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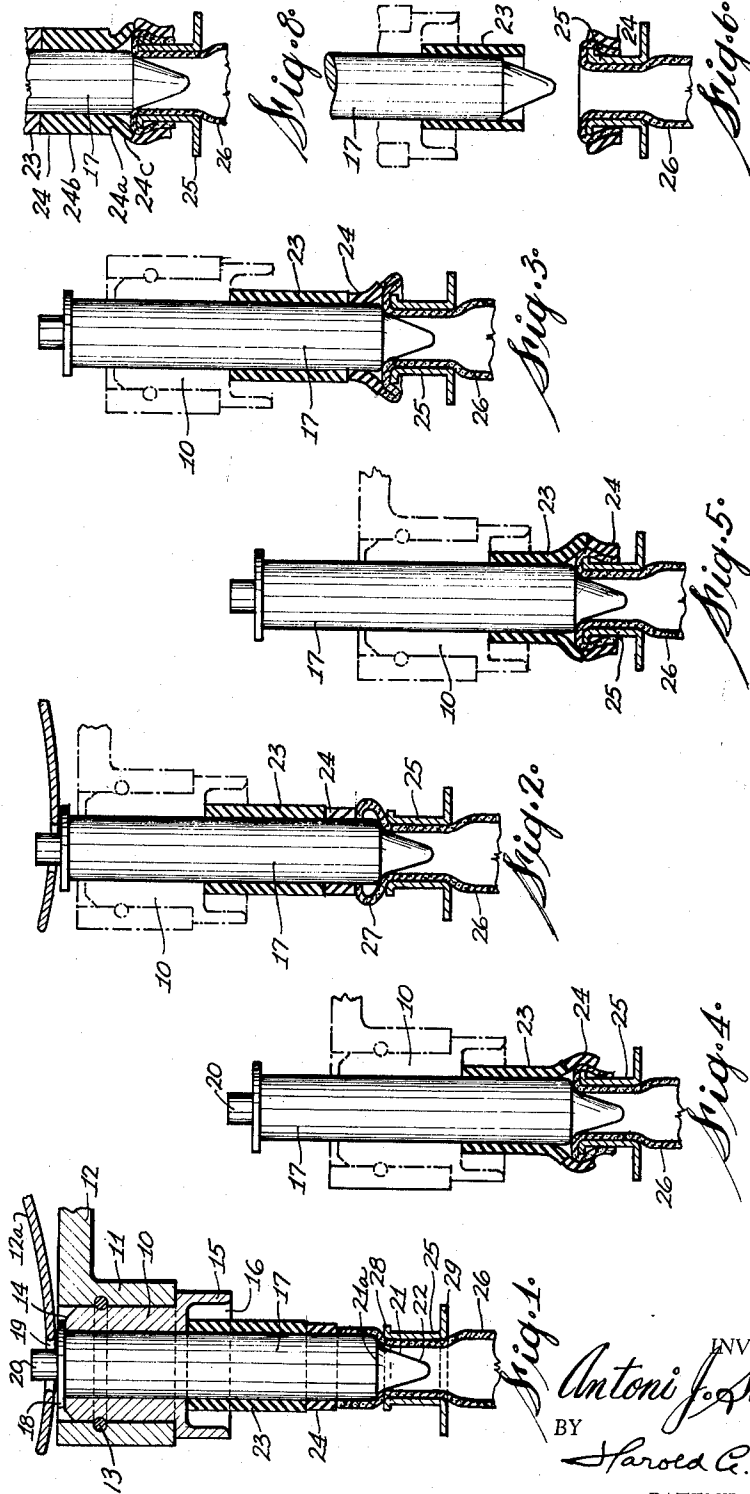
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VASCULAR EVERTING DEVICE

