

## CLAIMS

1. An intravascular blood pump for percutaneous insertion into a patient's vasculature, the intravascular blood pump comprising a pumping device and a supply line,
  - 5 - wherein the pumping device comprises a pump section having a blood flow inlet, a blood flow outlet and an impeller rotatable about an axis of rotation for conveying blood from the blood flow inlet to the blood flow outlet, and a drive section connected to the pump section and adapted to drive the impeller,
  - wherein the supply line is adapted to supply the drive section at least with electric  
10 energy for driving the impeller, and
  - wherein the pump section is arranged along the axis of rotation between the drive section and the supply line.
2. The intravascular blood pump according to claim 1, comprising an electrically conductive connection which extends along the pump section and electrically connects the  
15 supply line with a motor of the drive section.
3. The intravascular blood pump according to claim 1 or 2, wherein the pump section comprises a cannula having a longitudinal axis and being bendable along the longitudinal axis.
4. The intravascular blood pump according to claim 3, wherein the blood flow outlet of  
20 the pump section is arranged at a distal end of the cannula.
5. The intravascular blood pump according to claim 3 or 4, wherein the electrically conductive connection comprises one or more electric lines which extend along a wall of the cannula and electrically connect the supply line with the motor of the drive section.
6. The intravascular blood pump according to claim 5, wherein the motor of the drive  
25 section includes a plurality of motor cables and wherein an electrical connector is provided at or in a distance distally to a distal end of the cannula, preferably proximal of the blood flow outlet, where each of the plurality of motor cables is respectively connected to one of the one or more electric lines, the electrical connector preferably being a printed circuit board, and the

electrical connector preferably being covered with an insulating material, more preferably with a polymer coating, such as polyurethane.

7. The intravascular blood pump according to claim 6, wherein each one of the one or more electric lines is a stranded wire.

5 8. The intravascular blood pump according to claim 6, wherein each one of the one or more electric lines is a single wire.

9. The intravascular blood pump according to claim 5, wherein the motor of the drive section includes a plurality of motor cables which constitute the one or more electric lines extending along the cannula, and wherein an electrical connector is provided at or proximally  
10 of a proximal end of the cannula, preferably proximal of the blood flow inlet, where each of the plurality of motor cables is respectively connected to the supply line, the electrical connector preferably being a printed circuit board, and the electrical connector preferably being covered with an insulating material, more preferably with a polymer coating, such as polyurethane.

15 10. The intravascular blood pump according to any one of claims 5 to 9, wherein the one or more electric lines extend along the wall of the cannula in a longitudinal direction parallel to the longitudinal axis of the cannula, preferably along a neutral bending plane of the cannula which is predetermined by a central plane of curvature of the cannula, and are stretchable in the longitudinal direction.

20 11. The intravascular blood pump according to any one of claims 5 to 9, wherein the one or more electric lines extend along the wall of the cannula inside at least one bendable tube, which is preferably disposed along a neutral bending plane of the cannula which is predetermined by a central plane of curvature of the cannula.

12. The intravascular blood pump according to claim 11, wherein the one or more electric  
25 lines are laid with slack inside the at least one bendable tube.

13. The intravascular blood pump according to claim 11 or 12, wherein one bendable tube is provided for each one of the one or more electric lines.

14. The intravascular blood pump according to any one of claims 11 to 13, wherein a  
30 plurality of the at least one bendable tube is arranged on opposite sides of the wall of the cannula so as to create a neutral bending plane within the cannula.

