

Jan. 3, 1967

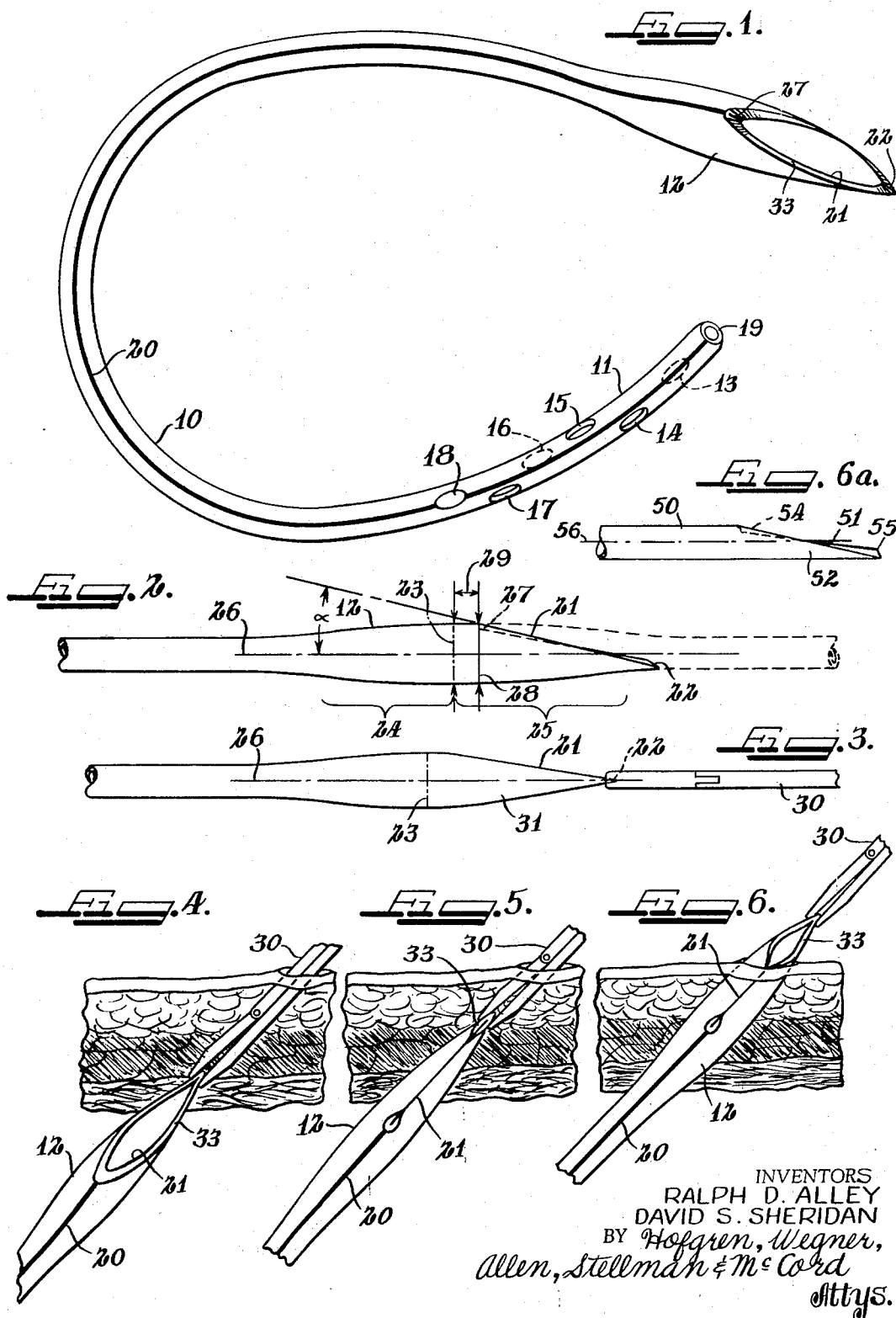
R. D. ALLEY ETAL

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INTERCOSTAL CATHETER

Filed Jan. 27, 1966

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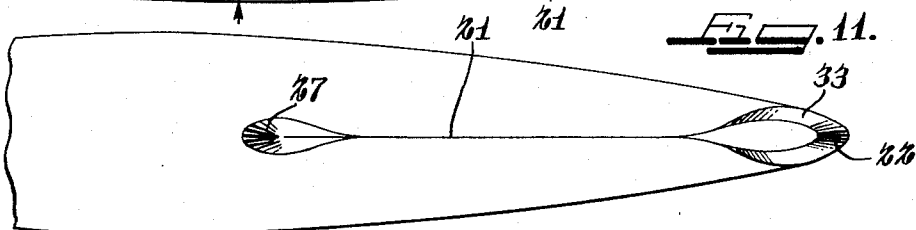
