United States Patent

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[54] **AUTOTRANSFUSOR ATRAUMATIC SUCTION TIP**
4 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **128/276**
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[50] **Field of Search** 128/276–278; 32/33

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ABSTRACT: A suction tip for use in the smooth, atraumatic withdrawal of blood from a surgical field which comprises a semispherical reservoir and a single orifice, flared catheter which projects into the reservoir and is attached thereto by means of a plurality of struts bridging the interior surface of the reservoir and the exterior surface of the catheter.

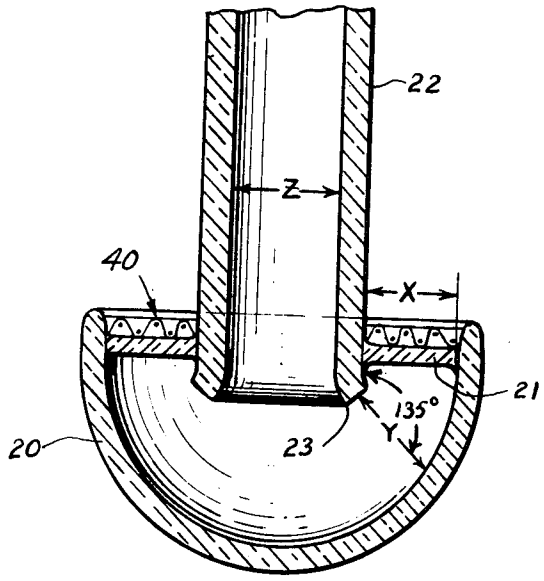


FIG. 3

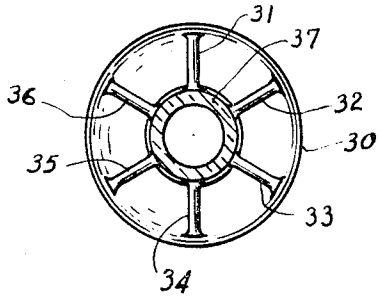


FIG. 1

FIG. 2

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AUTOTRANSFUSOR ATRAUMATIC SUCTION TIP

BACKGROUND OF THE INVENTION

Retrieval of whole blood from the operative field for processing and reinfusion into the patient is called autotransfusion. Its primary purpose is to conserve the reuse vital blood lost by intraoperative or emergency hemorrhage. Successful autotransfusion offers a major advancement in the practice of medicine today. Its provision for the immediate collection and return of compatible whole blood to the patient is far superior to donor blood transfusion with its inherent delays, expense and danger of transmitted disease and allergic reaction. It may be indicated for use in any major vascular catastrophe, especially in the face of uncontrolled loss from traumatic, obstetrical or operative technical hemorrhage. Specific instances wherein autotransfusion is of substantial value include the retrieval of blood from the thoracic cavity or pericardial sac in open heart surgery and organ transplantation.

A thorough understanding of the problems in autotransfusion reveals that it is critical to the entire operation that the whole blood suffer only a minimum amount of damage during the autotransfusion procedure. Red cell destruction (hemolysis) and other traumatic action of the blood should be carefully avoided because it may lead to harmful injury to the kidneys Red cells are exceedingly sensitive, their destruction being a function of numerous factors including the age and nature of the blood itself, the rapidity and skill of the collection, the degree of applied vacuum, and the suction tip design, etc. It is in the area of suction tip design, and apparatus design in general, where most difficulties, such as hemolysis, have arisen. Conventional suction tips, which are constructed so as to place the open, receiving end thereof directly on the wound or operative field, do not adequately displace the tissue surrounding the wound thereby resulting in excessive tissue-blood contact and the consequent cell fracture inherent therein. Such common designs also result in excessive blood turbulence, clogging, turbulent flow and a violent sucking of blood and air into the suction tip which are predominant factors in causing destruction of the red blood cells. The straight edges and sharp angles of such conventional designs also result in excessive contact between the tip edges and the blood, causing further fracture of the red cells. An additional disadvantage of conventional suction tips is their tendency to induce undesirable blood foaming.

Clogging of the suction tip by the presence of coarse debris has also been a major problem in the prior art designs. Thus, either the dimensions of the tip have not been conducive to uninterrupted flow or the filter which removes the debris present has not been judiciously situated.

It is, therefore, the primary object of this invention to provide a suction tip for use in autotransfusion apparatus which meets the necessary stringent requirements imposed thereon especially with regard to the atraumatic nature of its operation.

MOre specifically, it is an object of this invention to provide a suction tip for autotransfusion apparatus which minimizes blood turbulence, tissue-blood contact, foaming, cell fracture and clogging.

