Glutaraldehyde-tanned Bovine Carotid Artery Graft for Infrainguinal Vascular Reconstruction: 5-year Follow-up

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Objective: To assess the long-term patency of a modified biological conduit, the glutaraldehyde-tanned bovine carotid artery, in above-knee infrainguinal arterial reconstruction.

Patients and Methods: Prospective follow-up of a cohort of 58 above-knee femoropopliteal grafts in 55 patients. Graft patency was assessed at yearly intervals with doppler ankle pressure measurements.

Results: The median follow-up period has been 67 months. Nine grafts occluded within 30 days of surgery and a further 19 graft closures have been observed in the follow-up period. The overall cumulative primary graft patency at 1, 3 and 5 years was 70%, 61% and 56%, respectively. If the 30-day graft failures are excluded, the primary graft patency rises to 83%, 74% and 68% at 1, 3 and 5 years, respectively. Six limbs have been amputated, four above the knee and two below the knee. There were no graft aneurysms and no graft infections.

Conclusion: Results indicate that the modified bovine carotid artery graft with an above-knee anastomosis does not seem to be inferior to PTFE, but is inferior to reversed vein. Modified biological conduits offer a reasonable alternative to synthetic grafts for infrainguinal arterial reconstruction and appear to maintain acceptable long-term mechanical stability.

Key Words: Infrainguinal reconstruction; Claudication; Bovine graft; Vascular prosthesis.

Introduction

Experience with the use of biological vascular grafts reached a peak 10 years ago with the use of the human umbilical vein allograft for femoropopliteal bypasses. In comparative studies, umbilical vein grafts have proven superior to Polytetra-fluoroethylene (PTFE) in infrainguinal reconstruction. The early umbilical vein grafts were associated with a high incidence of graft degeneration and aneurysm formation of up to 46%, the method of glutaraldehyde fixation was modified, and the newer grafts have a lower risk of such complications, of the order of 17%. Nevertheless, there has been a general opinion that all biological substitutes may be prone to the same complications, and in Europe PTFE grafts have become the preferred conduit by most surgeons when the autologous saphenous vein is absent or of inadequate size.

The BioPolyMeric (BPM) graft (St Jude Medical, Inc., Minnesota, U.S.A.) is a glutaraldehyde-tanned bovine carotid artery. Some early clinical results with the BPM graft for infrainguinal arterial reconstruction were encouraging, and one study had primary patencies of 90% and 80% at 1 and 2 years, respectively. This suggested that the BPM graft achieved results similar to those of autologous saphenous vein. However, initial results with the use of another infrainguinal-fixed bovine carotid artery graft (Solcograft) were disastrous, with a high incidence of early graft deterioration and aneurysm formation, and appeared to confirm that this type of graft was prone to degeneration.

We report our long-term follow-up of patency of the BPM graft.

Patients and Methods

Between July 1988 and November 1991, 58 BPM grafts were implanted for infrainguinal vascular reconstruction in our institution. The majority of these grafts were inserted prior to the authors joining the institution. At that time it was believed that synthetic grafts used for above-knee reconstruction gave as good results as vein, and during this period the BPM graft...
Glutaraldehyde-tanned Bovine Carotid Artery Graft

Fig. 1. Cumulative primary graft patency rates for the BPM graft (n = 58). For a general comparison, our own primary patency rates for above-knee vein (n = 53) and PTFE (n = 85) grafts inserted since 1991 are also illustrated. Survival curves for PTFE and vein are calculated to the point at which the numbers become so small that standard error exceeds 10%. The numbers of grafts at risk after each 200-day interval are also illustrated.

was used as the primary conduit for all above-knee reconstructions. These grafts were inserted as part of a clinical trial, and accurate follow-up records have been maintained and the grafts have been reviewed continuously ever since.

Doppler ultrasound ankle pressures were routinely performed pre- and postoperatively, and were used as an objective method of assessment of graft patency. When doubt existed as to the patency of the graft, arteriography was used as confirmatory evidence. Patients were seen at 3, 6 and 12 months, and yearly thereafter. A total of 58 BPM grafts were inserted in 55 patients. There were 26 women and 32 men. The median age of the patients was 68 (inter-quartile range 60-73). Five patients were diabetic (9%) and 39 (71%) were active smokers prior to graft insertion. Details of how many continued to smoke after surgery are unavailable. The indications for surgery were disabling claudication in 53 limbs (91%) and rest pain in five.

Since 1991 we have used vein as the primary above-knee conduit. In the absence of vein, PTFE has been used as the alternative material for above-knee reconstruction. Since 1991, accurate follow-up data has also been collected for PTFE and vein grafts. Cumulative patency rates for PTFE and vein since 1991 are also presented for comparison purposes. However, in view of the fact that these grafts were inserted by different surgeons, for different indications, and that this was not a controlled comparative study, these other graft materials are not discussed in detail.

Cumulative graft patency are calculated by Kaplan-Meier life-table analysis and patencies compared by the log-rank test using a computerised survival analysis package (GraphPad Prism, GraphPad Software, Inc., San Diego, California, U.S.A.).

