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At What Peak Velocity Ratio Value Should Duplex-detected Infrainguinal Vein Graft Stenoses be Revised?

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Objectives: *To determine the peak velocity ratio (PVR) threshold at which to intervene and correct duplex detected vein graft stenoses.*
Design: *Prospective study.*
Materials: *Infrainguinal vein grafts in patients attending the vascular studies for routine postoperative surveillance.*
Methods: *Colour duplex detected stenotic vein graft lesions with a peak velocity ratio (PVR) between 2.0 and 2.9 were identified and monitored by serial duplex scans performed monthly for 3 months and then at 3-monthly intervals thereafter. At the end of the study period, the outcome of these lesions were analysed.*
Results: *Thirty-eight lesions were identified from 32 grafts. Of these lesions, sixteen (42%) resolved, 11 (29%) remained stable and 11 (29%) progressed to a PVR of $\geq$3.0 and underwent angioplasty. There were no occlusions in any of the grafts during the period of study.*
Conclusion: *Colour duplex detected vein graft stenoses with a PVR of less than 3.0 can be treated expectantly if grafts with stenoses with a PVR 2.0–2.9 are scanned every month for at least 3 months after detection.*

Key Words: Colour duplex; Vein graft stenoses; Peak velocity ratio.

Introduction

Postoperative infrainguinal vein graft surveillance using colour duplex is widely practised.[1–4] Over the years, several parameters have been derived from duplex examinations to estimate the degree of stenosis. Jäger *et al.*[5] first demonstrated that the relative increase of velocity across a stenosis could be used as an indicator of disease severity in native vessels, and since then the peak velocity ratio (PVR) has been used to grade stenoses that develop in vein grafts.[6–8] The threshold value for correction of detected lesions varies from one centre to another. A PVR of 2.0 corresponds approximately with a 50% or more reduction in vessel diameter and many centres,[9–12] including our own, intervene at this point in order to prevent subsequent occlusion. However, other authors have suggested that intervention is necessary only for those lesions with a PVR above 3.0[13] or 3.5.[14] The aim of the present study was to determine whether the threshold for intervention could be safely raised from a PVR of 2.0 to 3.0 without increasing the risk of graft thrombosis.

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Patients and Methods

A prospective study was commenced recruiting from patients attending the vascular studies unit of the Leicester Royal Infirmary for infrainguinal vein graft surveillance. The protocol for postoperative infrainguinal vein graft surveillance in this centre is a colour duplex examination of the graft and its anastomoses at 1, 3, 6, 9, and 12 months after surgery. Thereafter the patients are scanned at 6-monthly intervals. The scans are performed by experienced vascular technicians using one of two colour duplex scanners (Diasonics Masters, Diasonics sonotron, Bedford U.K. and ATL Ultramark 9 HDI, ATL Letchworth U.K.) at probe frequencies of either 5MHz or 10MHz. Detected stenoses are graded according to the calculated PVR. This is determined as the ratio of the peak velocity within the stenosis and the peak velocity of the adjacent segment of normal graft. Grafts were considered occluded if there was no colour on the duplex scan and no pulsatile flow on the pulsed Doppler.

Prior to the start of this study the PVR threshold for intervention was $\geq$2.0. However, starting in August 1995 this threshold was raised to $\geq$3.0. For the purposes of this study, grafts that developed a primary stenosis with a PVR of 2.0–2.9 were scanned every

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month. If the stenosis progressed to a PVR of ≥ 3.0 the stenosis was corrected by angioplasty; if, however, the stenosis regressed or remained stable for 3 months the graft returned to the routine surveillance protocol. A primary lesion was defined as one that was detected in an area of a graft that had no previous abnormalities or endovascular intervention. At the end of the study the data relating to the outcome of these stenoses was analysed.

Results

Two-hundred and ten vein grafts underwent post-operative surveillance between August 1995 and April 1997. During this period 12 stenoses in 11 grafts were detected with an initial PVR ≥ 3.0 and were immediately treated by angioplasty. A further 32 grafts developed 38 primary stenotic lesions with a PVR between 2.0 and 2.9.

Seventeen of the 32 grafts were *in situ*, 13 were reversed and two were composite. Twelve grafts were above-knee, 20 were below-knee. Thirty-two stenoses were located within the graft and six were at an anastomosis. Of the 38 stenoses with a PVR between 2.0 and 2.9, 16 (42%) regressed spontaneously, 11 (29%) remained stable and 11 (29%) progressed to a PVR of ≥ 3.0 and underwent angioplasty. No grafts with a PVR between 2.0 and 2.9 occluded whilst they were being 'observed'.

