The equipment was made available by a grant from the S.E. Metropolitan Regional Hospital Board.

REFERENCES

- Bernstein, L., D'Silva, J. L., and Mendel, D. (1952). *Thorax*, **7**, 255.
 Bickerman, H. A., Beck, G. J., and Barach, A. L. (1955). *J. chron. Dis.*, **2**, 247.
 Birch, C. A. (1960). *Practitioner*, **184**, 440.
 Cara, M. (1953). *Poumon*, **9**, 406.
 Clifton, M., and Stuart-Harris, C. H. (1962). *Lancet*, **1**, 1311.
 Cullen, J. H., and Reidt, W. U. (1960). *Amer. Rev. resp. Dis.*, **82**, 508.
 Davies, B. M., and Williams, D. A. (1955). *Brit. med. J.*, **2**, 293.
 Felix-Davies, D., and Westlake, E. K. (1956). *Ibid.*, **1**, 780.
 Fletcher, C. M. (1958). *Postgrad. med. J.*, **34**, 310.
 Gaensler, E. A. (1951). *Amer. Rev. Tuberc.*, **64**, 256.
 Kennedy, M. C. S. (1953). *Thorax*, **8**, 73.
 Lewinsohn, H. C., Capel, L. H., and Smart, J. (1960). *Brit. med. J.*, **1**, 462.
 Lorrman, G. (1959). *Thorax*, **14**, 146.
 Moyes, E. N., and Kershaw, R. A. (1957). *Lancet*, **2**, 1187.
 Needham, C. D., Rogan, M. C., and McDonald, I. (1954). *Thorax*, **9**, 313.
 Nicholson, H. (1955). *Practitioner*, **175**, 590.
 Tiffeneau, R., Bousser, J., and Drutel, P. (1949). *Paris méd.*, **39**, 543.
 Wright, B. M., and McKerrow, C. B. (1959). *Brit. med. J.*, **2**, 1041.

SIMPLIFIED ARTERIOVENOUS SHUNT FOR USE IN HAEMODIALYSIS

BY

JACK NAYMAN, F.R.C.S., F.R.C.Sed., F.R.A.C.S.

Haemodialysis Unit, Alfred Hospital, and Department of Surgery, University of Melbourne

Scribner *et al.* (1960) in their first description of an arteriovenous shunt for use in haemodialysis employed a supporting plate. This plate proved unsatisfactory because of the rotatory stresses imposed on the vessel cannulae, and has since been discarded. Various modifications in joining the by-pass to the vessel cannulae have been described (Quinton *et al.*, 1961; Sinclair *et al.*, 1961; Nayman, 1962). It has been the experience in this unit that a nut-bolt union which some of these designs incorporate is unsatisfactory. The threads on occasion have become filled with blood clot and the manœuvre of screwing the two components together has caused torsional strains on the by-pass and vessel cannulae. Hence it was thought advisable to discard the type of screw union previously described (Nayman, 1962).

The above designs of arteriovenous shunts involve the use of three tubular components (two vessel cannulae and a by-pass shunt) and either two or four junctions.

Principle and Material Used

A model has been designed in this unit which does not require a separate by-pass component and has only a single junction, which is of a non-screw type. The principle involved is to employ only arterial and venous cannulae, which for the purpose of haemodialysis are connected direct to the extracorporeal circuit.

At the termination of haemodialysis a shunt is effected by connecting the arterial cannula direct to the venous one. This technique requires a plastic that is flexible and allows some change in its alignment. Polytetrafluorethylene ("teflon") is wholly unsuitable because of its rigidity, and has been replaced by polyvinyl chloride. This plastic material does not have the same potential of repelling water that teflon has, but has proved eminently suitable for use in the treatment of acute renal failure, where there is no need for the arteriovenous shunt to be retained in position for periods longer than three to four weeks.

Fashioning of Cannulae Ends

Apposition between the respective vessel cannulae is effected by fashioning the distal ends of each into a right-angled flange, which facilitates a fairly large area of contact without any change in the internal diameter of the cannulae.

The construction of this right-angled flange utilizes the principle of heating the plastic to the required shape and maintaining this shape by cooling. The inherent quality of any plastic material is such that a change in shape has to be brought about in a graduated manner. It has been our experience that the shaping of this right-angled flange is

best done in two stages. The first stage entails converting the cylindrical shape into a cone. This is achieved by inserting a heated cone-shaped flaring mandrel into the end of the cannula (Fig. 1,A). The heat causes the plastic to flow on to the mandrel, and when the desired shape is obtained the cannula and mandrel are rapidly cooled (Fig. 1,B).

