

Transluminally-placed Coilspring
Endarterial Tube Grafts
*Long-term Patency in Canine Popliteal
Artery*

CHARLES T. DOTTER, MD

TRANSLUMINAL CATHETER DILATATION^{1,2} OFFERS A simple, rational and effective (90% lasting patency) alternative to conventional vascular surgery in the relief of primary atheromatous narrowing. Unfortunately, secondary luminal thrombosis often complicates the disease, leaving no lumen to dilate. The results of transluminal recanalization (catheter creation of a neolumen through a completely occluded segment) understandably are not in a class with those of dilatation. While spectacular and lasting successes have been achieved by catheter recanalization, vein grafting remains the treatment of choice for long-segment femoropopliteal occlusion. In a continuing effort to improve matters, a method for the percutaneous introduction and transluminal placement of tubular prostheses was developed and tested in dogs. The prompt thrombosis of all impervious tubes so placed led to the fabrication and trial of coilspring equivalents.

Work done in the Stella and Charles Guttman Institute for Vascular Research through Radiology at the University of Oregon Medical School, Portland, Oregon, was aided by grants from USPHS, HE 03275 and HE 06336, the Oregon Heart Association and the George Alfred Cook Memorial.

Much work by others is encompassed in this brief report. Special thanks are due: H. Auger, N. Day, O. Flizorth, J. Hearn, T. Hutchins, W. Massey, J. Pegg, J. Pennington, M. Quam, M. Robinson, T. Sasaki and J. Schenk.

Technique for Percutaneous, Transluminal
Placement of Tubes within Arteries

Using a suitable remote entry site and conventional techniques, a guide-catheter is first placed so that its tip traverses the intended graft site. The tubular prosthetic graft and pusher-catheter of similar cross-section are then slipped on and advanced over the guide-catheter until the graft has been seated as desired. Withdrawal of inner guide and pusher-catheters completes the procedure (Fig. 1). Care should be taken to avoid trauma and arterial spasm. Though it is yet to be done, transluminal graft placement at a site of arterial disease calls for preliminary preparation through dilatation or recanalization of the narrowed or occluded lumen. The leading end of the graft should be smoothly rounded so as to minimize any tendency to plough up an atheromatous intima.

To date, the above technique has been used to place grafts in the normal femoral or popliteal arteries of 25 dogs. The usual site of entry was the left carotid artery; though it was not essential, arteriotomy generally was used for catheter introduction. The tubular prostheses used varied from one to ten centimeters in length and one to three millimeters in outer diameter. Regardless of whether they were made of polyethylene, polyamide, Silastic or Teflon, no impervious plastic tube graft remained patent longer than 24 hours. Since graft patency was not an initial objective of the work, anticoagulants were not used in conjunction with the placement of a total of 19 plastic tubular prostheses. Follow-up angiography showed that occlusion was usually within the first twenty-four hours and pathologic examination revealed it due to thrombosis.

