tr>
<th></th>
<th>All patients</th>
<th>Non-diabetics wrist/forearm</th>
<th>Non-diabetics elbow</th>
<th>Diabetics wrist/forearm</th>
<th>Diabetics elbow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without revision</td>
<td>237 (68.3)</td>
<td>122 (67)</td>
<td>59 (67.8)</td>
<td>17 (85)</td>
<td>39 (67.2)</td>
</tr>
<tr>
<td>One revision</td>
<td>82 (23.6)</td>
<td>47 (25.8)</td>
<td>19 (21.8)</td>
<td>2 (10)</td>
<td>14 (24.1)</td>
</tr>
<tr>
<td>Two revisions</td>
<td>22 (6.3)</td>
<td>11 (6)</td>
<td>6 (6.9)</td>
<td>1 (5)</td>
<td>4 (6.9)</td>
</tr>
<tr>
<td>Three revisions</td>
<td>5 (1.4)</td>
<td>2 (1.1)</td>
<td>2 (2.3)</td>
<td>1 (1.7)</td>
<td></td>
</tr>
<tr>
<td>Five revisions</td>
<td>1 (0.3)</td>
<td>1 (1.1)</td>
<td>1 (1.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>347 (100)</td>
<td>182 (100)</td>
<td>87 (100)</td>
<td>20 (100)</td>
<td>58 (100)</td>
</tr>
</tbody>
</table>

Percentages are shown in parentheses.

Table 9. Indications for first revision, non-diabetic vs diabetic patients

<table>
<thead>
<tr>
<th></th>
<th>All patients</th>
<th>Non-diabetics</th>
<th>Diabetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrombosis</td>
<td>35 (31.8)</td>
<td>33 (37.5)</td>
<td>2 (9.1)</td>
</tr>
<tr>
<td>Long-segment stenosis</td>
<td>22 (20.0)</td>
<td>21 (23.9)</td>
<td>1 (4.5)</td>
</tr>
<tr>
<td>Post-anastomotic stenosis</td>
<td>14 (12.7)</td>
<td>14 (15.9)</td>
<td>7 (31.8)</td>
</tr>
<tr>
<td>Peripheral ischaemia</td>
<td>10 (9.1)</td>
<td>3 (3.4)</td>
<td>1 (4.5)</td>
</tr>
<tr>
<td>Venous hypertension</td>
<td>5 (4.5)</td>
<td>5 (5.7)</td>
<td>1 (4.5)</td>
</tr>
<tr>
<td>Cannulation problems</td>
<td>5 (4.5)</td>
<td>4 (4.5)</td>
<td>1 (4.5)</td>
</tr>
<tr>
<td>Aneurysm</td>
<td>3 (2.7)</td>
<td>2 (2.3)</td>
<td>1 (4.5)</td>
</tr>
<tr>
<td>Superficialization of basilic</td>
<td>7 (6.4)</td>
<td>3 (3.4)</td>
<td>4 (18.2)</td>
</tr>
<tr>
<td>vein</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active closure of anastomosis</td>
<td>7 (6.4)</td>
<td>2 (2.3)</td>
<td>5 (22.7)</td>
</tr>
<tr>
<td>Infection</td>
<td>2 (1.8)</td>
<td>1 (1.1)</td>
<td>1 (4.5)</td>
</tr>
<tr>
<td>Total</td>
<td>110 (100)</td>
<td>88 (100)</td>
<td>22 (100)</td>
</tr>
</tbody>
</table>

Percentages are shown in parentheses.

the indications were correction of a steal syndrome or of cardiac failure secondary to a high fistula flow rate. Some differences were noted between non-diabetic and diabetic patients. While 33 non-diabetic patients (37.5%) underwent emergency first revision due to fistula thrombosis, this occurred only in two diabetic patients (9.1%), a rate per patient-year of 0.045 vs 0.013. Correction of post-anastomotic and long segment stenoses (typical first complications of wrist/forearm fistulae) was necessary in 35 non-diabetic vs only in one diabetic patient, i.e. 39.8 vs 4.5%, possibly because elbow fistulae were more frequently created to obtain initially a high blood flow in diabetic patients. In contrast, more diabetic patients required revision to correct a steal syndrome, i.e. seven diabetic vs three non-diabetic patients (31.8 vs 3.4%) or closure of a-v fistula, i.e five diabetic and two non-diabetic patients (22.7 vs 2.3%). This was necessary mainly because of symptoms of peripheral ischaemia. Correction of venous hypertension and of post-anastomotic stenoses was required only in non-diabetic patients.