The median (range) time taken to develop a stenosis with a PVR of 2.0–2.9 was 12 (1–100) weeks after surgery. The time of onset of stenoses that progressed ($n=11$) was 8 (2–100) weeks compared to 18 (1–100) weeks for those that did not ($n=27$). This trend was not statistically significant ($P=0.46$, Mann–Whitney U-Test). Stenoses that did progress did so at a median (range) time of 6 (4–36) weeks from the time at which they were detected.

Discussion

There are several duplex derived parameters that can be used to grade the severity of a stenosis. These include the peak mean velocity, the peak systolic velocity index, the end-diastolic velocity and the peak velocity ratio.[13,15,16,17] In the present study we have used the PVR as the sole parameter to grade detected lesions because it has previously been shown to be highly sensitive for detecting lesions within vein grafts.[11] Many authors tend to repair all lesions with a PVR of 2.0 which corresponds approximately to a diameter reduction of 50%. One of the strongest arguments supporting the use of a PVR of 2.0 or more as a criteria to correct graft stenoses is evident in the study reported by Mattos *et al.*[9] In their study of 110 vein graft stenoses, 33 grafts harbouring lesions with a PVR of 2.0 or above were not corrected. The 3-year patency rate in these grafts was 57%. This was significantly worse than the 3-year patency of 83% achieved by correcting lesions with a PVR of 2.0 or more in 24 other grafts. Thus they concluded that lesions with a PVR of 2.0 were at a significantly increased risk of occlusion and that correction at this stage would significantly improve patency rates. There have been other studies supporting these findings.[4,16,18] The problem with these studies, however, is that they have not attempted to determine the natural history of these lesions by observing them until they developed a higher PVR before they were corrected.

In contrast, we have found that it is safe to observe stenoses that develop in vein grafts if the PVR is between 2 and 2.9. Interestingly, other authors have recently come to similar conclusions. Thus, Idu *et al.* recently presented their findings in a similar prospective study (Idu *et al.* – unpublished observations).[19] In their study, analysis of data from 300 patients showed that the PVR provided the best correlation with angiographic detected stenoses and that a threshold level of ≥ 3.0 was the optimal threshold for predicting grafts that would require revision. Caps *et al.*[8] using a cut off PVR of 3.5 reported no graft thromboses in lesions with a PVR of 2.5 or less. However, they experienced three thromboses in those grafts with a PVR between 2.5 and 3.5. This may be because of the slightly higher cut-off point that they used. Furthermore, those three grafts were associated with a significant reduction in the ankle brachial index (ABI) or return of symptoms.

Bandyk[14] suggested that asymptomatic lesions with a normal flow velocity and an ankle brachial index of more than 0.9 should attain a PVR of 3.5 before correction. Westerband *et al.* have recently completed a prospective study on 101 vein grafts designed to validate a threshold PVR of 3.5 as the criteria for intervention. In that study, of 43 grafts with stenosis (PVR ≥ 1.5), 20 (46%) remained stable or spontaneously regressed and the remaining 23 (54%) progressed. However, out of the 23 lesions that progressed, three occluded before intervention.[20] The occurrence of three occlusions in that study suggests that a threshold PVR of 3.5 may be too high and a PVR of 3.0 may be more appropriate.

Part of the problem in graft surveillance and duplex scanning is the paucity of knowledge on the natural history of detected stenoses. There is a tendency to

apply the same criteria used in native vessels to vein grafts.[11] However, the underlying cause of stenosis is different. The arteriosclerosis seen in the native vessels tends to be progressive whilst intimal hyperplasia has been known to spontaneously resolve.[21] This fact is supported by our results and there seems to be a consistent pattern emerging from the few studies on the natural history of vein graft stenosis. We found that most lesions that progress do so within a relatively short period of time (median time of 6 weeks) which is consistent with findings from other studies.[8,21]

This study has shown that if vein graft stenoses with a PVR of 2.0–2.9 remain stable during the course of 3 months, stenosis with a PVR <3.0 can be treated expectantly. We therefore conclude that with this protocol the threshold PVR for correcting duplex detected graft stenosis should be ≥ 3.0. This policy will markedly reduce the number of interventions without impairing graft patency.

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