THE USE OF TUBES CONSTRUCTED FROM VINYON "N" CLOTH IN BRIDGING ARTERIAL DEFECTS

A PRELIMINARY REPORT*

ARTHUR B. VOORHEES, JR., M.D., ALFRED JARETZKI III, M.D., AND ARTHUR H. BLAKEMORE, M.D.

NEW YORK, NEW YORK

FROM THE DEPARTMENT OF SURGERY, COLUMBIA UNIVERSITY, COLLEGE OF PHYSICIANS AND SURGEONS, NEW YORK, NEW YORK

THE EVOLUTION OF TECHNICS designed to restore normal blood flow through an artery deformed by trauma, disease, or developmental defect has been rapid and varied. The advances in the use of grafts and prostheses in bridging arterial defects have been reviewed by Deterling and Coleman[2] and Hufnagel.[4] The success of each technic is assayed by its ability to restore and maintain function of the impaired artery; failure of function is normally due to an occluding thrombus, a disruption, or a long term degenerative change. Although at present the homologous vessel transplant enjoys the greatest chance for success,[3, 5] technical limitations in its present state of development place it in the category of an elective procedure.

Presented herein is a preliminary report of a technic in which a plastic cloth prosthesis is employed. We believe it offers considerable promise not only for emergency use but for elective use as well, especially since this method avoids the present complicated aspects of arterial graft preservation.

It was observed in this laboratory that a simple strand of silk suture traversing the chamber of the right ventricle of the heart of a dog became coated in a few months throughout its length by a glistening film, free of macroscopic thrombi. As an outgrowth of this observation it was conceived that if arterial defects were bridged by prostheses constructed of fine mesh cloth, leakage of blood through the walls of the prosthesis would be terminated by the formation of fibrin plugs and would thus allow the cloth tubes to conduct arterial flow. In the absence of a foreign body reaction it was anticipated that massive thrombosis would not occur, that fibroblasts would grow into the interstices of the mesh replacing the fibrin plugs, and that the fibroblasts would then serve as a basis for endothelial proliferation, or undergo sufficient adaptation to form a functional intima.

MATERIALS

The prostheses were fashioned from 37 denier, 144 x 90 strands per square inch Vinyon "N"† cloth. The cloth was folded and stitched longitudinally to form tubes of desired length and diameter. Where the Vitallium cuffs were used, precision fitting of the prostheses was accomplished by constructing them with a slight flare at either end. Fifteen mongrel dogs were employed in this preliminary study.

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PROCEDURE

Single cloth prostheses were placed in the abdominal aorta of each dog. The tubes varied from 1 to 6 cm. in length and were sterilized by boiling prior to use. The dogs were anesthetized with intravenous Nembutal supplemented with open drop ether where necessary, and the abdomen was entered through a midline incision. A segment of the abdominal aorta between the renal and iliac arteries was mobilized and divided between rubber shod clamps. The ends were allowed to retract, and in some cases small segments of the aorta were resected. A previously fashioned Vinyon "N" tube of suitable diameter was anastomosed either by employing a running everting mattress silk suture or by employing the non-suture Vitallium cuff technic described by Blakemore.[1] After the rubber shod clamps were released and the arterial flow established, all visible clots were removed from the external surface of the cloth as well as the retroperitoneal area, and the abdomen was closed in layers.

The animals were not given anticoagulant therapy postoperatively. They were sacrificed at stated intervals and aortograms were procured prior to sacrifice (Figs. 1 and 2).

RESULTS

At the time of the anastomosis, bleeding through the wall of the prosthesis was surprisingly little, and the total blood loss never exceeded 100 ml. Following successful anastomosis and removal of the distal clamp there was a free escape of blood through the mesh of the cloth, but within the first 15 to 30 seconds there was a marked reduction of blood flow through the wall of the prosthesis. Simultaneously with this reduction, the proximal clamp was released and the prosthesis allowed to bear the entire arterial pressure. Additional bleeding through the wall of the cloth was minimal and ceased completely in another 15 to 30 seconds.