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2 Sheets-Sheet 1



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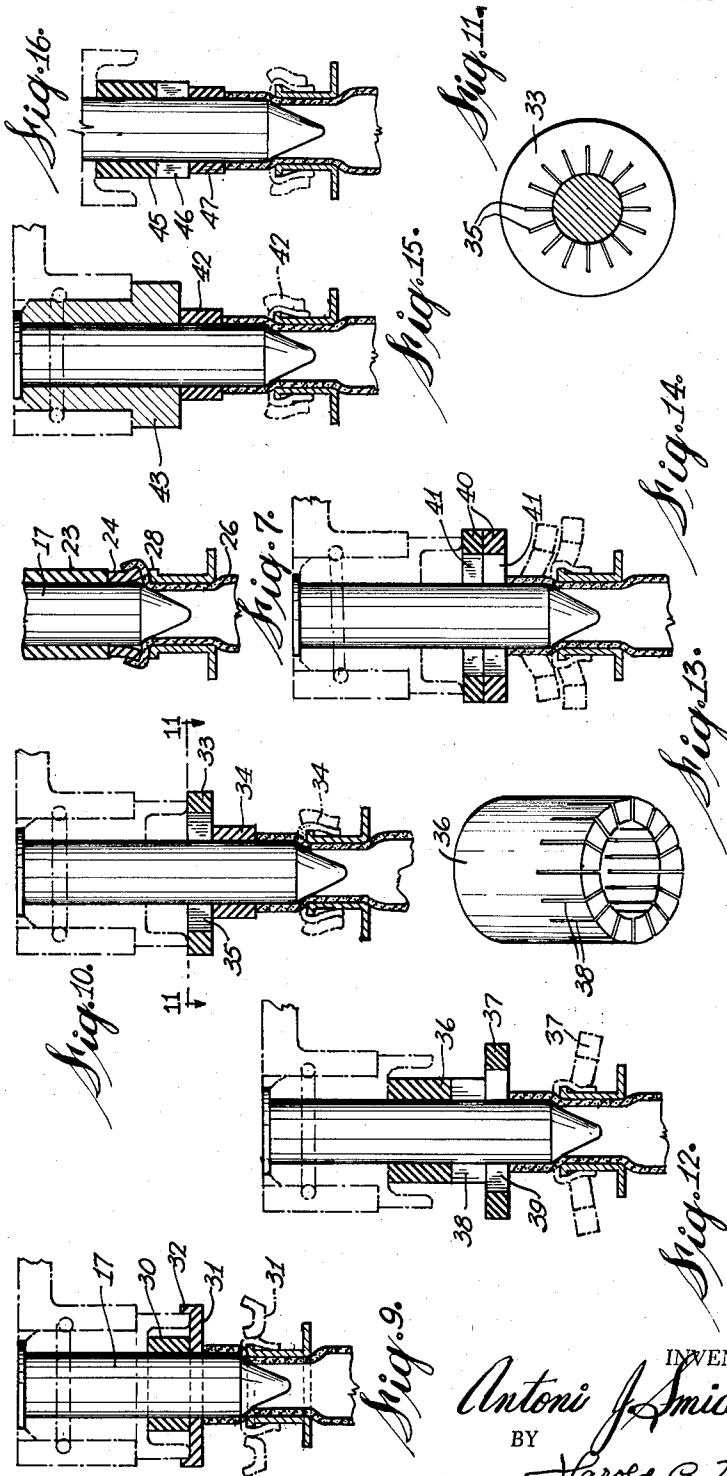
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VASCULAR EVERTING DEVICE

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9 Claims. (Cl. 128—334)

This invention relates to a device for everting the ends of blood vessels and the like and for retaining them in an everted position.

For the use of peripheral suturing apparatus such as described in United States Patent 2,940,451, it is desirable to provide means for facilitating the everting of the end of a blood vessel or the like over the end of a bushing and for holding the everted vessel in that position until a suture is made.

In United States Patent 3,057,355, there is described a vascular everter which may be employed to effectively perform its function in a rapid and satisfactory manner. The present invention relates to a vascular everter of similar type but modified form.

An object of the present invention is to provide a vascular everter which is simple in form, convenient to operate, gentle in action whereby injury to the vessel is avoided, and fully satisfactory in the type of everting operation effected.

Another object is to provide a vascular everter which effectively holds the everted vessel in desired position for performance of a subsequent suturing operation.

Another object is to provide a vascular everter which is capable of everting blood vessels of substantially all size ranges and particularly those in the smallest size range.

The invention may be said to reside in a vascular everter comprising a sleeve, a plunger mounted for reciprocal movement in said sleeve and being of uniform diameter throughout the major portion of its longitudinal extent, said plunger having a radially directed flange extending from one end of said major portion and a conical portion extending axially from the other end of said major portion, said conical portion having a maximum diameter less than the diameter of said major portion, and an annular everting-retaining member of elastic material arranged to be sleeved upon said major portion of said plunger and having an axial opening of a diameter less than that of said major portion. The invention also includes a pusher of elastic material arranged to be sleeved upon the major portion of the plunger between the sleeve and the annular everting-retaining member and having an axial opening of a diameter less than that of such major portion.