Remarkable differences were observed according to the primary location of the a-v fistula: 63/110 patients undergoing a first revision had a wrist/forearm fistula and 47 a primary anastomosis in the elbow region. Fistula thrombosis was observed in 27 patients with a wrist/forearm (42.9%), but in only eight patients with a primary elbow fistula (17%), and the same was true for the long-segment and post-anastomotic stenoses (23.8 vs 14.9% and 20.6 vs 2.1%). It is not surprising that more patients with an elbow fistula required a first revision to correct a steal syndrome, i.e. seven vs three patients (14.9 vs 4.8%).

Repair of aneurysm, superficialization of the basilic vein in the upper arm, and active closure of the anastomosis were required in 17 patients (36.2%) with primary elbow fistulae, but was not necessary in the patients with wrist/forearm fistulae.

Analysis of the 35 thrombotic events leading to a first revision reveals that early thrombosis (<4 weeks) was observed only in one diabetic patient, i.e. 39.8 vs 4.5%, possibly was seen only in 7/347 patients, i.e. 2%, and in most cases poor veins had been noted during surgery. No diabetic patient suffered from early thrombosis. In the remaining 28 patients first revision was necessary to correct late thrombosis occurring between 1.9 and 46.6 months after creation of the first anastomosis (10 non-diabetic patients (31.8 vs 3.4%) or closure of a fistula, i.e five diabetic and two non-diabetic patients (22.7 vs 2.3%). This was necessary mainly because of symptoms of peripheral ischaemia. Correction of venous hypertension and of post-anastomotic stenoses was required only in non-diabetic patients. In the 202 patients with a primary wrist/forearm fistula, 27 patients had to undergo first revision to correct a thrombosis (13.4%) vs only 8/145 patients with an elbow fistula (5.5%). Early thrombosis (<4 weeks) was never observed in patients with a primary elbow anastomosis.

Of the 10 cases with steal syndrome necessitating revision, seven patients were diabetic and three non-diabetic. The interval between creation of the anastomosis and first revision ranged from 6.5 to 18.6 months for non-diabetic and from 4.2 to 26.9 months for diabetic patients. Three patients had a primary wrist/
forearm fistula (two non-diabetic and one diabetic patient), and seven patients had a primary elbow anastomosis (one non-diabetic and six diabetic patients); two of these had a Gracz type anastomosis (one non-diabetic and one diabetic patient).

A second revision was required in 28/347 patients (8.1%), i.e. 22 non-diabetic and six diabetic patients. The figures are too small for further analysis. It may be of interest to note that six thrombotic events were observed (21.4%) whereas eight patients underwent a second elective revision to correct a clinically relevant stenosis (28.6%). In five patients closure of the anastomosis was necessary; in four diabetic patients because of peripheral ischaemia and in one non-diabetic patient because of venous hypertension resulting from obliteration of the superficial veins beyond the level of the elbow. Three non-diabetic patients underwent superficialization of the basilic vein in the upper arm. There were variable indications for second revisions in the remaining single patients.

Six patients underwent three revisions, only one patient a fourth and fifth revision. Thus, an analysis will not give comparable results.

Prosthetic grafts were never used for creation of the first a–v fistula. Graft material, exclusively PTFE, was required in 12/347 patients (3.5%) respectively in 13/146 revisions (8.9%).

In the 110 first revisions, PTFE graft material was inserted in six patients (5.5%): in one patient an upper arm a–v bridge graft was required, in four patients segmental veno–venous insertion was performed using PTFE of variable length, and in one patient with peripheral ischaemia a banding procedure was performed using a PTFE cuff. In the 28 second revisions PTFE prosthetic material was chosen in seven patients (25%): in one patient with a long-segment veno–venous PTFE segment, thrombectomy was required, two patients received a graft in a–v position, and in four patients, venous stenoses/aneurysms were repaired by veno–venous insertion of a PTFE prosthetic graft segment (Table 10).

Discussion

Little attention has been paid in the literature to the special and demanding problem of vascular access in the diabetic haemodialysis patient. Initial reports emphasized the generally poor outcome of vascular access surgery. Adams et al. [1] reported disappointing results of wrist a–v fistulae when only 49 out of 101 attempts at a functioning wrist fistula were successful. A higher initial success rate was reported for antecubital fistulae; at this site 19 out of 26 fistulae were usable. Based on such reports many authors recommended and performed primary PTFE bridge fistulae in up to 80% of diabetic patients [2]. Windsu raises the sceptical question ‘if conventional wisdom states that primary arteriovenous fistulae are still the best vascular access option for haemodialysis, why do the majority of procedures involve prosthetic graft fistula placement?’ [3]. A similar opinion was expressed by Conlon and Schwab [4]. Leapman et al. [5] came to the conclusion ‘that the arteriovenous fistula is not a panacea for vascular access’ and ‘that diabetics and elderly individuals are particularly vulnerable to poor outcomes with the arteriovenous fistula, and other access devices should be considered for this group of patients on haemodialysis’. To counter such opinion, the NKF-DOQI Clinical Practice Guidelines for Vascular Access [6] stated that ‘primary a–v fistulae should be constructed in at least 50% of all new patients elected to receive haemodialysis as their initial form of renal replacement therapy. Ultimately, 40% of prevalent patients should have a native a–v fistula’.

