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Identification of vein graft stenosis and assessment of sustainability of outcomes: Two sides of the same coin in vein graft surveillance

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A B S T R A C T

Autologous veins are the conduit of choice when performing an infra-inguinal arterial bypass procedure. However these grafts are at risk of failure. This is multifactorial in nature and relates to patient factors, factors relating to the procedure as well as adaptive processes which occur after the formation of an infrainguinal bypass graft. Duplex ultrasound assessment of haemodynamic findings within the graft is the most accurate method of identifying vein graft stenosis and identifying grafts which are at risk of failure. Duplex ultrasound examination findings together with clinical factors can be used to individualise vein graft surveillance. This review examines the steps involved in a successful vein graft surveillance program, how to optimise the cost utility of vein graft surveillance by identifying the grafts which are at highest risk of failure and how there has been a paradigm shift away from surgical revision and towards endovascular revision of failing infrainguinal grafts.

1. Introduction

Despite advances in endovascular techniques, lower limb bypass remains the gold standard treatment for infra-inguinal lower limb revascularization for peripheral arterial occlusive disease. These versatile procedures have been around for 70 years and despite their invasiveness (compared with endovascular techniques), requirement for autologous venous conduits and the need for regional or general anaesthesia they remain as much part of vascular surgeons' armamentarium in the 21st century as they did in the decades before [1].

Infra-inguinal vein grafts are at risk of failure, via the development of stenoses within the body of the graft or at the sites of proximal and distal anastomosis or the inflow or the outflow vessels [2–6]. Several pathological processes for the development of graft stenosis have been identified. These include technical errors during the formation of the proximal and distal graft anastomoses; injury to the graft from clamping during the bypass procedure; an abnormality of the vein that pre-exists its harvesting for use as a graft or incomplete division of the valve leaflets can contribute to stenosis [7–9]. Over time the graft is at risk from progression of atherosclerotic disease.

Given the significant impact on quality of life and healthcare economics of a major amputation should an infra-inguinal vein graft fail, there has been a lot of interest in identification of at risk grafts through regular surveillance. Vein graft stenosis is recognisable by duplex ultrasound scanning, a technique acknowledged for its accuracy in identifying and grading stenotic lesions that threaten graft patency [10]. Duplex scanning has been widely used for graft surveillance, the rationale being that identification (Fig. 1) and correction of stenotic lesions is likely to improve graft patency and limb salvage rates [11–13], Routine duplex surveillance of vein grafts is expensive, resource consuming and at times difficult to interpret. Vein Graft Surveillance Trial (VGST) trial revealed no significant difference in graft patency or limb salvage in the medium term between patients who were followed up clinically and those who underwent vein graft surveillance [14]. Consequently latest iteration of the Inter-Society Consensus for Management of Peripheral Arterial Disease (TASC II) recommended clinical surveillance and measurement of ankle brachial index pressures (if possible post exercise) and did not mention Duplex based graft surveillance as a recommendation [15].

The VGST had 2 major short comings the main one being that the patients were only included for randomisation at 6 weeks to 3 months after a duplex scan had identified them as successful grafts thereby excluding early graft problems in addition the duplex criteria used to identify at risk grafts had low positive predictive value for risk of imminent occlusion. On the other hand, VGST and many other authors have highlighted that the vast majority of vein grafts which are entered into a surveillance program complete the surveillance cycle without any need for re-intervention [14,16–19]. This relates to the excellent patency of infra-inguinal vein graft bypasses with serially normal ultrasound examinations. Therefore would be desirable to identify the highest risk grafts for ultrasound based surveillance whilst others can be followed up clinically [20].

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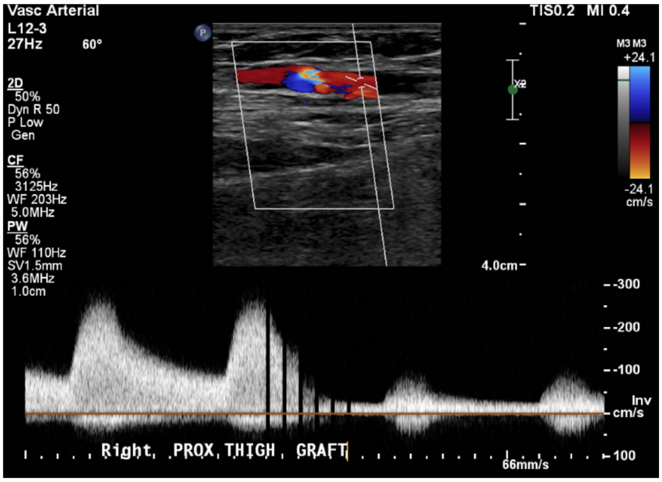

Fig. 1. Duplex examination of an infra-inguinal vein graft revealing a severe stenosis at the proximal anastomosis.

