Perioperative noninvasive hemodynamic ankle indices as predictors of infrainguinal graft patency


Of 129 femoropopliteal bypasses, 40 closed in 0 to 42 months. Early and late closures were not predicted by pre- or postoperative ankle/brachial pressure index (ABPI) or ankle pulse volume recording amplitude (APVR) or their increments (Δ). Of 141 femorotibial bypasses, 60 closed in 0 to 12 months, with 46 closing early (<1 month). Early failure occurred in 19 of 52 limbs (37%) with pre-ABPI <0.2 and 17 of 89 limbs (19%) with pre-ABPI >0.2 (p < 0.025). Similar significant differences in early patency occurred between limbs with pre-APVR <5 and >5 mm (29 of 94 [34%] vs. 7 of 47 [15%], respectively). Late closure was not predicted by either value. Thus in the 44 limbs with pre-ABPI >0.2 and pre-APVR >5 mm, only 11 grafts closed (25%), whereas if pre-ABPI was <0.2 or pre-APVR <5 mm, 49 of 97 grafts (51%) occluded within 17 months (p < 0.025). Postoperative or Δ indices had no predictive value. Preoperative ABPI <0.2 or APVR <5 mm was associated with twice the risk of early femorotibial graft closure; however, cumulative life-table patency was still 39% at 24 months. (J VASC Surg 1985; 2:307-11.)

Despite the large experience with femoropopliteal (FP) and femorotibial/peroneal (FTP) bypasses, there still remains some difficulty in the prediction of the eventual patency and clinical success of such procedures.

Perioperative noninvasive ankle hemodynamic testing has been proposed as one method of predicting early and late graft closure. However, Corson et al., who studied FP grafts, and Sumner and Strandness, who assessed femorotibial (FT) grafts, were unable to confirm the prognostic value of such tests. Accordingly, we have retrospectively evaluated our experience with infrainguinal arterial reconstructions to assess whether ankle hemodynamics would have been useful in predicting eventual graft patency.

METHODS

The results of 129 FP and 141 FTP bypasses performed for limb salvage at Montefiore Medical Center are included in this study. Noninvasive hemodynamic evaluation of patients undergoing these procedures was performed with the use of pulse volume plethysmography and Doppler-determined segmental limb pressures. Ankle/brachial pressure index (ABPI) and ankle pulse volume recording amplitude (APVR) in millimeters were calculated. Testing was performed just prior to and within 3 days after surgery.

Patients were examined every 2 weeks for the first 3 months after their operation and every 4 to 8 weeks thereafter. Postoperative patency of all arterial reconstructions was confirmed by objective criteria such as Doppler-determined ankle pressure measurements, pulse volume recordings, or contrast arteriography. Patients dying, those lost to follow-up, or those requiring a major amputation despite a patent arterial reconstruction had their patency intervals terminated at the time of these events. Patency rates were calculated by means of the cumulative life-table method, and statistical differences in the life tables were determined by the log rank method.

Graft material used for the FP bypasses was autogenous saphenous vein (ASV) in 22 instances and polytetrafluoroethylene (PTFE) in 107. Similarly, for FT reconstructions ASV was utilized in 43 and PTFE in 98 grafts. Diabetes was present in 171 patients. Principles of patient selection, graft choice, and intra- and postoperative management have been described previously.

Graft closure was determined in all patients by...
objective means such as loss of graft or distal pulses, return of noninvasive hemodynamic parameters to preoperative levels, or angiography when diagnostically necessary. Pre- and postoperative ABPI and APVR as well as ABPI and APVR increments (Δ) were assessed to determine if they could have been used as predictive values for graft closure or patency. Statistical analysis was performed by means of the Student t and chi-square tests.