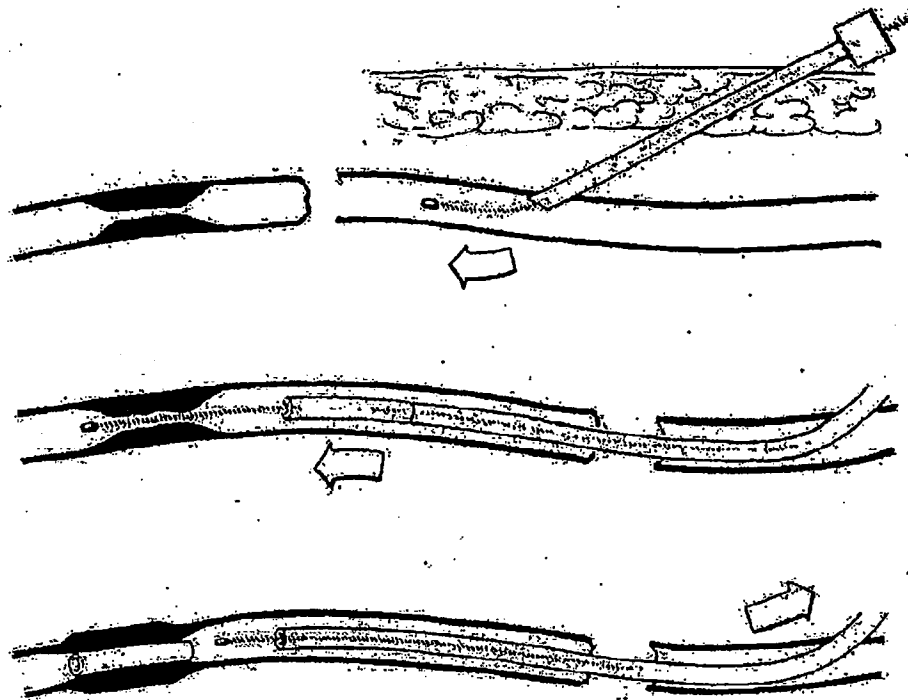


FIG. 1. Technique for percutaneous, transluminal placement of tubular prosthesis within blood vessels. Above: guide introduced through entry needle. Center: guide across narrowing, catheter pushes tube graft toward intended site. Below: withdrawal of guide and catheter leaves graft in place.



FIG. 2. Tubular coil spring endovascular prosthesis. OD 0.14", No. 5 stainless steel wire. Successful implants were 1 cm long.

Coilspring Tubular Prostheses

In the six final experiments, instead of impervious plastic tubing, the grafts were in the form of tubular, open-centered coilsprings wound from No. 5 stainless steel wire, with an outer diameter of 0.14 inches and ranging in length from 1 to 10 cm (Fig. 2). Heparin was given until occlusion occurred, or for four days after grafting. A 10-cm, a 3-cm and a 1-cm silicone-coated graft were found occluded the following day. Two out of three uncoated 1-cm coilsprings remain patent at two and a half years and two and a quarter years following insertion as shown on serial follow-up angiograms (Fig. 3, 4).

Discussion

This report illustrates a simple, basic technique for the transluminal placement of tubular endo-

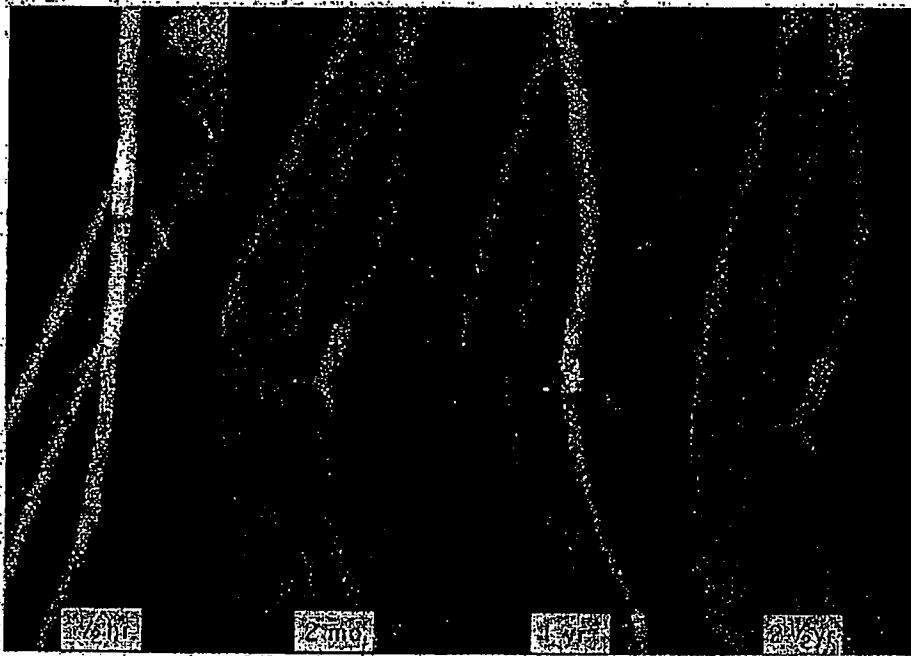


FIG. 3. 245-year patency of 1-cm coilspring graft placed by catheter from left carotid artery in 40-pound dog (3753). Distal migration took place on day of implantation (release of spasm?), but there was no subsequent change in position or patency.

vascular prostheses and points to possible advantages of open coilspring construction. Any prosthesis capable of long-term patency in the canine femoral system warrants attention; though, as Kimmouth, Rob and Simeone point out, "It appears that the success or failure of an arterial substitute in dogs bears no direct relationship to the results one will obtain when a similar substitute is used clinically for the peripheral arteries."³

The success of catheters in the management of atheromatous narrowing slows the feasibility of a transluminal attack; their shortcomings in the presence of complete occlusion have emphasized the need for further improvement, a long-range objective of the present investigation. Porstmann's successful transluminal plugging of 25 consecutive patent ducts without thoracotomy⁴ adds dramatic confirmation to the basic thesis that what can be better accomplished without operative exposure should be.