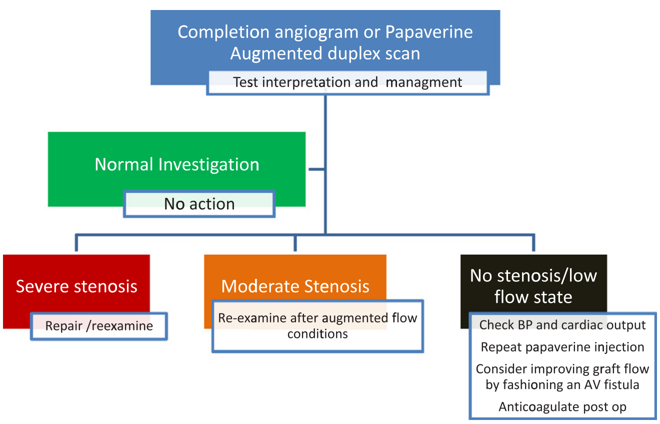

Fig. 2. Algorithm for Intraoperative completion examination of an infra-inguinal vein graft bypass modified from.

In the last 20 years there have been significant improvements in vascular surgery. These improvements have been derived by introduction of new technologies as well as expanded evidence base for treatment of vascular disease. The need for these improvements have been driven by the need to improve quality, efficacy and cost effectiveness of vascular interventions. This has been achieved through improvements in pathways of care, and quality improve programmes which are results driven [21]. A comprehensive surveillance program provides the evidence of successful revascularisation, graft patency and limb salvage which can be benchmarked against contemporary practice [21].

This review examines how vein graft surveillance program could optimise patency of infra-inguinal vein grafts and how it can provide evidence of quality of services provided.

1.1. Intraoperative assessment

Sustainable vein graft surveillance starts intraoperatively. Being confident of the technical adequacy of an infrainguinal bypass graft is an important first step in achieving graft patency and limb salvage. A satisfactory completion investigation is a powerful quality control measure. Despite this it is a step which is often not carried out. Between 6 and 10% of infrainguinal vein grafts occlude before the patient attends the first post-operative surveillance assessment of the graft. Many of these failures are due to technical issues such as thrombus formation, tunnelling errors, a twist in the graft or a narrowing in the venous conduit which was not suspected at the time of the procedure [6–9]. Completion angiography or intraoperative *papaverine-augmented duplex assessment* of the full length of the graft can identify technical issues, unexpected thrombus formation and low flow states so that they can be addressed in timely manner before the graft occludes. VGST avoided addressing this issue by randomising patients at 6 weeks or the first surveillance clinic visit. Tinder et al. have developed a very useful algorithm which helps clinicians address these intraoperative findings (Fig. 2) [20].

1.2. Post-operative surveillance

Whilst it is true that a significant proportion of vein grafts develop graft threatening stenotic lesions within the first year or 2 of the initial procedure, there is little evidence outside observational and case control studies which are performed by enthusiasts to suggest that duplex surveillance is associated with improved graft patency and improved limb salvage [22–28]. Duplex surveillance is resource intensive and difficult to justify on the basis of cost, unless a large number of vein grafts, and limbs are being saved [29,30].

A significant proportion of vein graft bypasses develop flow disturbance on duplex scanning at the time of the early post-operative surveillance examination. In fact most grafts which subsequently develop stenosis have evidence of such a finding at the time of the first duplex examination. This means that an early clinical and duplex US examination is potentially most important assessment of the graft surveillance [5,16,30,31]. Apart from denoting an early threat to patency, early abnormalities also predict the natural history of the graft and outlook for the limb in the medium term. It is possible to use this finding to select vein grafts at particular risk for duplex surveillance, thereby moderating the resource intensive nature of duplex based graft surveillance [6].

Clearly grafts which exhibit severe stenosis (Figs. 1–3) are at risk of failure and require intervention and those with mild flow abnormalities require further surveillance [25,26,31]. The fate of intermediate stenoses has been a matter for debate. This is a topic was not addressed by the VGST. VGST resolved the issue by having a very low threshold peak systolic velocity for defining clinically significant graft stenosis. This would remove intermediate stenoses as a category and means their natural history would not be addressed. Mofidi et al. [16], reported that several intermediate stenoses and flow abnormalities did not progress or significantly improved during follow-up and therefore require surveillance rather than immediate intervention [31–36]. Vesti et al. studied intermediate stenoses situated within the body of the graft that derived from valve cusps [33]. They reported that over half of these lesions regressed without intervention over the follow-up period [33]. The quality of the venous conduit used for bypass procedure is an important factor in determining graft patency following infrainguinal bypass. The use of venous conduits with preoperative diameter of less than 3.5 mm has been associated with a higher incidence of vein graft stenosis [19]. A diligent duplex based vein graft surveillance program can identify and treats these stenotic lesions. Sequential postoperative duplex scanning has revealed that vein grafts increase in diameter of the vein after being arterialized [37]. Grafts with small initial diameter respond more to shear stress, resulting in a greater increase in size than veins with large diameter [38]. A similar but competing process of adaptation is responsible for neointimal hyperplasia which can result in the development of vein graft stenosis [39]. Other gross and histological features of vein graft, such as reduced vein compliance, smooth muscle hyperplasia, and inflammatory infiltrates, have been associated with the development of vein graft stenosis [40–43].

Development of vein graft stenosis or occlusion is multifactorial in nature. Demographics, comorbidities and specific technical and procedural issues can identify graft cohort at risk of failure [31]. The implications of vein graft occlusion vary depending on what was the initial indication for the bypass procedure. This would mean that a