It is a further object to provide a suction tip which provides a reservoir for the collected blood so as to encourage rapid blood withdrawal as well as minimum foaming and vacuum reduction.

DETAILED DESCRIPTION OF THE INVENTION

The novel suction tip of the invention substantially overcomes the disadvantages inherent in the prior art suction tip. Thus, the suction tip comprises a semispherical reservoir connected to a single orifice, flared catheter which projects into the reservoir by means of a plurality of struts bridging the interior surface of the reservoir and the exterior surface of the catheter. The entire tip is composed of smooth surfaces and rounded contours in order to insure the passive, easy, nonturbulent, continuous flow of the whole blood. Furthermore, the

dimensions of the assembly are so established that the flow of blood always passes from a smaller into a larger area thereby maintaining the system in a clog-free state. It is these various aspects as well as the results obtained from actual usage of the tip that makes it superior to the prior art tips.

The reservoir or cup section of the novel suction tip serves a variety of functions. Its smooth spherical shape enables it to gently displace the tissue in the surgical wound and thereby minimize the excessive tissue-blood contact. In this manner, the blood pools and flows over rounded edges into its own sterile reservoir. The reduction in the amount of contact between the blood and the surrounding tissue also facilitates the continuous, passive flow of blood into the reservoir area and allows for collection without cell fracture. Furthermore, the isolated whole blood collected in the reservoir is now smoothly and passively evacuated from the field by partial vacuum via the single, flared-tip catheter. This is in contrast to prior art suction tips having no isolated reservoirs whose multiple openings were applied directly to the wound and thus were subject to discontinuous, turbulent and traumatic evacuation as a result of tissue contact, air aspiration and clogging.

The struts which connect the blood reservoir and the catheter also function as an important preliminary in situ filtration system. Thus, they serve to remove larger particulate matter from the blood such, for example, as fibrin clots, fat particles, bone chips and other coarse debris. The number of struts present in the assembly may be determined by the practitioner although the number should not be so excessive as to retard the steady flow of the whole blood. It has been experimentally determined that the presence of three to six struts per assembly is functional in view of the practicality of this configuration to the operating surgeon and the requisite size, support and filtration capability which is thereby provided.

A temporary external filter may also be placed over the struts where an abundance of particulate matter is present in the blood. Such filters are generally formed of polished stainless steel, monel metal or other conventional surgical metal or fine plastic weave and are of a fineness to catch small blood clots, i.e. with a 100 to 300 U porosity or weave. Polytetrafluoroethylene plastics (Teflon) are suitable filter materials. The basic requirement of these filters is that they be fine enough to remove excessive residual debris in the blood, such as in encountered in surgery in the nonserous cavities, that they do not retard the passive flow of the blood and that they be constructed of a suitable material.

The third essential component of the suction tip assembly is the single orifice, flared catheter. The blood is transported through the catheter to the aspirator tube which thereafter delivers it to the autotransfusor or cardiopulmonary bypass machine. The catheter extends into the reservoir in order that its flared opening lies below the surface of the blood pool during the aspiration procedure. Sucking of air, foaming and vacuum discontinuity are thus reduced by this positioning of the catheter. The flare on the end of the catheter also aids in obtaining silent, nonturbulent blood recovery.

The nonclogging nature of the tip and the substantial elimination of stasis of flow therein is a result of its filtration capability, previously discussed, and its dimensional relationships. Thus, the tip is so constructed that the blood always flows from a smaller area into a larger one, thereby avoiding the natural reduction in flow which would result from the opposite relationship. This pattern is reflected in the dimensions of the three openings in the tip through which the blood flows, namely, that the length of the strut, i.e. the distance between the catheter exterior wall and the reservoir interior wall, is smaller than the distance between the end of the catheter tube and the reservoir wall, taken at an angle of 135° to the catheter, which, in turn, is smaller than the internal diameter of the catheter tube. Although these dimensions are subject to variation, it is preferred that each succeeding opening be at least about 1 millimeter larger than the previous one. These dimensions should not conflict, however, with other essential

features of the tip assembly, e.g. they should not necessitate the formation of angles in the construction.

