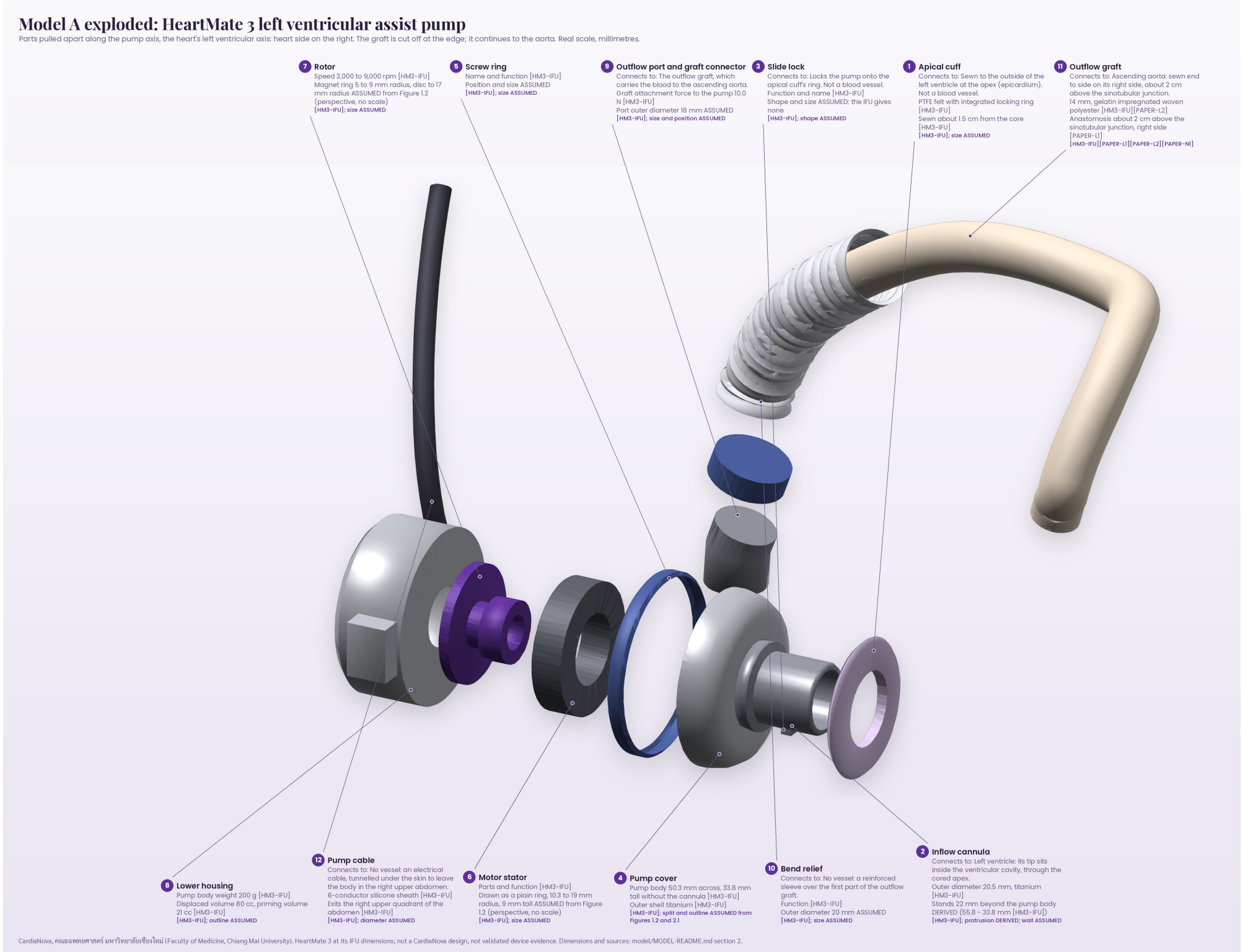


Model A, exploded and explained

HeartMate 3 left ventricular assist pump at its IFU dimensions: every part, what it does, what each tube connects to, and where each number comes from



Not a CardiaNova design and not validated device evidence. Another company's pump, drawn from its instructions for use so a CardiaNova geometry can be compared against it. No hardware was tested.