Results

There were no operative deaths. The median follow-up of all grafts is 67 months (IQ range 39-76 months) and for those patients still alive the median follow-up is 73 months (IQ range 61-77 months). Forty-five limbs have been followed up for at least 3 years, and 34 for more than 5 years. Thirty-two grafts (55%) remain...
patent, with a median follow-up of 69 months (IQ range 39–73 months).

The cumulative primary graft patency rates for the BPM graft are summarised in Fig. 1. This has been compared with our own subsequent patency rates for PTFE and vein since 1991. The overall cumulative primary graft patency for the BPM graft was 70%, 65%, 61%, 59% and 56% at 1–5 years, respectively. There was no statistical difference between the graft patency of the three materials.

Nine grafts occluded within 30 days of surgery and a further 19 grafts have closed in the follow-up period. Five of the early graft closures occurred in the first 13 grafts inserted, and four in the latter 45. This apparent “learning curve” in inserting grafts did reach statistical significance ($\chi^2=6.73, p<0.01$). If the nine early graft failures are excluded on the basis that they were due to technical errors, the cumulative primary patency rates rise to 83%, 79%, 74%, 71% and 68% at 1–5 years, respectively. Nine patients have died with functioning grafts after 3, 4, 15, 21, 31, 39, 44, 53 and 71 months, and five further patients have died with closed grafts.

One of the immediate graft failures resulted in a below-knee amputation 6 months later. Five other limbs have been amputated, one below the knee at 60 months and four above the knee after 9, 13, 17 and 65 months; all for late graft failures.

There have been no graft infections and no graft aneurysms have been found clinically.

Discussion

The first modified bovine carotid artery graft was used in 1963. The carotid artery of the adult cow was dialdehyde-tanned to strengthen the graft by cross-linking the collagen molecules. A high incidence of aneurysms and graft infections were reported, and this graft was abandoned. Many of the problems with these early bovine heterografts were thought to be due to the dialdehyde starching. This led to the development of the glutaraldehyde-tanned bovine carotid artery graft.

There are no long-term reports regarding BPM graft performance in infrainguinal arterial reconstruction. In 1992, Wagner published his early results in a series of 112 grafts implanted for severe peripheral vascular disease. Primary patencies at 1 and 2 years were 90% and 80% to the above-knee popliteal artery. No graft aneurysms or dilatation were observed and there were few infectious complications.

Another series of bovine carotid artery grafts (the Solcograft) deserves mention. In this series, eight of 26 grafts underwent severe degeneration within 4 months of insertion. This appeared to be in contradiction to the manufacturer’s data, which showed only four aneurysms forming in a series of 700 grafts. Nevertheless, this disastrous experience with this single graft led to its withdrawal from production.

Our results suggest that the BPM graft achieves long-term patency inferior to autologous vein but superior to PTFE. Although the difference between the BPM graft and the other two was not statistically significant, this may be a function of the relatively small numbers and short follow-up of the PTFE and vein grafts. In addition, in view of the fact that this was not a controlled clinical trial, it is difficult to imply too much significance from this finding, due to a possible different case mix and different surgeons. There is, however, a distinct trend for the patency of vein and BPM grafts to plateau after 1 year, whereas there appears to be constant attrition rate of PTFE grafts.

It is difficult for us to explain the nine early graft failures because these grafts were not inserted by ourselves. However, there does appear to be a learning curve in using the graft, and it is important that it is cut to exactly the right length. It must be assumed that these nine failures within 30 days can be attributed to technical errors which may have been overcome if the grafts had been revised. Seven of the other 19 graft failures occurred between 100 and 365 days, and it is reasonable to assume that these were due to intimal hyperplasia. The remainder of the graft failures are spread out and probably represent disease progression.

This series also questions the generally held opinion that all biological prosthesis are prone to developing aneurysmal dilatation. Previous experience with human umbilical vein had shown that graft aneurysms usually develop between 40 and 80 months after surgery. The issue of graft biodegradation has remained a major concern, preventing widespread use of biological conduits in peripheral vascular surgery. The BPM graft appears to retain most of its mechanical properties even after 5 years, with no graft aneurysms clinically, although detailed duplex follow-up would be required to substantiate this claim. Experimental studies in a canine model have demonstrated that, 45 months after implantation, most of the original bovine heterograft has been replaced by host tissues. It is possible to speculate that the biological prosthesis acts as a bioresorbable scaffold and mechanical integrity of the graft is promoted by the orderly replacement of structural elements.

It is unfortunate that this graft is no longer
manufactured, as further long-term experience, particularly to the infrageniculate vessels, would have been very informative. The modified bovine carotid artery graft appeared to offer a reasonable alternative to synthetic grafts for infrainguinal arterial reconstruction when vein was absent or of inadequate size. In view of our experience, we feel that concern regarding biodegradation and aneurysmal dilatation should not have prevented the further development of vascular prosthesis of biological origin.

References


Accepted 3 February 1997