An Improved Venous Cannula

Steven J. Phillips, M.D., et al

Steven J. Phillips, Department of Cardiopulmonary Surgery
University of Oregon Medical School, Portland, Oregon.
Christos Lolas, Department of Cardiopulmonary Surgery
University of Oregon Medical School, Portland, Oregon.
Edward Romanowski, Department of Surgery
Sinai Hospital of Detroit, Detroit, Michigan.

Rapid advances in the technology of extracorporeal circulation has allowed the firm establishment of clinical heart surgery[1,2]. Continuing progress is being made in the development of oxygenator systems and materials but less sophistication has been made in the design of venous cannulas[3,4]. Lacking in the design of the standard venous cannula is an aid which safeguards against slippage, allows accurate positioning, eliminates cava tourniquets and can improve the venous drainage rate when intermittent suction of the vessel wall onto the cannula orifices occurs[5]. This report describes a balloon tipped venous drainage[6] cannula whose design allows accurate cannula positioning and stabilization without tourniquets and improves venous drainage at high flow rates.

MATERIALS

A silicone rubber cannula, 40 cm long with an outside diameter of 12 mm and 2 mm wall thickness, was made as follows: A 30 cc inflatable rubber balloon was constructed in the wall of the cannula 0.5 cm behind the drainage orifice. Incorporated in the cannula wall is a 1 mm diameter conduit that connects the balloon lumen to a one-way inflation-deflation valve located near the extravascular end of the cannula (Figure 1).

METHODS AND RESULTS

Identical techniques for cannulae implantation is used experimentally and clinically. With the balloon deflated the cannulae are inserted into the right atrium through separate atrial appendage and atrial purse string sutures.

The balloons are partially inflated to allow their easy palpation while the cannulae are being positioned in the inferior and superior vena cavae (Diagram A). To achieve total cardiopulmonary bypass the balloon is inflated with enough heparinized saline to distend and occlude the cavae at the level of the cannulae drainage orifice (Diagram B). Inflation of the balloon internally fixed the cannulae within the cavae and prevents the cannulae from slipping.

Venous drainage rates were studied in 6 35 Kg dogs undergoing cardiopulmonary bypass with induced ventricular fibrillation. Venous cannulae with the balloon deflated were passed into the superior and inferior vena cava in the standard fashion. Tourniquets were passed around the cavae and tightened around the cannulae to achieve total cardiopulmonary bypass.

After a 10 minute stabilization period pump flow rates were gradually increased. At pump flow rates of 80 to 88 cc/Kg intermittent collapse of the cavae walls into the cannulae orifices occurred and no further increase in pump flow rates could be achieved. At this point, the cannulae balloons were inflated with heparinized saline and the tourniquets removed. Inflation of the balloons distended the cavae and lifted the collapsed vessel walls from the cannulae orifices. With the balloon inflated it was then possible to incrase the pump flow rate by approximately 10% (98-102 cc/Kg).