The invention will be described with reference to the accompanying drawings, in which

FIGURE 1 is a sectional side elevation of an everter in accordance with the invention in an initial everting position relatively to a vascular vessel,

FIGURES 2 to 6, inclusive, are sectional side elevations of the everter of FIGURE 1 in succeeding positions of the everting operation,

FIGURE 7 is a sectional side elevation of the everter showing a variation in the operation thereof,

FIGURE 8 is a sectional side elevation of a slightly modified form of everter,

FIGURE 9 is a sectional side elevation of a modified form of everter,

FIGURE 10 is a sectional side elevation of another modified form of everter,

FIGURE 11 is a sectional view on line 10-10 of FIGURE 10,

FIGURE 12 is a sectional side elevation of still another form of everter,

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FIGURE 13 is a perspective view of an everter element employed in the form of FIGURE 12,

FIGURE 14 is a sectional side elevation of another modified form of everter,

FIGURE 15 is a sectional side elevation of a still further modification of the invention, and

FIGURE 16 is a sectional side elevation of a still further modification of the invention.

Referring to FIGURE 1, the everter illustrated comprises a sleeve 10 which is adapted to be releasably mounted, as by a spring ring 13, in a tubular member 11 carried by a handle 12. Member 11, handle 12, and a flat spring 12a also carried by handle 12, are elements of a holder which may be employed to operate the everter of the present invention and which is described and illustrated in United States Patent 3,057,355.

As shown, the sleeve 10 has an upper end 14 adapted to be disposed adjacent the end of tubular member 11 to which the handle 12 is fixed, and a lower end 15 projecting from the other end of tubular member 11. While not essential, the lower end 15 may be provided with an internal cup-shaped recess 16. A plunger 17 is reciprocally mounted in the sleeve 10. The upper end of the plunger, i.e., the end adjacent handle 12, is provided with a flange 18 for engagement with the adjacent end edge of the sleeve to prevent the plunger from passing through the bore of the sleeve. The spring 12a resiliently urges the plunger into a position in which the flange 18 is in engagement with the sleeve. The spring 12a is slotted at 19 to receive a projection 20 on the end of the plunger.

As shown, the plunger 17 is of substantially uniform diameter throughout its length but has a steeply tapered conical portion 21 extending from the lower end thereof and terminating in a rounded end 22. The conical portion 21 has a maximum diameter less than that of the plunger and a radially inwardly extending annular shoulder 21a contiguous with and lying in a plane substantially normal to the axis of the constant diameter portion of the plunger and the conical portion thereof joins such portions.

The device includes a pusher in the form of a deformable flexible tube 23 which is sleeved onto the plunger and which is arranged to frictionally engage the surface of the plunger to maintain its position thereon but which permits reciprocation of the plunger with respect thereto. The tube 23 has an upper end portion normally received within the cup-shaped recess 16 with its end in engagement with the bottom wall of the recess. The lower end of the tube 23 is disposed below recess 16 for engagement with the upper end of an everting-retaining member in the form of a second deformable flexible tube 24, which, in the modification illustrated, is relatively shorter than tube 23, and which is also sleeved upon plunger 17 and in frictional engagement therewith. The lower end of tube 24 is disposed adjacent to but spaced above the lower end of the plunger.

Tubes 23 and 24 are formed of a resilient material such as rubber, plastic composition, or the like. Rubber of 40 to 50 Shore Durometer is particularly satisfactory for the material of the tubes.

A bushing of a suturing instrument is indicated at 25 and the end portion of a vascular vessel 26 is shown as passing through the bushing and protruding from the end thereof.

The diameter of the plunger must be slightly larger than that of the bore of the bushing. Moreover, the plunger, as employed in an instrument such as set forth in Patent 3,057,355, should have a length that will accommodate the lengths of the recess 16, tube 23, and tube 24, as well as provide an exposed length thereof equal approximately, in the modification shown, to its diameter.

As previously indicated, the bores of tubes 23 and 24 are smaller than the diameter of the plunger to ensure a snug

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fit thereon. Moreover, the thickness of the wall of each tube must be such as to provide adequate axial stiffness without loss of resiliency. It will be apparent that such wall thickness will depend upon the diameter of the plunger. By way of example, a suitable thickness would be in the range of .25 to .75 of the plunger diameter. It will be appreciated that such thickness will depend upon the hardness of the rubber employed, and the actual plunger size and its selection will depend to some extent on the blood vessel with which it is to be used.