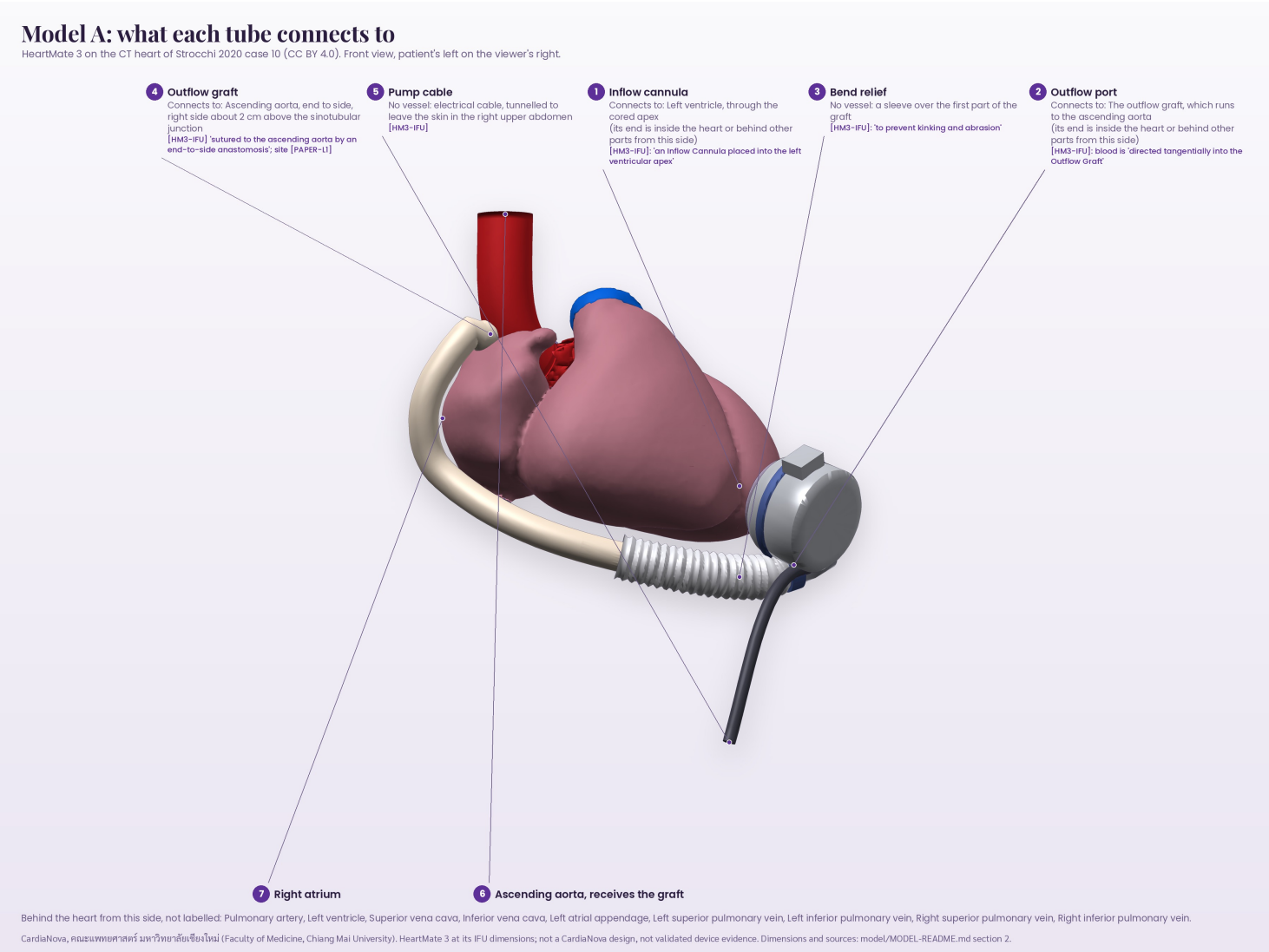
The twelve parts

Numbers match the callouts on the exploded view, counted from the heart outward along the pump axis. Parts that carry blood or attach to the body say what they connect to. The last column is the source key or the status of the number: ASSUMED is not published and was chosen so the part can be drawn; DERIVED is arithmetic or a measurement.