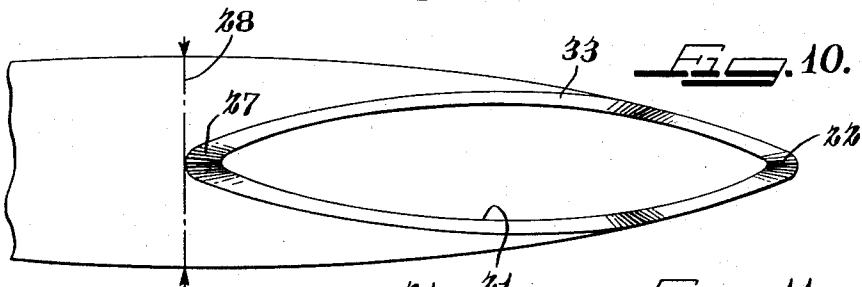
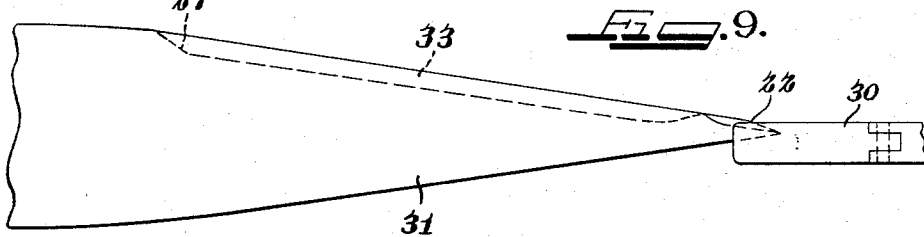
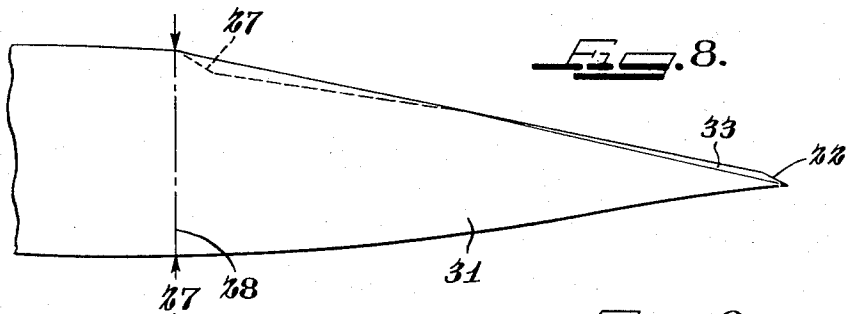
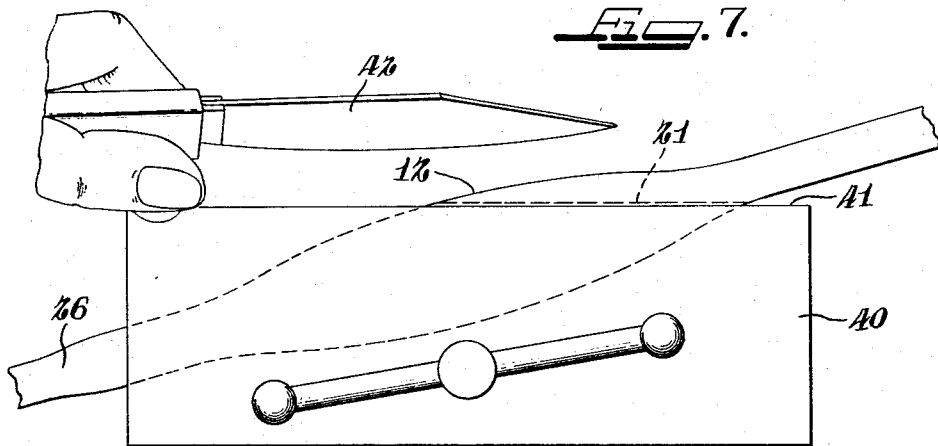
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INTERCOSTAL CATHETER