Of the 15 dogs, eight have been sacrificed, three died from causes other than failure of the prosthesis, and four are living and well (Table I). The eight dogs at the time of sacrifice were in their 153rd, 115th, 99th, 94th, 56th, 51st, 40th, and 19th postoperative days respectively. In four of these, the tubes were patent and without significant mural thrombi. In one, a mural thrombus occluded approximately 25 per

TABLE I.—*Vinyon 'N" Cloth Prostheses in Bridging Defects in the Abdominal Aorta.*

Dog Number	Technic of Anastomosis	Length of Graft	Length of Survival	Length of Survival	Patency at Autopsy
1	Vitallium cuff	2 cm.	19 days	Sacrificed	60%
2	Suture	4 cm.	94 days	Sacrificed	75%
3	Vitallium cuff	4 cm.	99 days	Sacrificed	100%
4	Vitallium cuff	3.4 cm.	153 days	Sacrificed	100%
5	Vitallium cuff	3.5 cm.	115 days	Sacrificed	100%
6	Vitallium cuff	3.5 cm.	1 day	Hemorrhage from insecure ligation of a vertebral artery	100%
7	Vitallium cuff	3.5 cm.	30 days	Distemper	Occluded*
8	Suture	3.2 cm.	86 days	Living	Good femoral pulsations
9	Vitallium cuff	5.8 cm.	84 days	Living	Good femoral pulsations
10	Suture	3.5 cm.	56 days	Sacrificed	100%
11	Suture	2.0 cm.	51 days	Killed in dog fight	100%
12	Suture	4.0 cm.	51 days	Sacrificed	Occluded†
13	Suture	6 cm.	71 days	Living	Good femoral pulsations
14	Vitallium cuff	4.7 cm.	40 days	Sacrificed	Occluded‡
15	Suture	1.0 cm.	63 days	Living	Good femoral pulsations

* Femoral pulsations not felt after the 9th postoperative day.
† Femoral pulsations not felt after the 30th postoperative day.
‡ Femoral pulsations not felt after the 3rd postoperative day.