RESULTS

FTP bypasses. Mean cumulative life-table patency rates for the 141 FT bypass grafts was 47% at 33 months (Fig. 1). All 60 closures occurred within 17 months, 46 closing early (<1 month). Scattergrams were constructed of graft closures and patent grafts vs. preoperative ABPI and APVR amplitude (Figs. 2 and 3), postoperative ABPI and APVR, and ΔABPI and ΔAPVR. As can be seen from Fig. 2, only three grafts were performed in limbs with preoperative ABPI >0.00 but <0.2. This is probably a reflection of the insensitivity of the Doppler probe when ankle pressures were very low. Accordingly, many signals were unrecordable, hence the large number of 0.00 ABPIs. Mean preoperative ABPI for the patent and closed grafts was 0.37 ± 0.3 and 0.27 ± 0.27, respectively. This difference was significant (p < 0.05). Thus it was believed that the preoperative ABPI may, indeed, be predictive of graft
closure. The 99% confidence limit for the SEM was 0.13, but as described, it is unlikely that the Life Sciences Doppler plethysmograph was accurate in measuring indices at this level. Accordingly, since its accuracy was improved at values >0.2 and since the lower level of the 95% confidence limit for the SEM was also 0.20, preoperative ABPI of 0.20 was arbitrarily chosen as a possible predictive value for graft patency or closure.

Mean preoperative APVR was 4.8 ± 4.5 and 3.3 ± 3.3 mm for patent and closed grafts, respectively (p < 0.01). As with ABPI, there was a subjective error in the interpretation of APVR in low ranges, that is, less than 5 mm. Thus the upper level of the 99.7% confidence limit for the SEM was chosen (i.e., APVR 5 mm) as a possible predictive value for graft patency or closure. Preoperative ABPI was less than 0.2 prior to 52 FTP grafts. Of these, 19 closed early (37%) and an additional seven closed by 10 months (13%), for a total closure rate of 50%. In comparison, of the 89 grafts in which preoperative ABPI was more than 0.2, 17 closed early (19%) and another 17 closed within 17 months of insertion (19%) for a total closure rate of 38%. The total closure rates for grafts placed when preoperative ABPI was >0.2 was not statistically different from those of grafts placed when preoperative ABPI was <0.2 (p < 0.1). However, early closure rates were significantly worse if preoperative ABPI was <0.2 (p < 0.02). Preoperative APVR <5 mm also correlated with graft occlusion. Of the 94 grafts in which APVR was <5 mm, 29 closed within 1 month (31%) and another 18 closed within 11 months of graft insertion (19%). Total closure rate was 50% (47 of 94). APVR was more than 5 mm prior to 47 grafts. Of these, seven closed early (15%) and an additional six closed within 17 months (13%). Total closure was 13 of 47 (28%). Thus early and total closure rates were statistically greater if preoperative APVR was <5 mm (p < 0.01).

Prior to 44 of the grafts, preoperative ABPI was >0.2 and APVR was >5 mm. Eleven of these grafts subsequently closed (25%). When the ABPI was <0.2 or APVR <5 mm preoperatively (97 of 141), 49 grafts subsequently closed (51%). The difference between these closure rates was significant (p < 0.025). The correlation between these prognostic indicators and early failure is further evidenced by the presence of at least one poor prognostic indicator in 31 of the 36 early failures (86%). Life-table patency rates for limbs with preoperative ABPI >0.2 and preoperative APVR >5 were statistically better (p < 0.05) than those for limbs in which preoperative ABPI was <0.2 or APVR <5 mm (Fig. 1).

Postoperative ABPI and APVR and increments of these values could not be measured in some patients for fear that the cuff would compress the distal anastomosis. Those values that were obtained were subjected to the same statistical analysis as for preoperative values. Results are tabulated in Table I. As can be seen, postoperative values were significantly better than preoperative values (p < 0.01), but graft closure could not be predicted by any of these postoperative values.