Another element which is critical to the proper functioning of the novel suction tip of this invention is its surface construction. As previously indicated, the suction tip is composed solely of smooth surfaces and rounded contours. All edges, such as those of the reservoir and the catheter, are rounded in order to minimize the occurrence of cell fracture. The materials which are utilized in the construction of the suction tip reflect this desire for smooth surfaces. Included among such suitable materials are glass, polished stainless steel and medical grade plastics such as polytetrafluoroethylene, silastic and polycarbonates. Where desired, and depending upon the primary material of construction, the assembly may be coated with a silicone solution and then dried in order to further insure the smoothness of the surfaces and to eliminate blood-surface reactions and foaming. These materials also provide greater flexibility in that the tip may be discarded after a single use or reused subject to adequate sterilization. It is to be noted that the one-unit construction of the tip allows for ready cleaning by conventional or modern sonic sterilizers.

The structure and dimensional relationships of the suction tip will be better understood by reference to the drawings accompanying the description, wherein:

FIG. 1 is a cross-sectional view of the suction tip made in accordance with the invention;

FIG. 2 is an enlarged cross-sectional view of the suction tip showing the basic dimensional relationships thereof; and

FIG. 3 is a horizontal section top view of the suction tip of this invention.

Referring now to Fig. 1, **11** represents the spherical blood reservoir which is connected to the single orifice, flared catheter **14** by means of struts **12, 13**. It will be seen that reservoir **11** contains only rounded edges and rounded contours. It can also be envisioned how the spherical shape of the reservoir displaces the tissue immediately surrounding the wound or operational field. The catheter **14** is connected to aspirator tube **15** which leads to the partial vacuum source or rotary pump.

The dimensional relationships of the tip are clearly delineated in FIG. 2. Thus, it will be seen that the flow of blood proceeds in a path from *x* to *y* to *z*. Accordingly, the distance between the reservoir **20** and the catheter **22** which is represented by *x* is smaller than the distance between the catheter end **23** and the reservoir **20** represented by *y*, which, in turn, is smaller than the inner diameter of the catheter **22** represented by *z*. It is also seen that the second dimension, i.e. the distance between the catheter and the reservoir wall, is measured along the line making a 135° angle with the catheter. This continuous widening of the path of the blood flow makes for a continuous, clot-free blood withdrawal. Insertion of filter **40** over the struts ends in avoidance of clots.

FIG. 3 clearly illustrates the strut formation of the suction tip of this invention. In the example depicted, six uniform, equally spaced struts **31, 32, 33, 34, 35, 36** connect the reservoir **30** to the catheter tube **37**. The arrangement of the struts **31, 32, 33, 34, 35, 36** provides a natural, in situ filtration system wherein coarse particulate matter is screened out of the transported blood.

By way of specific illustration, a suction tip in accordance with this invention was prepared which comprised a semispherical reservoir connected to a single orifice, flared catheter by means of three equally spaced struts. The entire tip was constructed of Pyrex glass and, thereafter, coated with a 5 percent, by weight, silicone solution and dried. The entire assembly exhibited smooth surface areas and rounded contours. The struts were 4 millimeters long, the distance between the catheter end and the reservoir wall was 5 millimeters and the inner diameter of the catheter tube was 6 millimeters. In a variety of actual uses, this suction tip provided atraumatic, clog-free blood withdrawal. Hemolysis was controlled and reduced to a minimum amount which was far below the tolerance of the human kidney.

It should also be noted that blood catheters are currently available in a variety of sizes, the inner diameter of some being as small as about 0.015 inch. However, constructing the suction tip of the invention, the catheter size selected must be such as to allow compliance with the dimensional and flow requirements specified herein for an operational tip. Accordingly, the minimum inner diameter of an applicable catheter tube will be about 3 millimeters.

While the invention has been described in terms of the specific embodiments herein, it should be apparent that variations thereof may be developed without departing from the spirit or scope of the invention.

What is claimed is:

1. An autotransfusor suction tip comprising a semispherical reservoir and a single-orifice, flared catheter which projects into said reservoir and is attached thereto by means of a plurality of struts bridging the area between the interior wall of the reservoir and the exterior wall of the catheter, the length of said struts being at least about 1 millimeter less than the distance between the end of the catheter and the interior wall of the reservoir with the latter distance being at least 1 millimeter less than the inner diameter of the catheter.

2. The suction tip of claim 1, wherein the inner diameter of the catheter is 1 millimeter greater than the distance between the catheter end and the interior wall of the reservoir which, in turn, is 1 millimeter greater than the length of said struts.

3. The suction tip of claim 2, wherein the inner diameter of the catheter is 6 millimeters, the distance between the catheter end and the interior wall of the reservoir is 5 millimeters and the strut length is 4 millimeters.

4. The suction tip of claim 1, wherein an external filter having a porosity of 100 to 300 U is placed over said struts.

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