CLINICAL EXPERIENCE WITH CIRCUMFERENTIALLY
REINFORCED EXPANDED POLYTETRAFLUOROETHYLENE
(E-PTFE) GRAFT AS A VASCULAR ACCESS FOR
HAEMODIALYSIS

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Summary

Circumferentially reinforced E-PTFE grafts were implanted 50 times in 46
patients. Seven grafts became occluded during the observation period of 233
patient-months. Puncture and haemostasis were quite satisfactory in the majority
of the patients. Histologically, the inner surface of the grafts was covered with a
thin fibrin layer. Puncture sites were stuffed with fibro-fibrinous tissue prevent-
ing bleeding or aneurysmal dilatation.

Clinical experience has proved the E-PTFE graft to be a suitable vascular
prosthesis for blood access.

Introduction

Vascular grafts for blood access have become an indispensable requirement for
maintenance haemodialysis. For this purpose, bovine heterografts have been
widely used with considerable success. However, several defects of the graft have
been disclosed in practice.

Expanded polytetrafluoroethylene (E-PTFE) graft introduced in this field
by Volder et al.1 appears to be superior to bovine graft in terms of antithrombo-
genicity and dimensional availability. The sole defect of the E-PTFE graft is its
weakness in tensile strength in a circumferential direction. A new graft was
developed in an attempt to overcome this defect.

Materials and Method

Graft The graft (internal diameter 4–6 mm, wall thickness 0.55 mm) is an
E-PTFE tube spirally reinforced with an E-PTFE tape. Each E-PTFE has a
fibril length of 30 µ (Figure 1).

Patients The grafts were implanted 50 times in 46 patients who were referred
to our centre for blood access problems. They had an average of 5.4 previous
shunt operations. Age distribution of the patients ranged from 4 to 67 years, with an average of 43.3 years. Their original diseases leading to renal failure were glomerulonephritis in 37, SLE in 3, hypoplastic kidneys in 3, diabetic nephropathy in 2 and polycystic kidney in 1.

**Operation** All grafts were implanted in the forearm except for a patient in whom a graft was anastomosed between the brachial artery and the axillary vein. A loop-graft was used in 38, and a straight graft was utilised in the remaining 12. In twenty, one anastomosis was placed in the upper arm with the lower part implanted in the forearm. End-to-side anastomosis was standard practice.

**Postoperative examination** Angiograms of the grafts including arterial and venous anastomotic sites were taken in 18 cases using 10–20 ml of Urographin®. Small pieces of the grafts removed from occluded cases were examined histologically.

**Results**

*Operation* was successfully carried out in all cases. Bleeding from the suture lines was easily controlled by finger pressure or topical application of oxidised cellulose. No bleeding was observed from the graft itself even without a pre-clotting procedure. Two loop-grafts were found to be occluded on the first post-operative day. In the remaining 48, the grafts were utilised for blood access.
Use of blood access  Puncture was begun 34 hours to 27 days after the implantation (average of 16.6 days). The grafts were easily identified by digital palpation, and subcutaneous fixation of the grafts was satisfactory. Puncture was usually performed without difficulty. Postdialytic haemostasis was mostly complete within 15 minutes.

Examination  Neither kinking nor stenosis were observed on angiograms of the grafts. However, narrowing of the venous anastomosis was observed in 7 cases involving the drainage vein up to 3 cm proximal to the suture line. Intraluminal hydrostatic pressure of the grafts measured after dialysis was 53 cm H₂O on average. No aneurysmal dilatation was found in any case during the observation period of up to 12 months (Figure 2).

Figure 2. Angiogram of E-PTFE loop-graft (52 days after implantation). Arrows indicate arterial and venous anastomoses
Complications  Mild to moderate oedema was observed in most of the cases on the day after the operation. However, it gradually diminished and disappeared within one to 3 weeks. Occlusion of the grafts occurred 7 times in 233 patient-months in addition to the two cases described above. Three occluded grafts were salvaged by simple declotting or a partial repair of the venous anastomosis, but renewal of the grafts was necessary for the remaining four patients.

Necrosis of the skin was observed at the site of venous anastomosis in one paediatric patient, probably due to poor blood supply. Granulation around the wound was satisfactory with a tendency to heal.

Sepsis occurred in 2 cases, possibly caused by inadvertent bacterial contamination of puncture needles. It was, however, easily controlled by the administration of antibiotics.