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Filed Jan. 27, 1966, Ser. No. 523,446

18 Claims. (Cl. 128—348)

This application is a continuation application of United States patent application, Ser. No. 358,767, filed Apr. 10, 1964, now abandoned, for an Intercostal Catheter which was a continuation-in-part application of United States patent application, Ser. No. 171,906, filed Feb. 8, 1962, now United States Patent No. 3,190,290 for an Intercostal Catheter.

The present invention relates to catheters and more particularly to intercostal catheters which are placed by drawing the proximal end out through a second incision or stab wound.

Catheters utilized in many surgical procedures are inserted through the original incision with the proximal end portion entering the incision first; a second incision is made; the forceps are inserted through the second incision to grasp the proximal end of the catheter; and the catheter is thereby pulled into the body until the distal end portion is properly positioned with the tube leading out through the second incision. Then, the proximal end is connected to an appropriate tubular connector. In the past, the proximal end of conventional catheters in general usage had a proximal end opening lying in a plane which was approximately at right angles to a center line of the tube. Since the gripping or jaw portions of forceps did not exceed the diameter of the proximal end opening, the opening was distorted when externally gripped by both jaws of the forceps so that opposite portions of the end were forced out from between the jaws as pressure was applied by the forceps to form a closed end having two protruding points which acted as dull barbs as the proximal end portion was pulled through body tissue and through a second incision. These protruding barbs would rip or tear the body tissue during this process. If forceps were applied to the proximal end of a conventional catheter formerly in general usage so that one jaw is placed internally and the other is placed externally to grip the catheter, the proximal end would not be distorted, but that portion of the circumference of the proximal end, which is not between the gripping jaws of the forceps, would make an even larger barb to catch and tear the body tissue as the forceps were used to draw the proximal end through body tissue and through a second incision.

The catheter disclosed in our copending application, Ser. No. 171,906, now Patent No. 3,190,290, minimized or reduced the ripping and tearing of tissue that had been caused by intercostal catheters in use prior to the invention disclosed by that application. The present invention provides an improved form of intercostal catheter which not only eliminates ripping and tearing of body tissue, but also substantially eliminates any coring of body tissue as a proximal end of an intercostal catheter is being drawn to and through a second incision or stab wound.

It is therefore an object of the present invention to provide a new and improved catheter.

A primary object of the present invention is to provide an intercostal catheter which not only eliminates tearing and ripping of tissue as the proximal end is drawn toward and through a second incision or stab wound by forceps, but in addition, to eliminate any coring effect of the tissue created by the proximal end opening.

A specific object is to provide a catheter with a fusiform section formed therein adjacent its proximal end with a slanted proximal end opening lying entirely within a proximal end slope of the fusiform section.

2

A further object is to provide a catheter with a proximal end opening lying entirely within the proximal slope of a fusiform section formed therein which defines a plane that is at less than a 30° angle with a center line of such a fusiform section.

An additional object is to provide a catheter or flexible plastic tube which has a proximal end opening defined by a warped end surface, which has an inwardly inverted heel portion and an outwardly inverted tip portion.

Still another object is to provide a catheter which has a fusiform section formed therein adjacent its proximal end and has a proximal end opening defined by a warped end surface which lies within the proximal slope of the fusiform section.