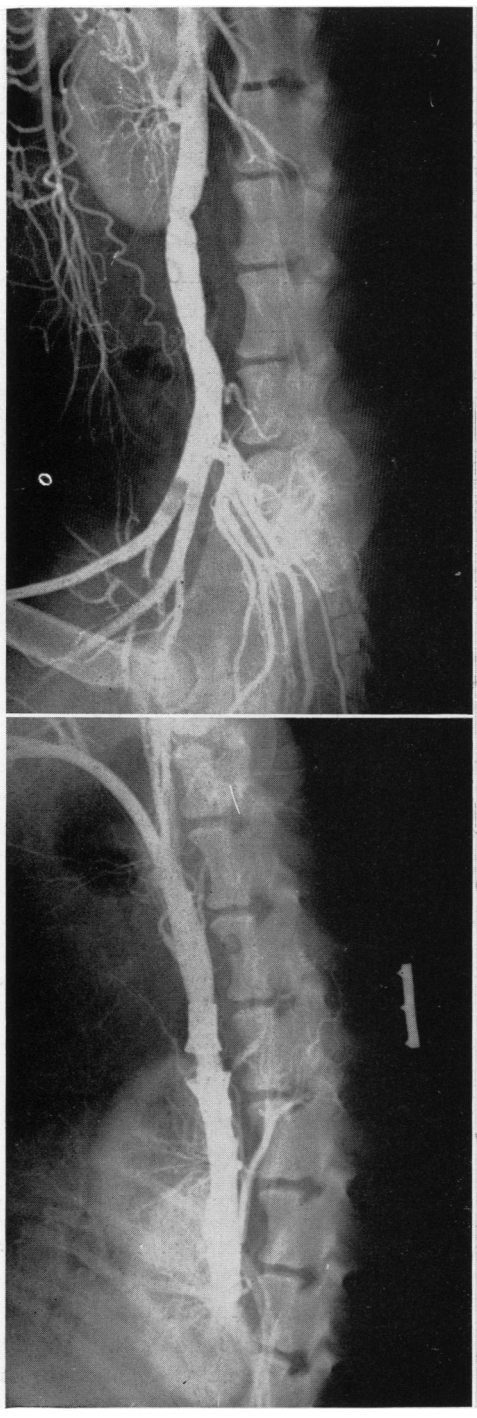

FIG. 1

FIG. 2

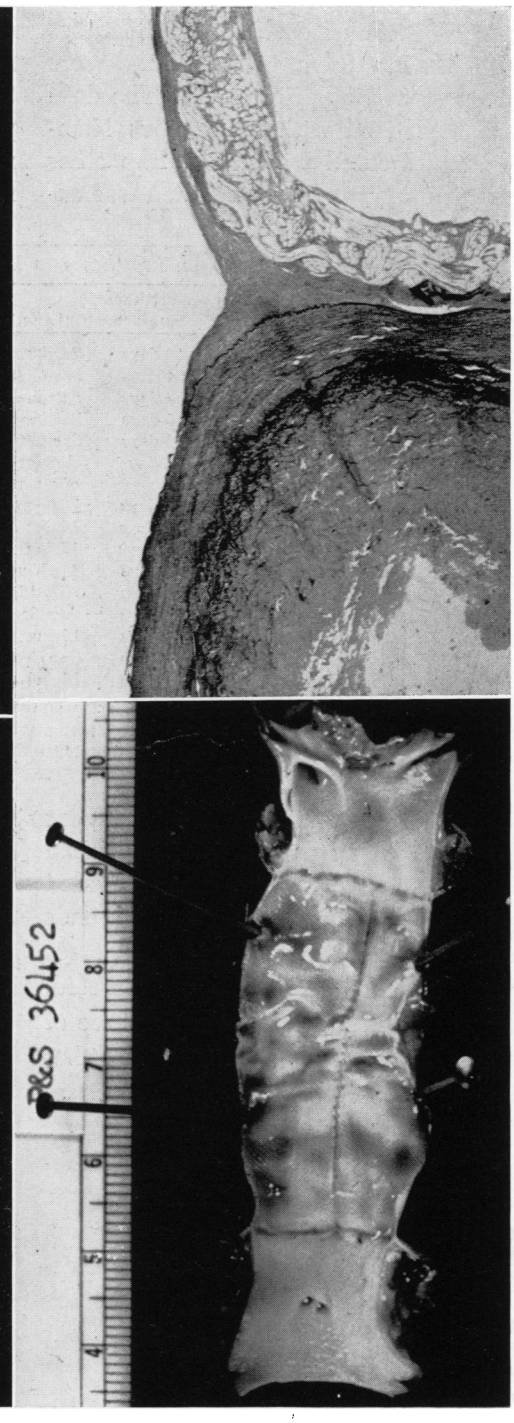

FIG. 3

FIG. 4

(See opposite page for legends.)