#	Part	Connects to, and what it does	Key numbers	Rests on
1	Apical cuff	Connects to: Sewn to the outside of the left ventricle at the apex (epicardium). Not a blood vessel. A PTFE felt cuff with an integrated locking ring, sewn to the epicardium at the apex. A plug of heart muscle is cored out inside it so the cannula can enter the ventricle. Its metal ring must stand above the felt so the pump's slide lock can grip it [HM3-IFU].	PTFE felt with integrated locking ring [HM3-IFU] Sewn about 1.5 cm from the core [HM3-IFU] Outer diameter 40 mm ASSUMED Thickness 3 mm ASSUMED	[HM3-IFU]; size ASSUMED
2	Inflow cannula	Connects to: Left ventricle: its tip sits inside the ventricular cavity, through the cored apex. The pump's inlet: a titanium tube rigidly fixed to the pump cover. It passes through the apical wall so blood from the left ventricle is drawn into the pump along its central axis [HM3-IFU].	Outer diameter 20.5 mm, titanium [HM3-IFU] Stands 22 mm beyond the pump body DERIVED (55.8 – 33.8 mm [HM3-IFU]) Wall 1.75 mm ASSUMED Tip inside the cavity of this heart at 10 and 19 mm along the axis; apical wall 4.0 mm DERIVED Bore continued down the pump axis to the rotor ASSUMED from Figure 1.2	[HM3-IFU]; protrusion DERIVED; wall ASSUMED
3	Slide lock	Connects to: Locks the pump onto the apical cuff's ring. Not a blood vessel. Secures the inflow cannula in the apical cuff and seals it (the IFU says it is used 'to establish hemostasis'). It will not engage unless it is fully retracted first [HM3-IFU].	Function and name [HM3-IFU] Shape and size ASSUMED; the IFU gives none	[HM3-IFU]; shape ASSUMED
4	Pump cover	The half of the pump body that faces the heart. The inflow cannula is fixed to it and the outflow graft hardware attaches to it [HM3-IFU]. Titanium outer shell.	Pump body 50.3 mm across, 33.8 mm tall without the cannula [HM3-IFU] Outer shell titanium [HM3-IFU] Cover height 11.5 mm ASSUMED (the IFU names the parts, not the split)	[HM3-IFU]; split and outline ASSUMED from Figures 1.2 and 2.1
5	Screw ring	Attaches the pump cover to the lower housing [HM3-IFU]. Drawn as the band seen in the IFU photograph.	Name and function [HM3-IFU] Position and size ASSUMED	[HM3-IFU]; size ASSUMED
6	Motor stator	A single stator both spins the rotor and holds it levitated: iron pole pieces, a back iron, copper coils and position sensors. By sensing the rotor magnet and controlling the drive and levitation coil currents, it actively controls the rotor's radial position and speed; the magnet's pull on the iron keeps the rotor from moving or tilting axially [HM3-IFU].	Parts and function [HM3-IFU] Drawn as a plain ring, 10.3 to 19 mm radius, 9 mm tall ASSUMED from Figure 1.2 (perspective, no scale) Pole count not published, so not drawn	[HM3-IFU]; size ASSUMED
7	Rotor	The only moving part, fully supported by magnetic levitation with no mechanical or fluid bearings. Blood arriving along the axis is thrown outward at right angles by the blades, collects in the volute and leaves tangentially into the outflow graft [HM3-IFU].	Speed 3,000 to 9,000 rpm [HM3-IFU] Magnet ring 5 to 9 mm radius, disc to 17 mm radius ASSUMED from Figure 1.2 (perspective, no scale) Blades not shown in the IFU figure; not drawn	[HM3-IFU]; size ASSUMED
8	Lower housing	Holds the stator, the pump chamber and volute, and the motor control electronics and software. The pump cable is permanently attached to it through a hermetically sealed feed-through [HM3-IFU]. The raised boss opposite the outflow is visible in IFU Figures 1.2 and 2.1; the IFU does not say what it is.	Pump body weight 200 g [HM3-IFU] Displaced volume 80 cc, priming volume 21 cc [HM3-IFU] Blood contacting titanium: fused titanium microspheres [HM3-IFU] Outline and boss ASSUMED from Figures 1.2 and 2.1	[HM3-IFU]; outline ASSUMED
9	Outflow port and graft connector	Connects to: The outflow graft, which carries the blood to the ascending aorta. Where blood leaves the volute tangentially into the graft. The graft can be detached here, so the pump can be replaced without sewing a new graft to the aorta [HM3-IFU]. The IFU says this hardware attaches to the pump cover; the model draws the port lower on the side, where run 29 read Figure 1.2. Unresolved.	Graft attachment force to the pump 10.0 N [HM3-IFU] Port outer diameter 18 mm ASSUMED Port height 42 percent of the body, 20 degree elevation ASSUMED	[HM3-IFU]; size and position ASSUMED
10	Bend relief	Connects to: No vessel: a reinforced sleeve over the first part of the outflow graft. A reinforced tube around the outflow graft that stops it kinking or wearing through; it can be taken off and put back during the operation, and it is never cut [HM3-IFU].	Function [HM3-IFU] Outer diameter 20 mm ASSUMED Length 80 mm ASSUMED	[HM3-IFU]; size ASSUMED
11	Outflow graft	Connects to: Ascending aorta: sewn end to side on its right side, about 2 cm above the sinotubular junction. A sealed woven polyester tube, cut to length and sewn end to side to the ascending aorta [HM3-IFU]. It runs under the right ventricle parallel to the diaphragm, then up beside the right atrium to the aorta [PAPER-N1].	14 mm, gelatin impregnated woven polyester [HM3-IFU][PAPER-L2] Anastomosis about 2 cm above the sinotubular junction, right side [PAPER-L1] Route [PAPER-L1][PAPER-N1]; exact path ASSUMED Last 8 mm touches the right atrial appendage in this heart DERIVED; kept at the sourced site	[HM3-IFU][PAPER-L1][PAPER-L2][PAPER-N1]