Further objects and advantages will become apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a perspective view of an embodiment of the present invention;

FIGURE 2 is a side elevational view of the proximal end portion of the embodiment of the invention illustrated in FIGURE 1;

FIGURE 3 is a side elevational view of the proximal end portion of the embodiment of the invention illustrated in FIGURE 1 where the proximal end tip is grasped by forceps to place tension on the catheter;

FIGURE 4 is an action view of the embodiment of the invention illustrated in FIGURES 1 and 2 as the proximal end is entering underlying body tissue as it is being drawn to a second incision or stab wound;

FIGURE 5 is an action view of the embodiment of the invention illustrated in FIGURES 1 and 2 as the proximal end is being drawn through the underlying body tissue as it is being drawn to the second incision or stab wound;

FIGURE 6 is an action view of the embodiment of the invention illustrated in FIGURES 1 and 2 as the proximal end thereof is emerging from a second incision or stab wound;

FIGURE 6a is a side elevational view of the proximal end portion of a modified form of the invention;

FIGURE 7 is an action view of a method of forming a warped proximal end of a catheter as illustrated in FIGURES 1 and 2;

FIGURE 8 is an enlarged side elevational view of the proximal end of the embodiment of the invention illustrated in FIGURES 1 and 2;

FIGURE 9 is an enlarged side elevational view of the embodiment of the invention illustrated in FIGURES 1 and 2 when it is under tension and being drawn through a second incision or stab wound as illustrated in FIGURE 5;

FIGURE 10 is an enlarged top elevational view of the embodiment of the invention shown in FIGURES 1 and 2; and

FIGURE 11 is an enlarged top elevational view of the proximal end of the embodiment of the invention illustrated in FIGURES 1 and 2 when it is under tension and being drawn through a second incision or stab wound as illustrated in FIGURE 5.

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail an embodiment of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated. The scope of the invention will be pointed out in the appended claims.

United States Patent No. 3,190,290, of which application Serial No. 358,767 is a continuation-in-part, illustrates an intercostal catheter having a flared section formed therein adjacent its proximal end which has a distal slope but no proximal slope. The proximal end

3

opening defines a plane, at less than a 45° angle with a center line of the flared section, which intersects the distal slope of the flared section. It has been found that the proximal end opening intersecting a portion of the distal slope of the flared section created a heel which would remain open when drawn through body tissue to and through a second incision or stab wound. This type of "open heel" will create a coring effect of a small amount of body tissue which passes between opposite sides of the proximal end opening adjacent the heel as the proximal end opening is drawn through the body tissue. While such a coring effect of the "open heel" is far less traumatic than the ripping and tearing created by catheters utilized previous to the present applicants' invention disclosed in U.S. Letters Patent 3,190,290, it is nevertheless desirable to eliminate every traumatic effect in the drawing of the proximal end of an intercostal catheter through a secondary incision. Therefore, the embodiment of the present invention illustrated in the drawings not only eliminates ripping and tearing of body tissue by the proximal end opening of an intercostal catheter, but in addition, it also eliminates the coring effect created by an "open heel" by providing a distal end opening in which the "heel" of the proximal end opening is depressed and does not open to the extent that it allows tissue to pass into the proximal end opening.

Referring to FIGURE 1, the catheter is composed of a tube portion 10, a distal end portion 11, and a fusiform proximal end portion 12. The distal end portion has a series of inlet openings 13-18 and an open distal end 19. The catheter is constructed of a seamless, flexible plastic material which is transparent to both light and X-rays. Embedded in the plastic material is an X-ray opaque line 20 running longitudinally along the catheter. The opaque line 20 is interrupted by the inlet opening 18 which in one preferred form is the most removed opening from the end 19 of the distal portion 11.