We strongly disagree with the above negative attitudes. Based on the evidence presented above we conclude that a primary native a–v fistula can be created in virtually all diabetic patients. We emphasize that we were never obliged to use a PTFE graft to create a first fistula in a diabetic patient.

Having disposed of the myth concerning the necessity of synthetic grafts, we wish to address the issue of the site at which the primary a–v fistula should be created in a diabetic patient. Our initial attempts at creating primary wrist fistulae encountered major obstacles, i.e. high rates of early thrombosis and reduced blood flow rates secondary to inadequate venous remodelling and dilatation. This constellation pointed to the feeding artery as the culprit. The problems were compounded by the increasing age of the diabetic population and by the poor state of peripheral veins as a result of repeated previous blood sampling and intravenous therapy during preceding hospitalizations.

In 1977 Anderson et al. [7] measured the blood flow rate in surgically created a–v fistulae. He and subsequent authors [8] found a flow rate in the radial artery of 20–30 ml/min. This increased up to 200–300 ml/min immediately after creation of an a–v fistula, and after maturation reached flow rates up to 600–1200 ml/min. Obviously such high flow rates are not achieved when feeding arteries are atherosclerotic and possibly exhibit impaired vasodilatation secondary to endothelial cell dysfunction. The pattern of atherosclerotic lesions in diabetes mellitus is a centripetal one, peripheral arteries being more severely affected than more proximal ones. This led us to select the proximal radial and the brachial arteries in the elbow region as primary locations for the creation of an a–v anastomosis in the majority of diabetic patients. Such

| Table 10. Use of ePTFE prosthetic graft material during first and second revisions |
|-------------------------------------------------|----------|---------|
| Total                                           | 110      | 28      |
| A–v ePTFE graft                                 | 1        | 2       |
| Veno–venous ePTFE segment                       | 4        | 4       |
| Banding with short ePTFE segment                | 1        | 1       |
| ePTFE graft thrombectomy                        |          |         |
proximally located fistulae are only safe, however, if
the length of the anastomosis is restricted to about 4
or 5 mm, i.e. the approximate diameter of the bra-
chial artery.

On the issue of which vein to select for anastomosis,
the elbow region offers many veins capable of permit-
ting sufficient yet not excessive fistula flow, allowing
for gradual dilatation of the vein. Because cannulation
can be performed easily early on, we prefer the cephalic
vein if this is available.

I wish to comment on several points that are per-
tinent to the question of whether our results can be
generalized. All the above access procedures were
performed by one nephrologist, so that uniformity of
procedures was guaranteed.

Since our institution has a CAPD programme, the
proportion of diabetic patients, i.e. 78/347 (22%), may
not be representative of the entire population of dia-
betic patients, but selection for CAPD was based on
the criterion of anticipated difficulties with creating
vascular access only in a few patients. The great
majority of fistulae were created in the forearm/wrist region, but the proportion was considerably
less in diabetic patients. The elbow region was
primarily chosen in 32% of the non-diabetic and 74% of the diabetic patients. In 50% of these diabetic
patients, we adopted the Gracz procedure [9], which
offers several advantages: the anastomosis is buried in
the depths of the elbow region. Only the superficial
venous system is cannulated, thus reducing the risk of
accidental puncture of the anastomosis that is present
whenever the anastomosis is located subcutaneously
e.g. between the proximal radial artery and the cepha-
lic antebrachial vein or the brachial artery and the
initial portion of the basilic vein). We adopted a
modification of the original technique: the perforating
vein is cut before it enters the deep venous system.
This limits the length of the anastomosis to the di-
meter of the perforating vein, i.e. 3–5 mm. In most
cases the vein is anastomosed to the brachial artery.
Because of considerable interindividual topographical
variation, in some patients the proximal radial artery
or even the ulnar artery were used. Our positive
experience is in agreement with the results of Elcheroth
et al. [10].