The tube 23 has a length sufficient to retain it on the plunger when positioned with a portion thereof projecting beyond the end of the plunger. It may be fixed to sleeve 10.

The length of tube 24 is, as shown, approximately equal to the bore of the bushing. However, it may be shorter and, in general, its length is governed by the size and proper functioning of the bushing.

In operation, with the associated parts positioned as shown in FIGURE 1, the projecting end portion of the plunger, including the conical portion 21, is inserted into the vessel 26 through the open end thereof protruding from the bushing 25. It will be noted that the conical portion 21 is no longer than the height of the bushing and is elongated to facilitate insertion into the vessel. In this position, the end of the vessel is in approximate engagement with the lower end of tube 24 and the vessel is locked in position by a gentle pressure exerted thereon by the shoulder 21a against the rim 28 of the bushing in response to a suitable tension of flat spring 12a.

The sleeve 10, with tubes 23 and 24, is now moved downwardly with respect to the plunger by means of the handle 12. The progressive effect of this movement is illustrated in FIGURES 2 to 6, inclusive.

As shown in FIGURE 2, the end of the vessel, under the direct pressure of tube 24, buckles outwardly, since it cannot move back into the bushing, forming a single bulge 27. It will be apparent that it is quite desirable that only a single bulge 27 be formed in the protruding vessel and to this end the length of the protruding portion should desirably be approximately equal to or less than its own outside diameter.

Further movement of the sleeve 10 forces the tube 24 to spread against rim 28 of the bushing taking with it the buckled end of the vessel 26 and forming it over the rim 28, as shown in FIGURE 3.

In some instances, the tube 24 may go in between the vessel and the plunger as shown in FIGURE 7; this happens, for example, when the vessel is oversized in relation to the bushing or is stretched.

In the next and final stage of the operation, as shown in FIGURE 4, the tube 24 is entirely over the vessel and has turned the latter completely over the bushing. In this position the protruding vessel end has been everted over the rim 28 and is held in such everted position by the encircling elastic tube 24. Further, in this position, the lower end of tube 23 has become deformed in pushing the tube 24 over the bushing. However, a major portion of tube 23 is still in frictional engagement with plunger 17.

With completion of the everting step, it is now only necessary to withdraw the device from the bushing, and with such withdrawal, the tube 23 moves with the plunger and is thus separated from the bushing, leaving, however, the short tube 24 in encircling retaining position with respect to the everted portion of the vessel on the bushing, as shown in FIGURE 6. It will be apparent that the tube 24 is of disposable type and is adapted to be removed from the vessel by severing following the suturing operation. Thus, a new tube 24 is required for each cuff turning.

It will be appreciated that the spring 12a is adapted to control pressure of the plunger against the bushing, preventing damage to the blood vessel while at the same time providing force for holding the blood vessel in position whereby it is prevented from being pushed back into the bushing.

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FIGURE 8 illustrates a slightly modified form of pusher tube 24 wherein such a tube, indicated at 24a, has a main body section 24b of increased thickness as compared with deformable end section 24c. Since section 24b is not readily subject to deformation, this structure will act to prevent pushing of the member 23 too far down on the bushing.

FIGURE 9 illustrates a modified type of everter wherein instead of tubes 23 and 24, a tube 30, serving as an axially rigid pusher, and a washer 31, serving as an everting-retaining member, of elastic material are provided on the plunger 17. Tube 30 has a length approximately equal to the axial extent of recess 16, and washer 31 has a diameter somewhat greater than that of the end 15 of the sleeve 10 whereby it is engaged by the edge of the wall forming recess 16. The washer may have a peripheral shoulder 32 for engagement with the outer surface of end portion 15.

The everting operation follows the same stages as described with respect to FIGURES 1 to 6. As shown in dotted lines, on completion of the everting operation, the washer 32 encircles the everted end of the vessel on the bushing to retain it in position thereon when the pusher 30 is retracted.

Referring to FIGURES 10 and 11, the modification therein shown comprises a washer 33, as the pusher member, and a tube 34, as the everting-retaining member, of elastic material positioned on the plunger 17. The washer 33 has a plurality of radial cuts 35 therein extending from its central opening wherein the washer is relatively stiff in the axial direction thereof but has a deformable annular section adjoining its axial opening. The washer is positioned for engagement by the end edge of end portion 15 of the sleeve 10. Tube 34 is located below washer 33. It will be apparent that the washer 33 will initially act upon tube 34 to perform the everting operation, as similarly shown in FIGURES 1 to 6, by reason of its deformable section, as indicated in dotted lines.