The proximal end portion 12 has a proximal end opening 21 which forms an outwardly inverted proximal end tip 22 and an inwardly inverted heel 27. Referring to FIGURE 2, the fusiform proximal end portion 12 has a maximum diameter indicated at 23 which separates a distal slope 24 and a proximal slope 25 of the fusiform section. The dashed line portion of FIGURE 2 illustrates the remainder of the proximal slope portion of the fusiform portion 12 before it is cut to form the proximal end opening 21. The plane of the proximal end opening 21 is at approximately a 15° angle with a center line 26 of the fusiform proximal end portion 12. The ratio of the diameter 28 of the fusiform section measured at the heel 27 to the maximum dimension of the proximal end opening 21 is a ratio of approximately 1:3. While the approximate angle (α in FIGURE 2) between the plane of the proximal end opening 21 and the center line 26 is 15° for an approximate ratio of 1:3; slight variations of this ratio will vary the angle α over a range from approximately 10° to 25°. Larger variations of the ratio will vary the angle from approximately 5° to 30°. The exact angle to be used for α varies with the composition of the plastic being used to form a catheter, temperature of the surrounding atmosphere, catheter size, and catheter wall thickness. Thus, exact angles selected for angle α will probably be within the range of 5° to 30° depending upon these factors. In some circumstances it may be desirable to utilize angles greater than 30° and approaching as high as 45°.

FIGURE 3 illustrates the shape assumed by the proximal end portion 12 when a tension is placed thereon as occurs when the tip 22 is grasped by the jaws of the forceps and the catheter is pulled through body tissue by the forceps. The catheter 10 is composed of a plastic material which is particularly flexuous at body temperatures but it is not unduly soft for its function as a catheter. Therefore, at body temperature, the proximal end becomes sufficiently flexuous that when a slight tension

4

is applied by the forceps' jaws, such as indicated at 30, a long portion of the bottom of the proximal slope, indicated at 31, will stretch sufficiently for the tip 22 to approximately align itself with the center line 26. Therefore, as the proximal end section 12 is being pulled through body tissue by a pair of forceps, the tip 22 will align itself with the center line 26 of the proximal end section and tube so that it presents essentially a conical wedge section to part tissues through which it is being pulled by the forceps.

The operation of the catheter will now be described in greater detail. The proximal end portion 12 is inserted into a primary incision of the chest. A second incision usually in the form of a stab wound is made at another position to receive the ends of a pair of forceps, such as 30. A surgeon inserts the forceps through the second incision or stab wound and manipulates them through the body tissue until he is able to grasp the tip 22 of the catheter between the jaws 30 of the forceps. As he then applies tension on the tip 22 to draw the proximal end of the catheter through the stab wound or second incision, the catheter will be at body temperature and, therefore, sufficiently flexuous to assume the shape illustrated in FIGURE 3 of essentially a head-on cone. Since the tip 22 has moved over to approximately the center line 26, the portion of the proximal end slope of the proximal end portion 12 surrounding the opening 21 will not be in tension because the pull is being taken directly from the tip 22 down the sides and bottom 31, as viewed in FIGURE 3, to the remainder of the catheter.

Referring now to FIGURES 4-6, the action of the tissue around the incision is more clearly illustrated. As a surgeon pulls the forceps through the incision, the tissue around the incision will close about the proximal end 12 of the catheter. The non-tensioned area around the opening 21 of the proximal slope will urge the sides of the proximal end opening 21 toward each other to form a substantial closure of the opening. Thus, any tissue which comes in contact with the opening 21 as it is being pulled through body tissue will not be urged into the opening so that it can be caught by the heel or most distal end of the opening, but rather, as the tendency of the tissue to be forced into the opening increases, this forces the opening even further toward closure. The tissue will slide over the opening without protruding into it. Thus, a coring action of the tissue by the opening is avoided. Since the opening does not extend to the maximum diameter or into the distal slope of the bulbous, fusiform end section 12, no barb or protrusion of any type can form at the heel 27. It has been found that a break at the maximum diameter of the fusiform proximal end section or one which extends into the distal slope allows tissue pressing against the distal end of the opening to force the opening apart sufficiently at the maximum diameter to allow a coring effect to take place and small portions of tissue to be cored out as the catheter is pulled toward and through the stab wound or the second incision. However, when the opening ends on the proximal slope, the effect of tissue pressure against the proximal end opening is to force the entire opening toward closure, thus preventing coring action from taking place.