15. The intravascular blood pump according to claim 14, wherein the cannula has an even number of blood flow inlet ports, more preferably four blood flow inlet ports.
16. The intravascular blood pump according to any one of claims 11 to 15, wherein the at least one bendable tube is made of a shape memory alloy.
- 5 17. The intravascular blood pump according to claim 16, wherein the shape memory alloy is nitinol.
18. The intravascular blood pump according to any one of claims 5 to 9, wherein the one or more electric lines extend meander-like along the wall of the cannula.
19. The intravascular blood pump according to claim 18, wherein the one or more  
10 meander-like extending electric lines are arranged along a neutral bending plane of the cannula which is predetermined by a central plane of curvature of the cannula.
20. The intravascular blood pump according to any one of claims 5 to 9, wherein the one or more electric lines extend helically along the wall of the cannula.
21. The intravascular blood pump according to claim 20, wherein the cannula includes one  
15 or more reinforcing windings which extend helically along the wall of the cannula and wherein an angular orientation of the one or more helically extending electric lines relative to the longitudinal axis of the cannula is different to an angular orientation of the one or more helically extending reinforcing windings so that the one or more reinforcing windings and the one or more electric lines overlap, wherein preferably the angular orientations differ by at  
20 least 5°, preferably at least 10°.
22. The intravascular blood pump according to claim 20 or 21, wherein the cannula includes one or more reinforcing windings which extend helically along the wall of the cannula and wherein an angular orientation of the one or more helically extending electric lines relative to the longitudinal axis of the cannula is opposite to an angular orientation of the  
25 one or more helically extending reinforcing windings so that the one or more reinforcing windings and one or more electric lines overlap.
23. The intravascular blood pump according to claim 20, wherein the cannula includes one or more reinforcing windings which extend helically along the wall of the cannula and wherein the one or more helically extending electric lines are placed between the one or more  
30 helically extending reinforcing windings.

24. The intravascular blood pump according to claim 23, wherein the one or more helically extending reinforcing windings include a plurality reinforcing windings arranged in parallel in an axial direction relative to the longitudinal axis of the cannula so as to be nested helically within each other, and wherein the one or more helically extending electric lines  
5 include a plurality of electric lines arranged such that exactly one of the plurality of electric lines is placed between two or more of the helically extending reinforcing windings.
25. The intravascular blood pump according to claim 24, wherein between two and nine of the reinforcing windings are present.
26. The intravascular blood pump according to any one of claims 23 to 25, wherein one or  
10 two or three of the one or more helically extending reinforcing windings are arranged between each of the one or more helically extending electric lines.
27. The intravascular blood pump according to any one of claims 23 to 26, wherein an electrically insulating layer is arranged between the helically extending reinforcing windings and the helically extending electric lines such that the reinforcing windings are arranged  
15 above the insulating layer and the electric lines are arranged below the insulating layer, or vice versa.
28. The intravascular blood pump according to claim 20, wherein the cannula includes one or more reinforcing windings, which extend helically along the wall of the cannula and wherein at least one of the electric lines is formed by a respective one of the reinforcing  
20 windings.
29. The intravascular blood pump according to claim 28, wherein an electrically insulating layer is arranged between the helically extending reinforcing windings such that neighboring reinforcing windings are arranged in alternating fashion above and below the insulating layer.
30. The intravascular blood pump according to any one of claims 20 to 29, wherein the  
25 one or more helically extending reinforcing windings are made of a flat wire.
31. The intravascular blood pump according to any one of claims 20 to 30, wherein the reinforcing windings are made of a shape memory alloy.
32. The intravascular blood pump according to any one of claims 5 to 31, wherein the one or more electric lines are arranged inside the wall of the cannula.

33. The intravascular blood pump according to any one of claims 5 to 32, wherein the wall of the cannula comprises a first foil and a second foil bonded to and covering the first foil, wherein at least one reinforcing member is arranged between the first and the second foils, preferably together with the one or more electric lines.
- 5 34. The intravascular blood pump according to claim 33, wherein the first and second foils are made of polyurethane.
35. The intravascular blood pump according to any one of claims 3 to 34, wherein the cannula is configured not to buckle when bent along its longitudinal axis by up to 180°.
36. The intravascular blood pump according to any one of claims 1 to 35, wherein the  
10 impeller is a axially-radially, diagonally or centrifugally delivering impeller.
37. The intravascular blood pump according to any one of claims 1 to 36, wherein the supply line is in the form of a supply catheter which preferably further includes at least a pressure sensor line.
38. The intravascular blood pump according to any of claims 1 to 37, comprising at least  
15 one anchor adapted to anchor the intravascular blood pump in a wall of a patient's blood vessel.
39. The intravascular blood pump according to claim 38, wherein the anchor comprises spikes that are expandable and collapsible.
40. The intravascular blood pump according to any of claims 1 to 39, comprising an  
20 anchoring structure at a distal end region of the intravascular blood pump.
41. The intravascular blood pump according to claim 40, wherein the anchoring structure comprises a hook or loop at an axial end of the distal end region.
42. The intravascular blood pump according to claim 41, wherein the loop is made from a soft, elastic material and forms an atraumatic distal extension at the axial end of the  
25 intravascular blood pump.
43. The intravascular blood pump according to claim 41, wherein the loop is provided at an atraumatic distal extension of the intravascular blood pump.

