

central or middle portion that does not include any openings, for example, as seen in Fig. 2. Use of such a bi-caval cannula can still drain blood at the superior and inferior venae cavae, while the right atrium is isolated for the surgical procedure.

SUMMARY

[0009] In some instances, multiple surgical procedures need to be made on a single patient. For example, a patient may require replacement or repair of an aortic or mitral valve, as well as a separate procedure on a tricuspid valve. Or more generally, a surgeon may need to perform separate procedures on the right and left sides of the heart of a patient. Previously, such situations involved the complete removal of a first type of femoral venous cannula after completion of the first procedure, and insertion of a second type of femoral venous cannula before beginning the second procedure.

[0010] Embodiments of the invention seek to provide a femoral venous cannula device that is adjustable between a multi-stage cannula and a bi-caval cannula, for example, to reduce the number of parts needed for cardiopulmonary bypass surgery. Embodiments of the invention also seek to provide such an adjustable cannula, to add flexibility and simplify procedures in situations where different cannulae are traditionally required. In accordance with the embodiments of the invention, there is provided a convertible femoral venous cannula that can be modified to be used in both procedures requiring a multi-stage cannula and procedures requiring a bi-caval cannula. Embodiments of the invention further provide a femoral venous cannula where a variety of different hole or opening configurations can be achieved, to adapt to various different procedures.

[0011] According to one embodiment, a device for use in cardiopulmonary bypass includes a cannula configured to be positioned in at least one of a right atrium, a superior

vena cava, or an inferior vena cava of a patient, the cannula having a first end, a second end, and a longitudinal axis extending between the first end and the second end. The cannula includes a first section at the first end, the first section including an outer wall and having at least one opening therethrough, a second section connected to the first section along the longitudinal axis, the second section including an outer wall and having at least one opening therethrough, and a third section connected to the second section along the longitudinal axis on a side of the second section opposite the first section, the third section including an outer wall and having at least one opening therethrough. In a first configuration, the openings in each of the first section, the second section, and the third section are respectively open to inner spaces defined by the first section, the second section, and the third section. In a second configuration, the at least one opening in the second section is occluded to restrict communication with the inner space defined by the second section, while the openings in the first section and the third section remain open to the inner spaces defined by the first section and the third section, respectively.

[0012] There is also disclosed a method for adjusting and positioning a femoral venous cannula in a patient for cardiopulmonary bypass during a cardiac procedure. The cannula has a first end, a second end, and a longitudinal axis extending between the first end and the second end, and includes a first section at the first end and including an outer wall and having at least one opening therethrough, a second section connected to the first section along the longitudinal axis and including an outer wall and having at least one opening therethrough, and a third section connected to the second section along the longitudinal axis on a side of the second section opposite the first section and including an outer wall and having at least one opening therethrough. In a first configuration, the openings in each of the first section, the second section, and the third section are respectively open to inner spaces defined by the first section, the second section, and the third section, while in a second configuration, the at least one opening in

WHAT IS CLAIMED IS:

1. A device for use in cardiopulmonary bypass, the device comprising a cannula configured to be positioned in at least one of a right atrium, a superior vena cava, or an inferior vena cava of a patient, the cannula having a first end, a second end, and a longitudinal axis extending between the first end and the second end, the cannula comprising:

a first section at the first end, the first section comprising an outer wall and having at least one opening therethrough;

a second section connected to the first section along the longitudinal axis, the second section comprising an outer wall and having at least one opening therethrough; and

a third section connected to the second section along the longitudinal axis on a side of the second section opposite the first section, the third section comprising an outer wall and having at least one opening therethrough;

wherein in a first configuration, the openings in each of the first section, the second section, and the third section are respectively open to inner spaces defined by the first section, the second section, and the third section; and

wherein in a second configuration, the at least one opening in the second section is occluded to restrict communication with the inner space defined by the second section, while the openings in the first section and the third section remain open to the inner spaces defined by the first section and the third section, respectively.

2. The device of claim 1, wherein in the first configuration, the cannula is configured as a multi-stage femoral venous cannula.

3. The device of claim 1 or 2, wherein in the second configuration, the cannula is configured as a bi-caval femoral venous cannula.

4. The device of one of claims 1 to 3, wherein a material of the second section of the cannula is more rigid than a material of at least one of the first section of the cannula or the third section of the cannula.
5. The device of one of claims 1 to 4, wherein the cannula further comprises a wall movable relative to the second section between a first position wherein the device is in the first configuration and the at least one opening in the second section of the cannula is open, and a second position wherein the device is in the second configuration and the at least one opening in the second section of the cannula is occluded by the wall.
6. The device of claim 5, wherein the wall is positioned along an inner surface of the outer wall of the second section of the cannula.
7. The device of claim 5 or 6, wherein the wall rotates circumferentially around the longitudinal axis to move between the first position and the second position.
8. The device of one of claims 5 to 7, wherein the wall moves laterally relative to the longitudinal axis towards either the first end or the second end of the cannula to move between the first position and the second position.
9. The device of one of claims 5 to 8, wherein the wall comprises a plurality of wall segments.
10. The device of one of claims 1 to 9, further comprising a tubular cover configured to be placed around the outer wall of the second section to occlude the at least one opening in the second section when the device is in the second configuration.
11. The device of claim 10, wherein the cannula is a multi-stage cannula.

12. The device of claim 10 or 11, wherein the cover is impermeable to blood.
13. The device of one of claims 10 to 12, wherein an adhesive on the cover permanently adheres the cover to the second section of the cannula when the device is in the second configuration.
14. The device of one of claims 10 to 13, wherein one cover is selected from a plurality of covers having different sizes for placement around the outer wall of the second section of the cannula when the device is in the second configuration.