FIG. 1.—Stages of formation of right-angled flange. A: Cone-shaped flaring mandrel prior to insertion into end of catheter. B: Cone-shaped flange formed. C: Section of right-angled flange and right-angled flaring mandrel. D: Section of junction, indicating how apposition of the right-angled flange is maintained by the male and female components.

A right-angled flaring mandrel is now inserted into this cone (Fig. 1,C). The above process is repeated and the cone is now converted into the desired right-angled flange.

These two right-angled flanges have to be maintained securely in position without any danger of leakage, and must be capable of withstanding any stresses occasioned by movement. At the same time this junction has to be so designed that the connexion to the extracorporeal circuit is simple and rapid.

Junction

The right-angled flanged ends are secured in position by a non-screw "perspex" male-and-female junction. The male and female counterparts are each threaded over the vessel cannulae. These fittings are so designed that the external diameter of the male end, the internal diameter of the female recess, and the diameter of the flanged ends of the vessel cannulae are all congruent (Fig. 1,D). The union of the male and female parts will therefore ensure adequate contact of the flanged ends. This is maintained and secured by an appropriately designed spring clip.

This spring clip is fixed to, and in the disengaged position pivots on, the expanded end of the male part of the junction fitting. The other end of the spring is shaped so as to engage over the distal end of the female fitting. When in this engaged position the spring is prevented from slipping

by an encircling metal safety-clasp as shown in Fig. 2. These clasps are disposable. This clip-on spring is so designed that the manipulations of engagement and disengagement are easy to perform, and the tension in the engaged position is such as to maintain a union, free from

effluent limb of this arc. The use of a superficial vein allows, in many instances, the placement of the junction at the apex of the external arc.

The vessel components are shown held together by two pins, and the streamlined course in forming the arc is well illustrated. The flexibility of the polyvinyl-chloride is well adapted to assume this and any other desired position (Fig. 2).

FIG. 2.—Reconstruction of shunt removed after 15 days. The junction is placed asymmetrically in the external arc.

leakage and unaffected by pressure changes and stress effects.

Description of Completed Shunt

This model is such that it is tailored to the specific requirements of each individual patient. It has been our practice to cannulate the brachial artery at the elbow and either the associated vena comitans or one of the related superficial veins. The internal diameter of the vessel is measured and cannulae of corresponding size are selected for construction of the shunt. We have found the use of tapered catheters (manufactured by Travenol and ranging in size from No. 4 F to No. 14 F) very suitable. This enables the appropriate size for each patient to be selected, and the redundant lengths are cut off and discarded. The shunt is then fashioned as described above. A special apparatus and equipment has been designed for this purpose, which will be recorded in detail later. After insertion of these cannulae the distal ends of both artery and vein are divided so that the course of the cannulae to the skin surface is as smooth as possible.

Because this model is different from previously described patterns the nomenclature of its component parts must be established.

This arteriovenous shunt pursues a course which commences in the artery, then passes through the subcutaneous tissues to reach the exterior, where it describes a smooth arc and then returns through the skin and subcutaneous tissue to a superficial vein or to a deep vena comitans.

In Fig. 2 the course of a shunt that had been in place for 15 days is shown. The curvature that had been assumed while in position in the patient has been reconstructed.

The main components of the shunt can be described as follows: (1) Vessel component (length of lumen of vessel); (2) subcutaneous component (part between emergence from vessel and penetration of skin); (3) external arc. This has an apex and two limbs—namely, afferent or arterial and effluent or venous.

When the vena comitans has been used the excursion of the external arc is usually fairly small because of the close apposition of the vessel components, and in order to avoid kinking of the cannulae the junction is usually placed asymmetrically in either the afferent or

Connexion to Extracorporeal Circuit

The arterial circulation is first arrested by the application of a sphygmomanometer cuff on the upper arm, which is inflated. The metal clip is then removed, the clip-on spring is disengaged, and the male and female components of the junction are separated. Fig. 3 is a drawing of a shunt with the sphygmomanometer cuff in position.

In order to connect the vessel cannulae to the male Luer-Lok fittings of the extracorporeal circuit two special adaptors have been constructed. These are shown in Fig. 4, and consist of a proximal and distal end, the proximal end being shaped so as to receive the male Luer-Lok fittings of the outflow and inflow tubes of the extracorporeal circuit.

FIG. 3.—Drawing of shunt prior to connexion to extracorporeal circuit. The sphygmomanometer cuff is banded in position. The encircling safety-clasp has been removed.

The proximal ends are shaped to fit the male and female parts of the junction by being fashioned into reciprocal female and male counterparts. The spring on the male component of the vessel cannula clips on to the proximal

FIG. 4.—Reconstruction of connexion to extracorporeal circuit by specially designed adaptors. The junction is disengaged and the external arc opened up.

female end of one adaptor. The proximal male end of the other adaptor has a similar spring which clips on to the female component of the other vessel cannula.