Theoretic advantages of transluminally-placed coilspring vascular liner prostheses include: the internally-grafted segment of vessel is not removed, incised or even exposed, thus avoiding trauma to an already diseased vessel. Blood loss at the treated site, perivascular hematoma and sutures are not likely to cause difficulty. Open-coil construction permits prompt fibroblastic envelopment and the rapid formation of a new, firmly anchored, autogenous lining surface, thereby favoring continuing patency. Prototype models have shown that coilsprings, either stretched out or wound up and hooked to a controlling mandrel, can be reduced in diameter, favoring their easy introduction and placement. Upon their externally-effected release from the mandrel, they automatically expand for a bigger lumen and better anchoring at the site of placement. Should progress and further experimental work ever lead to a clinical role for transluminal grafting, it seems

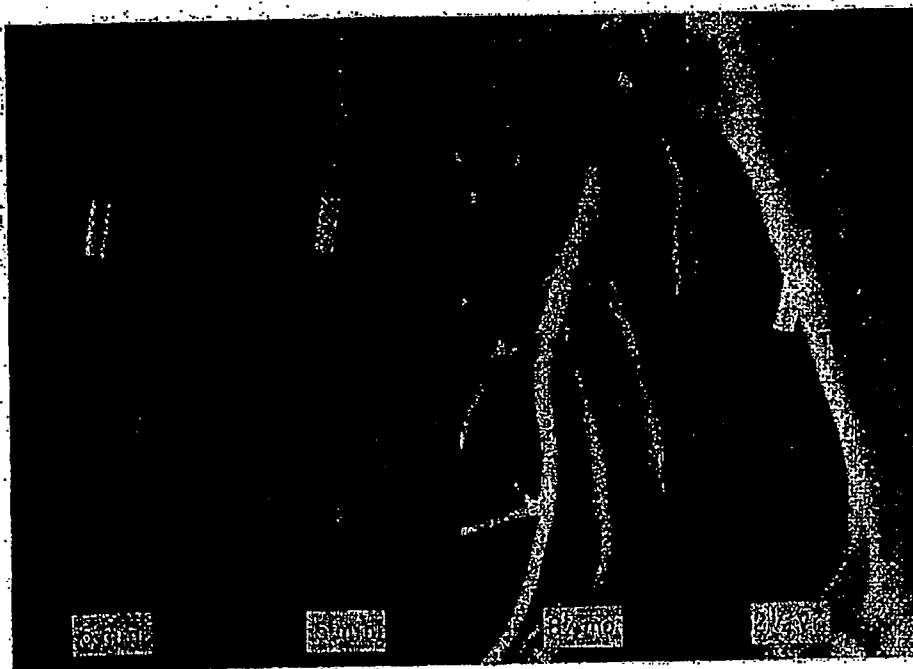


FIG. 4. 2 1/4-year patency of 1-cm collspring graft placed transluminally from left carotid artery in 44-pound dog (3940). No change following initial postplacement migration. Graft does not obstruct adjacent branches.

possible that the demand for technical skill may be desirably less than that now required for competent vascular surgery.

Summary

Tubular prosthetic grafts introduced via carotid arteries were placed transluminally in femoropopliteal arteries in 25 dogs using simple catheter techniques. While various impervious plastic tubes clotted promptly, the adoption of an open collspring configuration has made possible long-term patency. Advantages of this potentially useful approach include freedom from the trauma usually associated with surgical vascular reconstruction.

Key words: graft, catheter dilatation, collspring, femoropopliteal, occlusion.

Address for correspondence: Charles T. Dotter, MD, Department of Radiology, University of Oregon Medical School, 3181 SW Sam Jackson Park Road, Portland, Ore. 97201

REFERENCES

1. Dotter, C. T. and M. P. Judkins: *Circulation* 30:654, 1964.
2. ———, J. Rösch and M. P. Judkins: *Surg. Gynec. Obstet.* 127:794, 1968.
3. Kimmouth, J. B., C. G. Kib and F. A. Simcone: *Vascular Surgery*. Baltimore, Williams and Wilkins Co., 1966.
4. Förstmann, Von W., L. Wierny and H. Warnke: *Fortschr. Röntgenstr.* 109:133, 1968.