#	Part	Connects to, and what it does	Key numbers	Rests on
12	Pump cable	Connects to: No vessel: an electrical cable, tunnelled under the skin to leave the body in the right upper abdomen. Permanently attached to the lower housing. Outside the body it joins the modular cable; together they form the driveline to the system controller, with duplicate sets of three conductors, two for power and ground and one for communication [HM3-IFU].	6-conductor silicone sheath [HM3-IFU] Exits the right upper quadrant of the abdomen [HM3-IFU] Diameter 6 mm ASSUMED; drawn as a stub	[HM3-IFU]; diameter ASSUMED

Every tube and what it connects to



Tube or line	Connects to		Rests on
Inflow cannula	Left ventricle, through the cored apex		[HM3-IFU]: 'an Inflow Cannula placed into the left ventricular apex'
Outflow port	The outflow graft, which runs to the ascending aorta		[HM3-IFU]: blood is 'directed tangentially into the Outflow Graft'
Bend relief	No vessel: a sleeve over the first part of the graft		[HM3-IFU]: 'to prevent kinking and abrasion'
Outflow graft	Ascending aorta, end to side, right side about 2 cm above the sinotubular junction		[HM3-IFU] 'sutured to the ascending aorta by an end-to-side anastomosis'; site [PAPER-L1]
Pump cable	No vessel: electrical cable, tunnelled to leave the skin in the right upper abdomen		[HM3-IFU]