**Fig. 4.** Cumulative life-table patency rates for FP bypasses according to preoperative ABPI and APVR amplitude.

### Table I. FTP grafts

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<th>Open</th>
<th>Closed</th>
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<tbody>
<tr>
<td>ABPI</td>
<td>0.37 ± 0.3</td>
<td>0.27 ± 0.27</td>
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<tr>
<td>Postoperative</td>
<td>0.88 ± 0.26</td>
<td>0.94 ± 0.17</td>
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<tr>
<td>PVR</td>
<td>4.8 ± 4.5</td>
<td>3.3 ± 3.3</td>
</tr>
<tr>
<td>Δ</td>
<td>17 ± 9</td>
<td>13 ± 10</td>
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<tr>
<td>Δ</td>
<td>12 ± 6</td>
<td>10 ± 8</td>
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FP bypasses. Cumulative life-table patency rates for the 129 FP bypass grafts was 55.3% at 57 months (Fig. 4). Forty grafts closed between 0 and 42 months, with 11 closing early. ABPI was unobtainable in 10 patients because severe arterial calcification prevented occlusion. Preoperative, postoperative, and incremental values of ABPI and APVR are tabulated in Table II according to whether the grafts remained open or closed. As can be seen, there was no statistically significant difference between open
Table II. FP grafts

<table>
<thead>
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<tbody>
<tr>
<td>ABPI</td>
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<tr>
<td>Preoperative</td>
<td>0.35 ± 0.24</td>
<td>0.34 ± 0.25</td>
</tr>
<tr>
<td>Postoperative</td>
<td>0.76 ± 0.26</td>
<td>0.66 ± 0.34</td>
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<tr>
<td>Δ</td>
<td>0.4 ± 0.15</td>
<td>0.31 ± 0.19</td>
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<tr>
<td>PVR</td>
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<tr>
<td>Preoperative</td>
<td>3 ± 3</td>
<td>3 ± 3</td>
</tr>
<tr>
<td>Postoperative</td>
<td>14 ± 9</td>
<td>12 ± 7</td>
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<tr>
<td>Δ</td>
<td>11 ± 8</td>
<td>9 ± 7</td>
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and closed grafts for any value. Furthermore, closure rates were similar when FP grafts were placed in limbs with preoperative ABPI <0.2 and those with preoperative ABPI >0.2 (11 of 33 vs. 26 of 82, respectively [p < 0.5]). Likewise, closure rates were similar for grafts placed in limbs with preoperative APVR <5 mm and those with preoperative APVR >5 mm (34 of 105 vs. 6 of 24, respectively [p < 0.1]). Six of 23 grafts (26%) closed when preoperative ABPI was >0.2 and APVR was <5 mm. Either preoperative ABPI <0.2 or APVR of <5 mm was noted prior to 106 FP grafts, 34 of which subsequently closed (34%). The difference in these closure rates was not statistically significant (p < 0.5). Cumulative life-table patency rates were also not statistically different (Fig. 4).

DISCUSSION

Patency rates for infrainguinal bypass grafts for atherosclerotic arterial disease are dependent on a number of variables, including the site of bypass, graft material, indications for the operation, and technical ability of the surgeon. Since these procedures are time consuming, costly, and carry a low but significant mortality rate, it would be advantageous to predict in advance which grafts have an increased chance of failure. An often-suggested cause of graft failure or closure is obstruction to distal outflow. Since noninvasive hemodynamic testing can give some indication of the state of the distal vascular bed, such tests have been correlated with the eventual success of reconstructive arterial operations. Bone et al. in 1976 assessed the thigh pressure index in patients undergoing aortofemoral bypass. If this measurement was >0.85, significant improvement in symptoms occurred in only 63% of patients in comparison with 100% of patients with a thigh pressure index <0.85. However, thigh pressure index did not predict graft closure. These results were confirmed by Garret et al.

Sumner and Strandness analyzed 31 FTP bypass grafts. Graft failure could not be predicted by preoperative ABPI. However, only three grafts failed early and 13 failed late. With so few failures, the statistical relevance of their findings remains questionable.