Connexion to the extracorporeal circuit is shown in Fig. 5. In this instance the junction was situated in the afferent limb close to its emergence from the skin. The outflow and inflow tubes are passing in opposite directions in an endeavour to disturb the shape of the arc as little as possible. Fig. 4 indicates how the arc can be opened up

FIG. 5.—Showing connexion of patient to extracorporeal circuit.

and the adaptors are placed in position. The male Luer-Lok fittings are placed in the distal end of each adaptor.

At the termination of haemodialysis the sphygmomanometer cuff is again inflated, the adaptors are removed and the arterial and venous limbs of the external arc connected to one another.

This shunt has now been used in 20 patients and a total of 52 dialyses have been performed. It has proved eminently satisfactory because of its simplicity, its few parts, and the facility with which it can be tailored to the specific requirements of the individual patient.

Summary

A simplified arteriovenous shunt is described.

No by-pass component is employed and only a single junction is used.

Connexion to the extracorporeal circuit and re-establishment of the arteriovenous shunt is simple and rapid.

I wish to thank Mr. F. H. Caldwell for his invaluable help in the construction and development of this arteriovenous shunt. To Mr. E. Mackay I am indebted for the photographs and my thanks to Mr. G. Hillas for Figures 1 and 3.

REFERENCES

- Nayman, J. (1962). *Lancet*, **1**, 727.
 Quinton, W. E., Dillard, D. H., Cole, J. J., Scribner, B. H. (1961). *Trans. Amer. Soc. artif. intern. Organs*, **7**, 60.
 Scribner, B. H., Buri, R., Caner, J. E. Z., Hegstrom, R., Burnell, J. M. (1960). *Ibid.*, **6**, 104.
 Sinclair, I. S. R., Henderson, M. A., Simpson, D. C. (1961). *Lancet*, **2**, 410.

CONTROL OF ANTICOAGULANT THERAPY BY THROMBOTEST METHOD

BY

J. W. KEYSER, M.Sc., Ph.D., F.R.I.C.

Reader in Chemical Pathology in the University of Wales at the Welsh National School of Medicine; Honorary Consultant in Biochemistry, the United Cardiff Hospitals

From the Institute of Pathology, Royal Infirmary, Cardiff

In his original publication on the thrombotest, Owren (1959) gave the therapeutic range of clotting activity in anticoagulant therapy as 10 to 30% of normal. The lower level was determined by the risk of bleeding and the upper level by the risk of inadequate therapy. In the light of further experience the upper limit was subsequently lowered to 25% (Owren, 1961) and still more recently to 20%, a level of 15% being aimed at (Owren, 1962a, 1962b). Loeliger (quoted by Owren, 1962b) aims at 12%, his therapeutic range being 7 to 15%.

According to Poller (1962), in most centres the main danger to patients on anticoagulant treatment is not haemorrhage but rather a recurrence of thrombosis or the development of embolism; and in a review of venous thrombosis in two hospitals in the United States Zollinger *et al.* (1962) found that therapy with prothrombin depressants had been ineffective in at least 60% of the cases, as judged by an analysis of the laboratory results, and in many patients pulmonary embolism occurred, presumably as a result of inadequate dosage.

It is known that a thrombotest level between 10 and 25% of the normal does not represent as marked a depression of coagulation activity as a similar figure obtained by the Quick prothrombin test or one of its modifications (Lempert and Poller, 1960; Vigran, 1961; Poller, 1962; and others). This accounts for the reduc-

tion in dosage of anticoagulant that usually results from a change from the Quick test to the thrombotest.

In view of these considerations it seemed important to compare the thrombotest with the prothrombin technique in use in this laboratory, especially as the existence of numerous modifications of the prothrombin test have led to some uncertainty about the comparability of the results obtained in different centres; for example, it has been shown in this laboratory (Powell, 1957) that prothrombin ratios (see below) obtained by the use of a fresh brain emulsion (Toohey, 1941, 1950; Owen and Toohey, 1941) are considerably higher than those obtained with an extract of acetone-dried brain.

On the assumption that it is desirable to lower the coagulability of the blood as much as possible without undue risk of haemorrhage, the results of this investigation suggest that in the control of anticoagulant therapy with the thrombotest a range of 8 to 15% is preferable to one of 10 to 20%.

Material and Methods

More than 200 specimens of citrated venous blood, mostly from patients with myocardial infarction, were tested. Most of the patients were receiving phenindione (phenylindanedione; "dindevan"), but some were receiving nicoumalone (3-[2-acetyl-1-(4-nitrophenyl)ethyl]-4-