CLAIMS

1. A cryoneedle comprising:

an outer tube having a distal section to be placed at or near a target area of a patient's anatomy and a longitudinal axis;

a gas supply line positioned within the outer tube, the gas supply line configured to supply a cryogas for forming an ice ball on an outer surface of the outer tube over the distal section;

an expansion chamber located within the distal section such that the gas supply line terminates in the expansion chamber;

an electrical resistance heater provided coaxially with the gas supply line and the outer tube to facilitate heating of the distal section of the cryoneedle;

a heat exchange helix contacting the inner surface of the outer tube; and

a return gas flow lumen defined annularly between the heat exchange helix and the gas supply line adapted to carry cryogas from the expansion chamber along a return flow path,

the heat exchange helix adapted to provide generally uniform rate of heat transfer in the distal section such that the ice ball formed on the outer surface of the outer tube is generally symmetric in shape along the longitudinal axis of the outer tube;

wherein the coils of the heat exchange helix are in contact with the inner wall of the outer tube, but not in contact with the heater or the gas supply line.

2. The cryoneedle of claim 1, wherein the heat exchange helix is positioned coaxially with an axis of the outer tube.

3. The cryoneedle of claim 1, wherein the outer tube has an outer diameter of about 2.1 millimeters.

4. The cryoneedle of claim 1, wherein the expansion chamber is adapted to expand the cryogas, and the expanded cryogas flowing in the return flow lumen is adapted to cool incoming cryogas flowing through the gas supply line.

5. The cryoneedle of claim 1, wherein the heat exchange helix has a helix pitch defined axially between adjacent turns of the heat exchange helix, the helix pitch being configurable along the heat exchange helix to generate an ice ball having an ellipsoidal or spherical shape.

6. The cryoneedle of claim 5, wherein the helix pitch along the heat exchange helix is constant substantially over the distal section.

7. The cryoneedle of claim 5, wherein the heat exchange helix along the heat exchange helix has a first pitch over a first portion of the distal section and a second pitch over a second portion of the distal section.

8. The cryoneedle of claim 7, wherein the first pitch is greater than the second pitch, such that the cryogas enhances heat transfer over the second portion of the distal section such that the ice ball has a symmetric shape.

9. The cryoneedle of claim 1, wherein the heat exchange helix is a helical spring.

10. The cryoneedle of claim 9, wherein the heat exchange helix is made of a metal.

11. The cryoneedle of claim 1, wherein the heat exchange helix has a heat exchange surface area at the distal section, the heat exchange surface area providing sufficient heat transfer between the cryogas and the outer tube such that the outer tube is cooled to a temperature of between about -150 degree Celsius and about -145 degree Celsius when the cryogas temperature is about -155 degree Celsius and about -150 degree Celsius respectively.

12. The cryoneedle of claim 1, further comprising an insulating sheath substantially surrounding the gas supply line and thereby forming a barrier between the return gas flow lumen and the outer tube over a portion of a length of the outer tube, the insulating sheath having an inner diameter sufficient to create an annular gap between the gas supply line and an inner wall of the insulating sheath, the annular gap being in fluid communication with the return gas flow lumen to receive cryogas flowing therethrough.

13. The cryoneedle of claim 12, wherein the inner diameter of the insulating sheath is about 1.32 mm.

14. The cryoneedle of claim 12, wherein the insulating sheath surrounds the gas supply line over a portion of the length of the outer tube such that, in use, expanded cryogas directly contacts the outer tube over an exposed region, the exposed region having an exposed region length, the exposed region length adapted to generate an ice ball having a predetermined aspect ratio.

15. The cryoneedle of claim 12, wherein the annular gap defined between the outer wall of the insulating sheath and the gas supply line has a diameter sufficient to minimize back pressure acting on the expanded cryogas flowing through the annular gap from the return gas flow lumen.

16. The cryoneedle of claim 1, wherein the gas supply line is coaxial with the longitudinal axis of the outer tube.

17. The cryoneedle of claim 1, wherein the heat exchange helix contacts the inner surface of the outer tube at the distal section.

18. A cryoneedle comprising:

an outer tube having a distal section to be placed at or proximal to a target area of a patient's anatomy;

a gas supply line placed within the outer tube, the gas supply line configured to supply a cryogas for forming an ice ball on an outer surface of the outer tube proximal to the distal section;

an expansion chamber placed within the distal section such that the gas supply line terminates in the expansion chamber;

an electrical resistance heater provided coaxially with the gas supply line and the outer tube to facilitate heating of the distal section of the cryoneedle;

a heat exchange helix contacting the inner surface of the outer tube, the heat exchange helix having an increasing surface area per unit distance of

the distal section such that the ice ball has a generally symmetric shape; and

a return gas flow lumen defined annularly between the heat exchange helix and the gas supply line adapted to carry cryogas from the expansion chamber toward a proximal section, the return gas flow lumen providing a helical return path for the cryogas from the expansion chamber toward the proximal section

wherein the coils of the heat exchange helix are in contact with the inner wall of the outer tube, but not in contact with the heater or the gas supply line.

19. The cryoneedle of claim 18, wherein the heat exchange helix is configured to enhance heat transfer from the cryogas to the outer tube over a second portion of the distal section such that the cryogas evenly cools the outer tube over the entire length of the distal section.