It has been found that any angle of the proximal end opening when the proximal end opening is entirely within the proximal slope of less than 30° with a center line of the proximal end portion 12 is satisfactory for providing a substantially non-coring proximal end portion construction. Although this provides a wide range of angles for the proximal end opening, it has generally been found that the most preferred angle for various size catheters is an angle of approximately 15° between a plane defined by the end opening and the center line. Although the relationship of the maximum diameter and the maximum dimension of the proximal end opening 21 is not critical, it has also been found desirable for many sizes of catheters to utilize an approximate 3:1 ratio be-

tween the maximum diameter of the opening and the heel diameter of the fusiform proximal end section.

Two features of the construction of the fusiform end section 12 contribute to the smooth non-coring passage of the proximal end through a second incision or stab wound as illustrated in FIGURES 4-6. The first of these features is the placing of the tapered proximal end opening 21 entirely in the proximal slope of the fusiform section 12. Referring again to FIGURE 2, the heel 27 of the opening 21 is spaced from the maximum diameter 23 by a distance illustrated generally at 29. This distance varies with the size catheter utilized and its wall thickness but is generally within the range of $\frac{3}{16}$ to $\frac{1}{2}$ inch. With some small space between the maximum diameter of the fusiform section and the heel 27 the force of the tissues surrounding a secondary stab wound must of necessity form a cone as illustrated by the FIGURES 4-6. As aforementioned, if the heel 27 were exactly at the maximum diameter or extended into the distal slope, the tendency would be for the opening 21 to spread apart at the maximum diameter. This of course would create the aforementioned coring of the tissue.

The second feature illustrated in the drawing which causes the proximal end to form itself into a cone is the warped end surface 33. If all points of the end surface 33 laid in the exact same plane when no pressure or force was being applied to the proximal end section 12, a large amount of coring would be eliminated as long as the proximal end opening 21 is within the proximal slope 25. However, substantially all coring is eliminated by warping the end surface 33 as illustrated in the drawings.

Referring now to FIGURES 8-11, the warped end surface 33 is more clearly illustrated. Referring specifically to FIGURE 8 which is a side elevational view, the surface 33 by being warped provides for an inwardly inverted heel 27 (inner wall edge is depressed) and by being warped at the tip provides for the outwardly inverted tip 22 (inner wall edge raised). FIGURE 10 illustrates the top elevational view of the surface 33 with the inner wall depressed at the heel portion and rising to a raised tip portion. FIGURES 9 and 11 respectively show the position assumed by the surface 33 when tension is applied to the catheter through the tip 22 as would be applied when the proximal end is pulled through a secondary stab wound as illustrated in FIGURE 5. The surface 33 closes together with almost a perfect meeting seam as shown in FIGURE 11 because the heel 27 being inwardly inverted is devoid of material which tends to force the opposing sides of the opening 21 apart and the rolling warp of the opposite sides of the end surface 33 provides the proper end surface as a diameter of the proximal slope of the fusiform section diminishes. This provides essentially flush mating surfaces to complete the cone. Near the heel 27, the fusiform section is bent inwardly only a short distance before the opposite portions of surface 33 meet, while at points progressively closer to the proximal end, the surface 33 is turned inward to form the cone through an increasingly greater number of radial degrees. Therefore, a lesser surface angle is required for a flush mating of points of the symmetrically opposite sides of the surface 33 as the tip is approached. The warp construction illustrated in the figure provides a smooth outer appearance across the closed opposing symmetrical sides of the opening 21.