In fact, pre- and postoperative ABPI, APVR, ΔABPI, and ΔAPVR were not useful in predicting eventual FP graft closure. It should be noted that although there were more patients studied in which PTFE had been used as the graft material, patency rates for PTFE and ASV grafts were similar. We have previously reported that bypasses to isolated popliteal arteries have patency rates that approach those of grafts to vessels with better runoff. Thus, if angiographic evaluation of runoff is not significant in predicting graft patency, it is not surprising that other noninvasive hemodynamic variables including ABPI, none of which proved capable of discriminating future success or failure of aortofemoral bypass grafts. O'Donnell et al., utilizing the Life Sciences pulse volume recorder, also evaluated a devised measurement of a runoff resistance in aortofemoral grafts. When FP Ω ([thigh pulse volume recording amplitude – APVR] ÷ 15 mm) was >0.2, there was a 100% failure rate, but if FP Ω was <0.2, the failure rate was 31%. However, failure was clinically determined and did not imply graft closure.

Bernstein et al. noted the value of ABPI and toe pulse reappearance time in predicting the clinical success of aortofemoral grafts.

Noninvasive hemodynamic testing has also been used to predict the efficacy of infrainguinal bypass grafts. Dean et al. studied 112 patients undergoing FP bypass. When ABPI was <0.2, only 9% of grafts remained patent. Their findings were statistically so significant that they questioned whether bypasses should be performed in patients with such low ABPI. Corson et al. found that 21 of 22 early failures occurred when preoperative ABPI was <0.5. However, 15 failures occurred with ABPI >0.3. Late failures occurred in patients throughout the range of ABPI and did not correlate with closure. They also studied postoperative ABPI and its increment (ΔABPI) and found a significant relationship with early graft failure (p < 0.001). All the early graft failures occurred with a ΔABPI <0.4. Our experience with such postoperative tests has shown that on many occasions the graft has already closed prior to testing. Inclusion of such unimproved values will spuriously improve correlation between postoperative tests and early failure. In our study such values were excluded from analysis.

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these noninvasive tests that also assess runoff do not have predictive value. Perioperative noninvasive assessment of ABPI and APVR is valuable in determining the degree of ischemia and in differentiating single from multifocal disease. Also, graft patency and the degree of improvement following graft placement can be well evaluated, but these indices should not be utilized to predict the outcome of FP bypass, even in the presence of an isolated popliteal segment.

When preoperative ABPI and APVR were correlated with femorodistal bypass graft patency, a significant correlation was encountered. Only 25% of the grafts closed when preoperative ABPI was >0.2 and preoperative APVR was >5 mm. On the other hand, if either ABPI was <0.2 or APVR was <5 mm, 51% of grafts subsequently closed. Postoperative ABPI, APVR, and their increments (Δ) did not correlate with ultimate graft patency.

Despite these findings, the clinical utility of these tests remains limited. Although the graft failure rate doubled in the presence of a poor prognostic factor, almost half the grafts remained patent. In addition, the 33-month cumulative life-table patency rate for this group of patients was still 31%. Thus we do not believe that the presence of either one of these two poor prognostic factors should exclude the patient from being considered a candidate for femorodistal grafting unless there are other significant findings that rule out surgery.

CONCLUSION

One hundred twenty-nine FP bypasses and 141 FTP bypasses underwent noninvasive hemodynamic evaluation before and immediately after surgery. Patients were followed postoperatively for up to 57 months. Preoperative, postoperative, and incremental values of ABPI and APVR were evaluated to determine if any value could have been used to predict graft closure or patency. None of these values had any such prognostic significance for patients undergoing FP bypass. Similarly, postoperative measurements also did not predict the outcome of femorodistal bypass grafts.

If preoperative ABPI was <0.2 or APVR was <5 mm, 51% of FTP grafts closed, usually within 1 month of insertion. Since half the grafts remained patent despite the presence of either one of these two poor prognostic factors, we do not believe that such values should be used to exclude patients from consideration for FTP bypass.

REFERENCES