FIG. 5

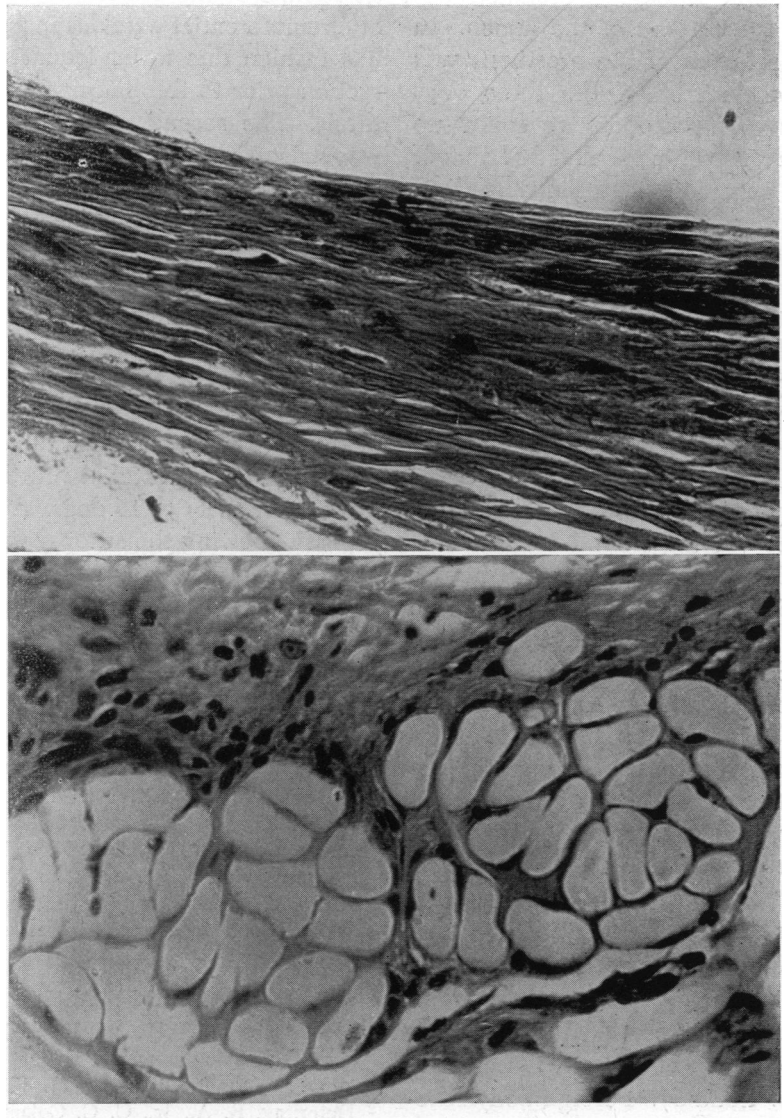

FIG. 6

FIG. 1.—Dog No. 4. Retrograde aortogram of cloth tube area prior to sacrifice; Vitallium cuff technic. Survival time 153 days; prosthesis completely patent.

FIG. 2.—Dog No. 10. Retrograde aortogram of cloth tube area prior to sacrifice; suture technic. Survival time 56 days; prosthesis completely patent.

FIG. 3.—Dog No. 5. Photograph of Vinyon "N" prosthesis placed in the abdominal aorta 115 days previously. The entire lumenal surface of the cloth is covered by a glistening intimal coat (see Figs. 4, 5, and 6). The longitudinal suture line, made in preparing the tube, can be seen.

FIG. 4.—Dog No. 5. Photomicrograph of the junction of aorta and prosthesis. The depression at the line of the anastomosis has been accentuated in removing the Vitallium cuff. Note that the line of anastomosis has been sealed by the ingrowth of fibrous tissue. (Verhoeff stain x 35.)

FIG. 5.—Dog No. 5. Photomicrograph of the intimal layer covering the cloth prosthesis. The layer is composed of flattened fibroblasts and collagen fibers. (Trichrome stain x 300.)

FIG. 6.—Dog No. 5. Photomicrograph of two fibers of the cloth *in situ*. The fibroblasts have grownbetween the fibrils as well as the fibers. (Hematoxylin and Eosin stain x 300.)

cent of the lumen of the prosthesis, and in another a mural thrombus occluded approximately 40 per cent of the lumen. In two dogs the lumen of the prosthesis was completely occluded. Of the three dogs that died in the postoperative follow-up period, one died within the first 24 hours of hemorrhage resulting from insecure ligature of a lumbar artery; one died of distemper on the 30th postoperative day; and one was killed in a fight on the 51st postoperative day. Of these three, two had functioning prostheses prior to death that were filled with postmortem clot at the time of autopsy. The third, in which death was due to distemper, had complete thrombosis of the prosthesis.

At autopsy, all prostheses were enclosed in scar tissue varying from 1 to 5 mm., in thickness. However, the scar tissue showed no constricting tendency in those that were functioning. In every prosthesis, with the exception of the three in which there were occluding thrombi and the one in which the animal died of hemorrhage on the first postoperative day, the internal surface of the cloth was covered by a fine, almost transparent film which varied in color from that of the underlying cloth to a pale pink (Fig. 3). On subsequent microscopic examination it was noted that this film consisted of multiple layers of flattened cells and collagen fibers strikingly similar to the architecture of the normal aorta with the notable absence of elastic and smooth muscle elements (Figs. 4 and 5). Foreign body reaction about the Vinyon "N" fibers, in the form of wandering cell infiltration and giant cell formation, was completely absent. Fibroblasts growing into and through the interstices of the cloth could be seen throughout the sections (Fig. 6).

On careful examination of the prostheses which were partially or completely thrombosed, it was apparent that technical errors were the major contributing factors. The most common finding in this group was shortening of the graft with the formation of circumferential wrinkles in an accordion-like fashion due to inadequate arterial resection prior to the placement of the prosthesis. The second most common finding was stricture at the line of anastomosis produced at the time of operation.

The four dogs still living in this preliminary series are in their 86th, 84th, 71st, and 63rd postoperative days respectively. All have full, strong femoral pulsations indicative of functioning prostheses.

SUMMARY

Porous Vinyon "N" cloth tubes have been used as bridging arterial prostheses in the abdominal aorta of 15 dogs. A preliminary report reviewing the autopsy findings of 11 of the series has been presented. Eight of the 11 autopsied dogs had functioning prostheses throughout their postoperative courses. Of the four living dogs, all have excellent femoral pulsations. The longest postoperative follow-up period was 153 days; the shortest was 24 hours.

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