Those skilled in the art will recognize that the warped surface disclosed in the preferred embodiment illustrated in the drawing may be provided on an end opening of straight or other types of tubing, as shown in FIGURE 6a, with the result that such other types of tubing may be drawn through incisions in tissues with a minimum of coring. Thus, all such modifications are intended to be within the scope of the appended claims. Specifically, the straight sided tubing 50, which could be the tube 10 of a catheter of FIGURE 1 without the fusiform section,

has a warped end surface 51 on the proximal end 52 of said catheter. The warped end surface 51 has the inverted heel 54 (inner wall edge is depressed) and the outwardly inverted tip 55 (inner wall edge raised). The angle of the surface 51 with respect to the center line 56 of the tube 50 and the manner of operation of the warped end surface as the tube is drawn through body tissue and a second incision or stab wound is the same as that described with respect to FIGURES 1 through 6 and will not be repeated here.

Referring now to FIGURE 7, a method for providing a warped end surface on the fusiform proximal end section of a catheter is illustrated. A proximal end fusiform section such as 12 is clamped in a vise 40 with the result that the fusiform section is pressed flat to form flat surface portions in the section. The center line 26 is placed at an angle to the top surface 41 of the vise 40 to which it is desired to slope the other proximal end opening 21. A knife or other cutting instrument such as 42 is then utilized to cut along a plane which is parallel to the top of the vise 41 and therefore perpendicular to the flat pressed surface portions created temporarily by the pressure of the vise. The fusiform proximal end 12 is then removed from the vise and allowed to assume a normal unstressed shape which is the shape illustrated in FIGURES 8 and 10. Therefore, the warped surface 33 may be produced by an extremely simple method.

Thus, those skilled in the art will recognize that the present invention contemplates the encompassing of all forms of such structures which, regardless of their exact relative dimensions, produce a non-coring proximal end for an intercostal catheter, as herein described. This scope is set forth by the appended claims.

We claim:

1. A catheter having a distal end and a proximal end comprising: a tube of flexible plastic material having at least one opening in the distal end portion thereof, a fusiform section formed in the tube adjacent the proximal end which has a distal slope and a proximal slope, and a proximal end opening lying within said proximal slope.

2. A catheter having a distal end and a proximal end comprising: a tube of flexible plastic material having at least one opening in the distal end portion thereof, a proximal end opening in said tube having a warped end surface, said warped end surface having an inwardly inverted heel portion and an outwardly inverted tip portion, said plastic material being sufficiently pliable at body temperatures that said proximal end opening will be urged toward closure when a tension force is applied to the proximal end.

3. A catheter having a distal end and a proximal end comprising: a tube of flexible plastic material having at least one opening in the distal end portion thereof, a fusiform section formed in the tube adjacent the proximal end which has a distal slope and a proximal slope, and a proximal end opening lying within said proximal slope and normally defining a plane which is at less than a 30° angle with a center line of the fusiform section.

4. A catheter in accordance with claim 3, wherein said proximal end opening has an inwardly inverted heel portion and an outwardly inverted tip portion, and said plastic material is sufficiently pliable at body temperatures that said opening will be urged toward closure when a tension force is applied to the proximal end.

5. A catheter having a distal end and a proximal end comprising: a tube of flexible plastic material having at least one opening in the distal end portion thereof, a fusiform section formed in the tube adjacent the proximal end which has a distal slope and a proximal slope, and a proximal end opening lying within said proximal slope and normally defining a plane which is at approximately a 15° angle with a center line of the fusiform section.

6. A catheter in accordance with claim 5, wherein said proximal end opening has an inwardly inverted heel portion and an outwardly inverted tip portion, and said

7

plastic material is sufficiently pliable at body temperatures that said opening will be urged toward closure when a tension force is applied to the proximal end.

7. A catheter having a distal end and a proximal end comprising: a tube of flexible plastic material having at least one opening in the distal end portion thereof, a fusiform section formed in the tube adjacent the proximal end which has a distal slope, a proximal slope, and a proximal end opening partially defined by a heel lying within said proximal slope and having a length approximately equal to three times the diameter of said fusiform section, measured at the heel.