44. The intravascular blood pump according to any one of claims 40 to 43, wherein the anchoring structure comprises a neck-and-head structure at an axial end of the distal end region.
45. The intravascular blood pump according to claim 44, wherein a connecting surface  
5 between a head and a neck of the neck-and-head structure is inclined by  $90^\circ$  relative to a longitudinal axis of the intravascular blood pump, or the connecting surface is inclined by more than  $90^\circ$  relative to the longitudinal axis of the intravascular blood pump so as to form an undercut.
46. The intravascular blood pump according to claim 44 or 45, wherein the neck-and-head  
10 structure is formed in a recess of the distal end region.
47. The intravascular blood pump according to claim 44 or 45, wherein the neck-and-head structure is formed at an end of an atraumatic distal extension.
48. An introducer set, comprising an intravascular blood pump according to any one of  
15 claims 40 to 47 and a connecting catheter which comprises a connector adapted to connect to the anchoring structure of the intravascular blood pump.
49. The introducer set according to claim 48, wherein the connector comprises a hook adapted to hook into the anchoring structure of the intravascular blood pump.
50. The introducer set according to claim 48, wherein the connector comprises a gripper  
20 having a first grip and a second grip adapted to close or grip around the hook or loop of the intravascular blood pump.
51. The introducer set according to claim 50, wherein the gripper has a gripping surface, wherein the gripping surface is inclined by  $90^\circ$  relative to a longitudinal axis of the connecting catheter.
52. The introducer set according to claim 50, wherein the gripper has a gripping surface,  
25 wherein the gripping surface is inclined by more than  $90^\circ$  relative to the longitudinal axis of the connecting catheter so as to form an undercut.
53. A method of placing an intravascular blood pump in a patient, the blood pump comprising a pump section having a blood flow inlet and a blood flow outlet and an impeller rotatable about an axis of rotation and sized and shaped for conveying blood from the blood

flow inlet to the blood flow outlet, the blood pump further comprising a supply line, preferably a supply catheter, connected to the pump section and adapted to supply energy, preferably electric energy, for driving the impeller, the method comprising the steps of:

- 5       - placing a first guide wire through the patient's vascular system, including through the patient's heart, such that it extends out of the patient's body with a first end through a first percutaneous access on an arterial side of the vascular system, preferably through the axillary artery or subclavian artery, and with a second end through a second percutaneous access on a venous side of the vascular system, preferably through the subclavian vein or axillary vein, and
  - 10       - using the first guide wire in the further procedure of placing the intravascular blood pump into the patient's body through the second percutaneous access.
54. The method of claim 53, comprising one or more of the following steps:
- 15       - inserting a transseptal sheath from the venous side of the patient's vascular system through a passage created in the septum of the patient's heart into the left side of the heart, and advancing the first end of the first guide wire through the transseptal sheath into the left part of the heart and pulling back the transseptal sheath,
  - 20       - wherein preferably the transseptal sheath is inserted through a third percutaneous access into a vein below the vena cava inferior, preferably a femoral vein, and further comprising the steps of: inserting a snare catheter through the second percutaneous access into a vein above the vena cava superior, advancing the snare catheter into the vena cava superior towards the first guide wire, catching the first guide wire with the snare catheter, and moving the second end of the first guide wire into the third percutaneous access and out of the second percutaneous access with the aid of the snare catheter,
  - 25       - expanding the passage through the septum, preferably using a balloon catheter,
  - advancing an introducer sheath through the septum, preferably with the aid of the balloon catheter, such that a front part of the introducer sheath extends into the left part of the heart, preferably into the left ventricle,
  - withdrawing the balloon catheter, where applicable,

- advancing a maneuverable catheter, preferably a Swan-Ganz catheter, through the introducer sheath into the left part of the heart, preferably into the left ventricle,
- preferably, advancing a second guide wire through the first percutaneous access into the left part of the heart, preferably into the left ventricle, and
- 5 - guiding the first end of the first guide wire towards and out of the first percutaneous access with the aid of the maneuverable catheter, preferably by inflating a balloon of the Swan-Ganz catheter and following the patient's blood flow, preferably along a direction which is indicated by the second guide wire.