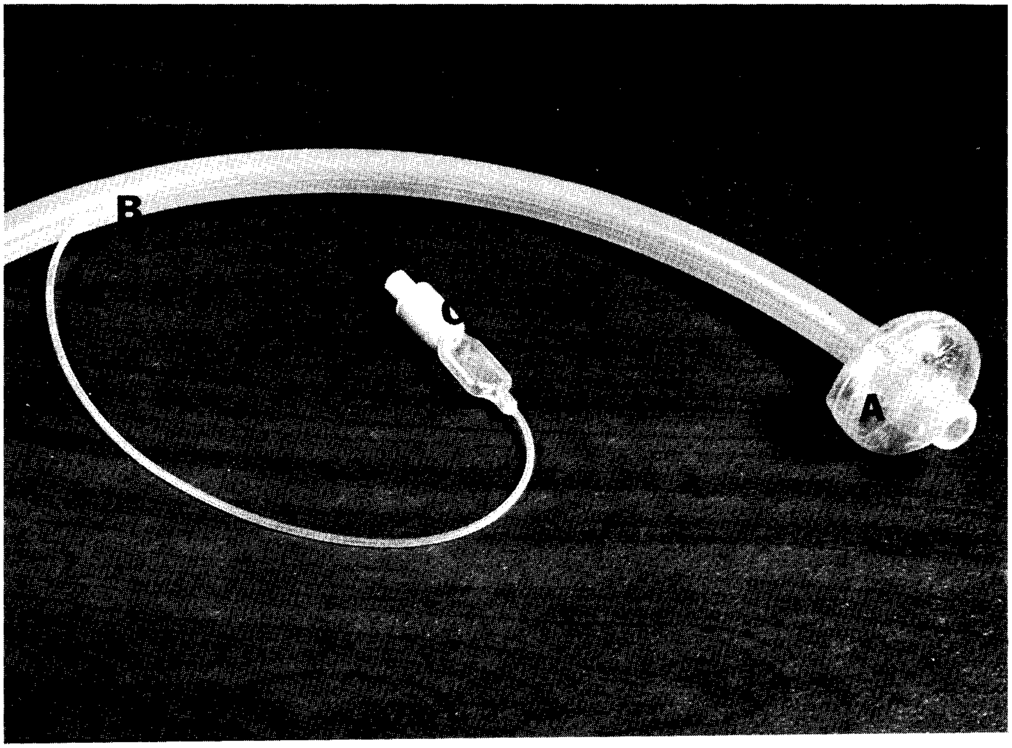

Figure 1

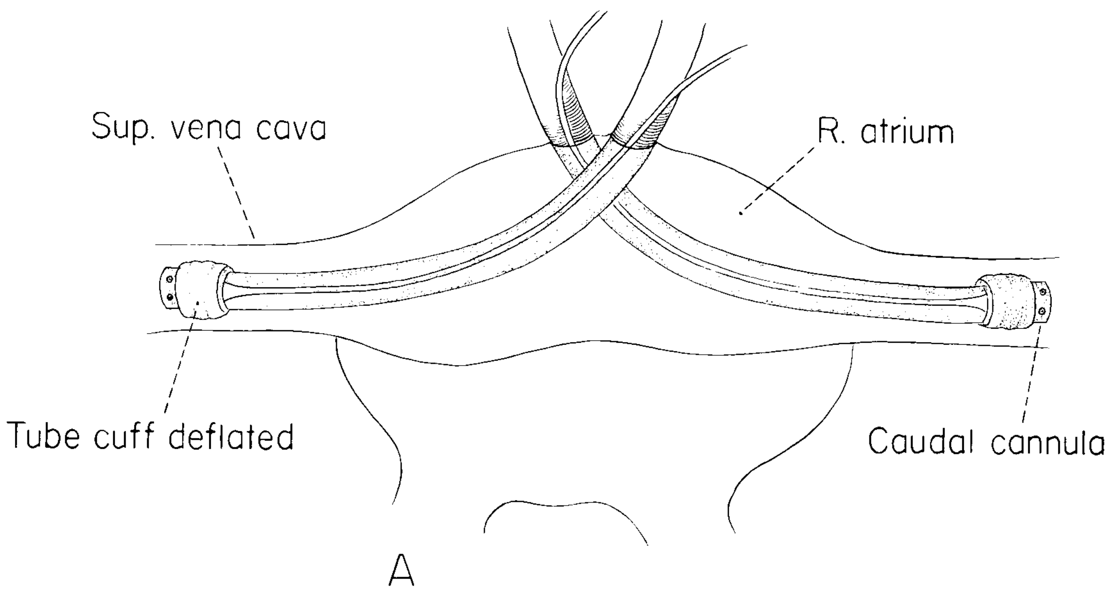

Diagram A

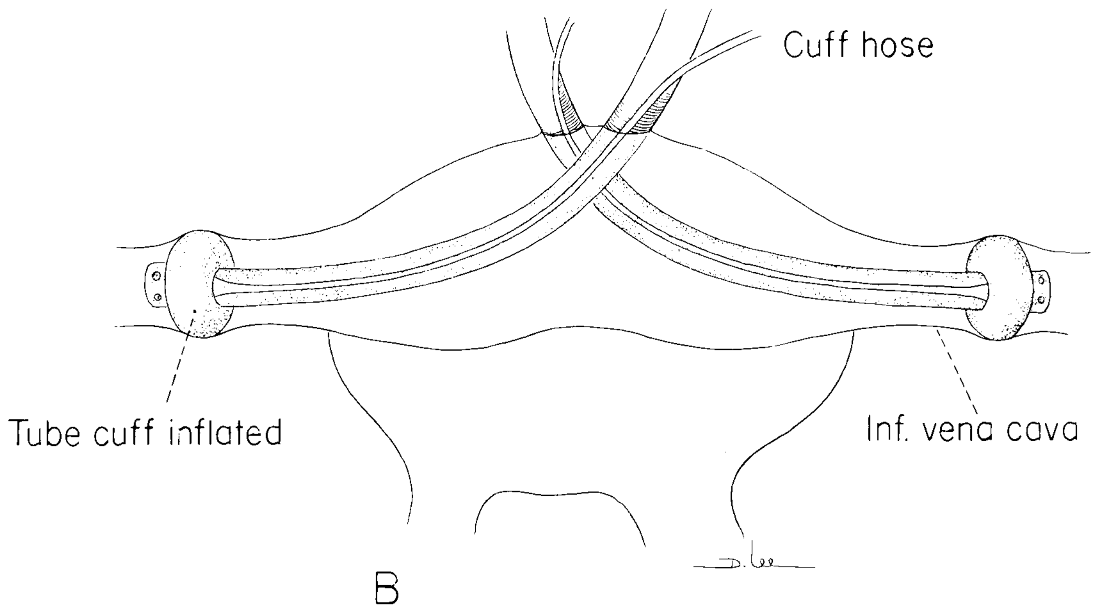

Diagram B

DISCUSSION

The venous connections necessary for heart-lung bypass require isolation of the inferior and superior vena cavae and the insertion of cannulae into each of these vessels. Venous drainage cannulae are usually introduced through purse-strung controlled openings in the right atrium. To achieve total heart-lung bypass and cannulae stabilization it is usually necessary to pass tourniquets around the cavae and snug these tourniquets around the cannulae. The passage of tourniquets around the inferior and superior vena cavae is time consuming, requires undesirable manipulation of the heart and vena cavae and is fraught with the possibility of injuring the vessel wall.

The balloon tipped venous drainage cannula eliminates the necessity of cavae dissection for the placement of tourniquets. Instead of the cavae being snugged around the cannulae by tourniquets, the vessels are now distended by the balloons. After initial insertion of the cannula into the atrium the balloon can be partially inflated. This allows easy palpation of the balloon through the cava wall for optimal positioning.

After positioning the balloon can then be completely inflated. This provides internal fixation of the cannula in the desired position and establishes total cardiopulmonary bypass.

The rate of flow obtainable during cardiopulmonary bypass is generally limited by the length and orifice diameter of the venous cannulae[7]. Other factors that effect the rate of venous flow include position of the cannulae in the vena cavae, the pressure gradient and resistance across the venous circuit[8], and mechanical factors such as kinks in the venous line.

Once cardiopulmonary bypass is established the major limiting factor for venous flow is the occurance of a negative central venous pressure when too great a gravity suction is applied. This results in the intermittent colapse of the cava walls onto the orifices of the venous cannulae.

Since it is not usually possible to substitute the venous cannulae once cardiopulmonary bypass is established, changes in the venous flow rates can be accomplished by modifying the pressure gradient or resistance in the venous circuit. This is usually done by raising or lowering the oxygenator or venous reservoir or by repositioning the cannulae. These maneuvers, at the least, are cumbersome, time consuming and interrupt the rhythm of surgery.