8. A catheter in accordance with claim 7, wherein said proximal end opening has an inverted tip portion and said plastic material is sufficiently pliable at body temperatures that said opening will be urged toward closure when a tension force is applied to the proximal end.

9. A catheter having a distal end and a proximal end comprising: a tube of flexible plastic material having at least one opening in the distal end portion thereof, a fusiform section formed in the tube adjacent the proximal end which has a distal slope and a proximal slope, a proximal end opening lying within said proximal slope and normally defining a plane which is at approximately a 15° angle with a center line of the protuberant section, a longitudinal line of X-ray opaque material embedded in said flexible plastic tube, and an inlet opening interrupting said line of X-ray opaque material near the distal end.

10. A catheter having a distal end and a proximal end comprising: a tube of flexible plastic material having at least one opening in the distal end portion thereof, a fusiform section formed in the tube adjacent the proximal end which has a distal slope and a proximal slope, a proximal end opening lying within said proximal slope and normally defining the plane which is at approximately a 15° angle with a center line of the fusiform section, a longitudinal line of X-ray opaque material embedded in said plastic material, and a number of inlet openings in said tube near its distal end with only the inlet opening furthest from the distal end interrupting said line of X-ray opaque material.

11. A catheter having a distal end and a proximal end comprising: a tube of flexible plastic material having at least one opening in the distal end portion thereof, a fusiform section formed in the tube adjacent the proximal end which has a distal and a proximal slope, and a proximal end opening defined by a warped end surface and lying within said proximal slope.

12. A catheter having a distal end and a proximal end comprising: a tube of flexible plastic material having at least one opening in the distal end portion thereof, a fusiform section formed in the tube adjacent the proximal end which has a distal and a proximal slope, and a proximal end opening defined by a warped end surface having an inwardly inverted heel portion and an outwardly inverted tip portion and lying within said proximal slope.

13. A catheter having a distal end and a proximal end comprising: a flexible plastic tube having at least one opening in the distal end portion thereof, said proximal end having a tapered end opening defined by a warped

8

end surface, said end surface having an inwardly inverted heel portion and an outwardly inverted tip portion.

14. A catheter having a distal end and a proximal end comprising: a flexible plastic tube having at least one opening in the distal end portion thereof, the proximal end having a tapered end opening defined by a warped end surface, said end surface having an inwardly inverted heel portion and an outwardly inverted tip portion and generally defining a plane which is at less than a 30° angle with a center line of the tube.

15. A catheter having a distal end and a proximal end comprising: a flexible plastic tube having at least one opening in the distal end portion thereof, the proximal end having a tapered end opening defined by a warped end surface, said end surface having an inwardly inverted heel portion and an outwardly inverted tip portion and generally defining a plane which is at less than a 30° angle with a center line of the tube, said plastic tube being sufficiently pliable at a predetermined temperature that said opening will be urged toward closure when a tension force is applied to said end, and a longitudinal line of X-ray opaque material embedded in said plastic tube.

16. A catheter having a distal end and a proximal end comprising: a tube of flexible plastic material, a fusiform section formed in the tube adjacent the proximal end which has a distal and a proximal slope, and a proximal end opening defined by a warped end surface and lying within said proximal slope, said warped end surface having a heel portion and a tip portion, and said plastic material being sufficiently pliable at body temperatures that said opening will be urged toward closure when a tension force is applied to the proximal end.

17. The method of forming a tapered warped end surface on a flexible plastic catheter which comprises pressing said tube flat to form flat surface portions in said tube and cutting through the pressed tube along a plane which makes less than a 45° angle with a center line of said tube and is substantially perpendicular to the flat pressed surface portions.

18. The method of forming a warped end surface on a fusiform plastic section of a catheter which has a distal slope and a proximal slope comprising pressing said fusiform section flat to form flat surface portions in said section and cutting through the pressed fusiform proximal slope along a plane which makes less than a 30° angle with a center line of said fusiform section and is substantially perpendicular to the flat pressed surface portions.

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