Referring to FIGURES 12 and 13, a tube 36 of elastic material serves as a pusher and a washer 37 also of elastic material serves as the everting-retaining member. Tubes 36 is somewhat similar to tube 23 but is somewhat stiffer and requires a plurality of cuts 38 in the lower end portion thereof to permit ease of spreading action over the rim 28 of the bushing. The length of the cuts limits the "follow up" travel of the pusher member 36, thus preventing deposit of member 37 beyond its proper location. Washer 37 is similar to washer 33 and also has a plurality of radial cuts 39 forming a deformable annular section adjoining its axial opening. In this instance, the washer 37 remains in encircling relation to the everted vessel on the bushing and the tube 36 is withdrawn therefrom with the plunger. It will be apparent that, as in FIGURE 1, tube 36 may be fastened to sleeve 10.

Referring to FIGURE 14, a pair of superimposed elastic washers 40 are provided on the plunger, each washer having radial cuts 41 therein adjoining its axial opening.

Referring to FIGURE 15, a single elastic tube 42 serving as an everting-retaining member is provided on the plunger, and instead of sleeve 10, a sleeve 43 having a smooth unrecessed end face 44 for engagement with the end tube 42 is provided to serve as a sleeve and pusher. In the absence of a resilient member such as 23, FIGURE 1, the upper end of tube 42 will be disposed generally radially opposite the rim of the bushing at the completion of the everting operation. Actually, to guard against injury to the vessel, an end portion of the tube may be left in protruding relation to the bushing. Such a protruding end portion does not interfere with the subsequent suturing operation. It will be apparent that the face 44 must offer as little resistance as possible to spreading of the end of the tube thereon during the everting operation. Thus, the sleeve 43 is desirably made of a material such as that known under the trademark "Teflon."

FIGURE 16 illustrates a modification wherein a pusher

member 45 of elastic material (similar in structure to member 36 of FIGURES 12 and 13) having a plurality of cuts 46 in the lower end portion thereof and an everting-retaining member in the form of an elastic tube 47 are provided.

I claim:

1. A vascular everter comprising a cylindrical sleeve, a plunger mounted for reciprocal movement in said sleeve and having a major constant diameter portion, a radially directed annular shoulder lying in a plane substantially normal to the axis of said plunger, said shoulder being contiguous with and extending inwardly from one end of said constant diameter portion, and a conical portion having a maximum diameter less than that of said constant diameter portion and being contiguous with and extending axially from said shoulder, and an everting-retaining annular member of elastic material having an axial opening in unstretched condition thereof of a diameter less than that of said constant diameter portion and being sleeved in stretched condition upon said constant diameter portion for snug engagement therewith.

2. A vascular everter as defined in claim 1, wherein said annular member is a rubber tube having a constant internal diameter from end to end thereof.

3. A vascular everter comprising a sleeve, a plunger mounted for reciprocal movement in said sleeve and having a major constant diameter portion, a radially directed flange extending outwardly from one end of said constant diameter portion, a radially directed annular shoulder lying in a plane substantially normal to the axis of said plunger, said shoulder being contiguous with and extending inwardly from the other end of said constant diameter portion, and a conical portion having a maximum diameter less than that of said constant diameter portion and being contiguous with and extending axially from said

shoulder, said flange having seating engagement with one end of said sleeve, said plunger projecting beyond the other end of said sleeve, and a pair of annular members of elastic material each having an axial opening in unstretched condition thereof of a diameter less than that of said constant diameter portion and being sleeved in stretched condition upon said constant diameter portion for snug engagement therewith.

4. A vascular everter as defined in claim 3, wherein said annular members are tubes of different lengths.

5. A vascular everter as defined in claim 3, wherein said annular members are washers.

6. A vascular everter as defined in claim 3, wherein one of said annular members is a tube and the other of said annular members is a washer.

7. A vascular everter as defined in claim 3, wherein said annular members are formed of rubber of 40 to 50 Shore Durometer.

8. A vascular everter as defined in claim 3, wherein one of said annular members is a washer having a plurality of radial cuts extending from its said axial opening to form a deformable annular section thereof adjoining said axial opening.

9. A vascular everter as defined in claim 3, wherein one of said annular members is a tube having a plurality of cuts extending longitudinally from one end thereof to form a deformable section adjoining said one end.

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