55. The method of claim 54, comprising one or more of the following steps:

- 10 - attaching, preferably in a form-fitting manner, a front end of a coupling catheter to the first end of the first guide wire and guiding the coupling catheter through the patient's vascular system, including through the patient's heart, using the first guide wire until the front end of the coupling catheter extends through the second percutaneous access out of the patient's body, preferably while simultaneously withdrawing the maneuverable catheter from  
15 the patient's body,
- coupling a distal end of the intravascular blood pump to the coupling catheter, preferably in a form-fitting manner, and advancing the intravascular blood pump through the patient's vascular system, including through the septum, so as to place the pump section into the left part of the heart, preferably across the aortic valve,
- 20 - preferably, anchoring the intravascular blood pump in a wall of a blood vessel, preferably in an aortic wall, preferably by moving a plurality of spikes from a circumference of the intravascular blood pump from a radially collapsed configuration to a radially expanded configuration to engage the wall of the blood vessel,
- decoupling the coupling catheter from the distal end of the intravascular blood pump  
25 and withdrawing the coupling catheter from the patient's body, and
- withdrawing the introducer sheath from the patient's body.

56. The method of claim 54, comprising one or more of the following steps:

- withdrawing the maneuverable catheter from the patient's body while keeping the first end of the first guide wire extending through the second percutaneous access out of the patient's body,
- guiding the introducer sheath along the first guide wire through the patient's vascular system, including through the patient's heart, until the front end of the introducer sheath extends through the second percutaneous access out of the patient's body,
- feeding the second end of the first guide wire through a loop provided at a distal end of the intravascular blood pump and advancing the second end of the first guide wire through the introducer sheath until the second end of the first guide wire extends out of the front end of the introducer sheath,
- gripping the first end second ends of the first guide wire which extend through the second percutaneous access out of the introducer sheath and advancing the intravascular blood pump along the introducer sheath through the patient's vascular system, including through the septum, so as to place the pump section into the left part of the heart, preferably across the aortic valve,
- releasing or unfeeding the first guide wire from the loop provided at the distal end of the intravascular blood pump and withdrawing the first guide wire from the introducer sheath,
- withdrawing the introducer sheath from the patient's body, and
- preferably, anchoring the intravascular blood pump in a wall of a blood vessel, preferably in an aortic wall, preferably by moving a plurality of spikes from a circumference of the intravascular blood pump from a radially collapsed configuration to a radially expanded configuration to engage the wall of the blood vessel.

57. A method of placing an intravascular blood pump in a patient, the blood pump comprising a pumping device, the pumping device comprising a pump section having a blood flow inlet and a blood flow outlet and an impeller rotatable about an axis of rotation and sized and shaped for conveying blood from the blood flow inlet to the blood flow outlet, and a drive section connected to the pump section and adapted to drive the impeller, the blood pump further comprising a supply line, preferably a supply catheter, connected to the pumping device and adapted to supply the drive section at least with energy, preferably electric energy, for driving the impeller, the method comprising the steps of:

- accessing the patient's thoracic cavity;
- creating a puncture through an apical wall of the heart of the patient to access the left ventricle of the heart;
- advancing the pumping device through the puncture in the apical wall such that the
- 5 blood flow inlet of the pump section is disposed in the left ventricle of the heart, the blood flow outlet of the pump section is disposed in the patient's aorta, the supply line extends through the puncture in the apical wall out of the patient's body, and the drive section is disposed in the aorta.

58. The method of claim 57, comprising the step of anchoring the intravascular blood pump

10 in a wall of a blood vessel, preferably in an aortic wall, preferably by moving a plurality of spikes from a circumference of the intravascular blood pump from a radially collapsed configuration to a radially expanded configuration to engage the wall of the blood vessel.

59. A kit for placing an intravascular blood pump in a patient comprising the following tools:
- 15 - a transseptal sheath (17), which may include a puncture tip end or separate puncture needle and a dilator,
  - a first guide wire (20A),
  - a second guide wire (20B),
  - an introducer sheath (19),
  - 20 - a snare catheter (18),
  - a balloon catheter (22),
  - a maneuverable catheter (23),
  - either a connecting catheter (25) or a tube (24).