Inflation of a balloon incorporated in the tip of a venous cannula permits a simple way to alter the venous pressure gradient in the following way: Inflation of the balloon located at the tip of the cannula circumferentially distends the vena cava. This maneuver mechanically lifts the collapsed wall of the vena cava off of the cannula drainage orifice and allows the venous flow rate to normalize.

Limited clinical application of this newly designed venous cannula has borne out the experimental impression.

SUMMARY

A balloon tipped venous drainage cannula that improves venous drainage and eliminates the necessity of caval dissection for snares and allows more accurate positioning is described. The simplicity of design combined with improved efficiency simplifies cardiopulmonary bypass.

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Reflections:

On the Quality of Perfusion

The philosophy of a former technician

By Frank Fitton

(Reproduced as written for your perusal and consideration.)

During the past couple of years we have seen the more obvious emergence of many new gas exchange devices with no direct blood/gas interface. Namely membrane oygenators. The controversy regarding the values of pulsatile flow have briefly re-emerged into the limelight and drifted back into the twilight for re-emergence at a later date. We have been given "proof positive" that the filtration of aggregates from bank blood is an absolute necessity. The search for better blood substitutes for use in haemodilution continues at full steam with more sophistacated (and more expensive) physiological solutions appearing from time to time. We have finally acknowledged the fact that micro-bubbles are probably here to stay. This is because methods have been utilised for detecting the little devils and many people have realized that this fact alone is worthy of scientific investigation. We are even more uncertain to-day whether 'tis better to perfuse the coronary arteries or utilise ischaemic arrest. The list goes on and on.

What has happened to the art of perfuiosn? To-day so called "routine" cardiopulmonary bypass (I have put "routine" in quotes because there is no such thing as a routine cardiopulmonary bypass) for the repair of surgical defects seem to be getting more of a science and less of an art. I remember a few years back when cardiopulmonary bypass was 75% an art and 25% a science. To-day the reverse seems to be true and I sometimes wonder whether this "scientific progress" is really contributing to an improved quality of perfusion or whether a sort of unerring faith in scientific progress is dulling the brain and hazing the eyes.