Selection of the type of fistula must take into consid-
eration the reduced life expectancy of diabetic patients.
At the end of the follow-up period, only 20.5% of
diabetic patients were alive with a functioning primary
or revised vascular access in the same extremity, com-
pared with 44.6% of non-diabetic patients. If one
anticipates limited survival on haemodialysis, it seems
reasonable to create the vascular access in the elbow
region. This approach offers a higher delivered dose
dialysis and a better quality of life than failed, non-
maturing peripheral anastomoses. In the majority of
our patients with elbow fistulae, the first cannulation
of the superficially located cephalic vein was possible
within 2–14 days after the operation. We feel that
there is nothing mysterious about diabetic patients and
that the putative endothelial cell dysfunction does not
account for closure of the fistula. Indeed, the primary
patency rate was nearly identical in non-diabetic and
diabetic patients. This was true both for wrist/forearm
and for elbow fistulae.

Apart from fragmentary reports [11,12] which can
be criticized on several accounts, no information is
available with which we could compare our experience
concerning fistula revision, but the above results are
less catastrophic than anticipated by the uncontrolled
opinion of clinical nephrologists. Nevertheless, several
comments are appropriate.

Remarkably, no significant difference was noted
between non-diabetic and diabetic patients in the rate
of revisions per patient year at risk. Indeed, the lowest
rate of revision was found for diabetic patients with
wrist a–v fistulae. This may be due at least in part to
selection, because patients with anticipated poor arter-
ial inflow were selected for primary elbow fistulae. This
low rate is remarkable in view of the results of Sands
and Miranda [13], who reported 3.6 revisions per
patient year at risk because of thrombosis of PTFE
bridge grafts.

Recently Schwab [14] reported that 80–85% of all
access complications and failures are secondary to
thrombosis. In our experience amongst the 110 patients
with first revisions, only 35 patients (32%) had throm-
bosis. If one assumes that early thrombosis is often
due to surgical problems, it is of particular note that
only seven (2%) of the 347 non-diabetic and diabetic
patients had an early thrombosis, i.e. within the first
month, and this was seen only in non-diabetic patients.
No diabetic patient had early thrombosis of primary
wrist or elbow fistula. In the latter cases, the greater
diameter of the vessels and the higher blood flow rate
may protect against thrombotic occlusion. Late throm-
bosis causing first revision occurred in only two of 78
(2.6%) diabetic patients.

Major indications for elective first revision were
clinical signs of fistula dysfunction (‘failing fistula’),
e.g. post-anastomotic and long-segment stenoses of
forearm veins. This was less frequent for elbow a–v
fistulae. If forearm anastomoses are created with tiny
veins, injury to the perivenous nutritive tissue and/or
pre-existing injury to the vein may prevent adaptive
dilatation of the vein, create a low-flow situation, and
predispose to thrombosis and stenosis.

In view of the high rate of peripheral atherosclerotic
arterial lesions it is not surprising that the first revision
due to peripheral ischaemia had to be performed more
frequently in diabetic patients, and this was particularly
seen in high-flow elbow fistulae. This complication
arose in 9% of diabetic patients. Repair of aneurysms,
superficialization of the basilic vein in the upper arm,
and active closure of the anastomosis were not neces-
sary in any diabetic patient with a wrist/forearm fistula,
but there was a definite risk in patients with primary
 elbow fistulae.

A second revision was necessary in 28/347 (8.1%),
22 non-diabetic and six diabetic patients. Six patients
underwent three revisions, only one patient a fourth
and fifth revision. These figures are too small to permit any generalized conclusion.

No prosthetic grafts were used to create first a–v fistulae. Subsequently graft material (exclusively PTFE) was required in 12/347 patients, respectively in 13/146 revisions.

Absolute priority was given to the patients’ native vessels whenever possible. In our opinion, there is no indication for the primary insertion of PTFE bridge grafts in patients with poor arterial and venous vessels. Bridge grafts require an excellent arterial inflow and an excellent venous outflow. Otherwise complications will set in soon. In our experience a superior strategy is to increase first the diameter of the feeding artery and of the draining vein by creation of an a–v anastomosis, followed by conversion into a bridge graft in a second-step procedure, as published by Kheogane et al. [15]. On the other hand PTFE material, when used in veno–venous situations, permits great flexibility in the repair of aneurysms and stenoses. In any case, the well-known increased risk of infection in prosthetic grafts argues for restricted use of graft material, especially in diabetic patients, but we acknowledge that the PTFE graft material helped to solve some problems in our patients.

In conclusion, we emphasize that creation of vascular access in diabetic patients remains a continuous challenge for the vascular surgeon and the nephrologist.

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