Histology  Five grafts were re-explored at declotting or at partial repair of the anastomosis. Fibro-fibrinous tissue adhered tightly to the outer surface of the grafts and the grafts themselves had become somewhat rigid and changed in colour from white to light yellow.

On microscopic examination, the inner surface was covered with a thin fibrin

![Image](image_url)

Figure 3. Microscopic section of E-PTFE graft (x 100 — reduced for publication). Intimal surface is indicated by an arrow
layer and an adventitia-like fibrinous tissue tightly covered the outer surface (Figure 3).

An amorphous fibrin-like substance filled the alveolar structure of
the graft, with a scanty ingrowth of fibroblasts.

The graft material was penetrated and disrupted at the puncture sites, which were easily identifiable under the microscope, and the wall defects were replaced by fibro-fibrinous tissue, thus preventing bleeding or aneurysmal dilatation (Figure 4).

Discussion

When choosing vascular grafts for blood access, four points should be evaluated: patency, puncturability, durability and dimensional availability.

With regard to the patency of E-PTFE grafts, there is plenty of evidence to support their superiority to other grafts in the field of vascular surgery. Our rate of occlusion per patient-month was 1/33, which is quite acceptable for patients with serious difficulties in maintaining blood access. Main causes of occlusion were thought to be firstly, narrowing at the venous anastomosis, secondly, thrombus initiation at puncture sites, and thirdly excessive compression of the grafts for haemostasis.

Oedema, which was often observed postoperatively, was possibly induced by fluid filtered through the graft wall as well as by surgical trauma. However, it gradually diminished in 1–3 weeks, leaving no serious problems with blood access.
Puncture was begun rather late in this series. The reason was to give the grafts enough time to adhere tightly to the surrounding tissues. However, taking into consideration the fact that no laceration or subcutaneous haematoma developed in the cases in which puncture started within a week, the interval between the implantation and the start of puncture could be shortened. Four grafts were implanted in the forearms of paediatric patients. Small calibre grafts (4—5 mm, ID) were utilised in these cases. Optional selection of size is one of the advantages of the synthetic graft.

The only defect of the graft disclosed during the study was a loss of elasticity which was caused by invasion of plasma into the fine network of the graft wall. The flattening in the transverse section of the graft observed in several of our cases may be ascribed to the qualitative change in the graft in addition to compression between the skin and muscle. Penetration through the back wall of the graft appears likely to occur in such a situation.

Thrombosis and stenosis at the site of venous anastomosis is a well-documented complication of vascular graft implantation. E-PTFE graft is no exception. To overcome the difficulty and to facilitate the surgical procedure, a new E-PTFE graft with a non-expanded portion which serves as a vessel tip at one end has been developed. Animal experiment using the hybrid graft (a hybrid of cannula and puncturable graft) has been successful.

References

2 Soyer, T, Lempinen, M, Cooper, P, Norton, L and Eiseman, B (1972) Surgery, 72, 864

Open Discussion

BOEN (Amsterdam) Could you please explain the formation of oedema in this situation?

OTA Yes, oedema was often observed after operation. A filtrate which comes through the graft wall is considered to be a major cause of the oedema. But it gradually diminished, so it is not a serious problem.

BOEN We also had oedema formation which lasted for months. Do you have any trouble with bending the elbow if you have a graft in the upper arm?

OTA We ask the patients not to bend the arm for a long time. Another point is to locate the graft to the radial or the ulnar side at the time of operation to minimise the risk.

KAYE (Montreal) We think the oedema is due to a large volume of blood entering the veins and interfering with the normal venous return. If this is correct oedema should be much more prominent in grafts with a high flow and grafts which are looped, that is from the brachial artery, rather than in straight grafts.
Have you noticed any difference in the amount of oedema in the straight as opposed to looped grafts?

OTA The degree of oedema is usually more severe in looped grafts, that is true. One reason is the one you have just pointed out. The other reason is that in the case of loop grafts, their length is nearly twice that of straight ones. So one might expect ultrafiltrate to be doubled. In addition to these two factors, intragraft blood pressure may play a significant role in the production of the oedema fluid.

IKINGER (Heidelberg) You observed seven occlusions. Were these early or late occlusions?

OTA All these occlusions occurred within two months. That is relatively early, I think.

IKINGER Concerning your histological findings: did you observe the ingrowth of connective tissue from the inside or from the outside of the graft?

OTA Almost no ingrowth of connective tissue was observed except into the puncture sites. In this situation the connective tissue comes from outside.