Vessel or chamber	Relation to the pump or blood flow	Rests on
Ascending aorta	receives the graft	[DATA-S1] root; extension ASSUMED
Pulmonary artery	not connected to the pump	[DATA-S1]
Left ventricle	drained by the cannula	[DATA-S1]
Right atrium		[DATA-S1]
Superior vena cava	into the right atrium	tag 12 and plane 23 [PAPER-S1]
Inferior vena cava	into the right atrium	tag 13 and plane 24 [PAPER-S1]

Vessel or chamber	Relation to the pump or blood flow	Rests on
Left atrial appendage		tag 7 and plane 18; identity DERIVED from position
Left superior pulmonary vein	into the left atrium	tag 8 and plane 19; identity DERIVED from position
Left inferior pulmonary vein	into the left atrium	tag 9 and plane 20; identity DERIVED from position
Right superior pulmonary vein	into the left atrium	tag 11 and plane 22; identity DERIVED from position
Right inferior pulmonary vein	into the left atrium	tag 10 and plane 21; identity DERIVED from position

How it works

Blood path. Left ventricle, inflow cannula (2), into the rotor (7) along its axis, thrown outward at right angles by the blades, around the volute in the lower housing (8), out tangentially through the outflow port (9), along the graft (11), sewn end to side to the ascending aorta [HM3-IFU]. The pump works in parallel with the heart; it does not replace it [HM3-IFU].

One moving part. The rotor is fully supported by magnetic levitation, with no mechanical or fluid bearings. A single stator (6) of iron pole pieces, back iron, copper coils and position sensors both turns the rotor and actively controls its radial position and speed; the magnet's attraction to the iron resists axial movement and tilt [HM3-IFU]. Speed range 3,000 to 9,000 rpm.

Attachment. The apical cuff (1) is sewn to the epicardium, a plug of heart muscle is cored out, the cannula is inserted, and the slide lock (3) locks the pump to the cuff's ring and seals it. The graft can be detached from the pump, so the pump can be exchanged without a new aortic suture line [HM3-IFU].

Power. The pump cable (12) is permanently attached to the lower housing, tunnelled under the skin, and leaves the body in the right upper abdomen, where it joins the modular cable to the system controller: duplicate sets of three conductors, 4 W nominal, 10 to 17 V DC [HM3-IFU]. It carries no blood.

Placement checks on this heart

Check	Result
Heart surface points inside the pump housing	0; nearest 5.3 mm
Cannula tip inside the left ventricular cavity (ray parity test)	yes at 10 and 19 mm along the axis; not at 0 and 4 mm, which lie in the apical wall
Bend relief and pump cable clearance from the heart	at least 10.0 and 29.8 mm
Graft centreline closer than its radius to the heart	only the last 8 mm before the anastomosis, down to 2.0 mm, so up to 5 mm of overlap with the right atrial appendage
Left ventricular axis of this heart against the healthy male mean [PAPER-O1]	8.9 degrees

What is assumed, what is unresolved, where it comes from

Assumed

- Sizes of the parts inside the pump (stator ring, rotor magnet ring and disc) read roughly from the IFU's perspective cutaway, Figure 1.2, which has no scale; the rotor blades are not shown there and are not drawn.
- Where the pump cover meets the lower housing, the slide lock, the housing boss and the screw ring sizes; the IFU names these parts but gives no dimensions.
- Apical cuff 40 by 3 mm, cannula wall 1.75 mm, outflow port 18 mm, bend relief 20 by 80 mm, pump cable 6 mm.
- The graft's path between the sourced route and the sourced anastomosis site; the pump's rotation about its axis.

Unresolved

- The IFU says the outflow graft hardware attaches to the pump cover; the port is drawn at 42 percent of the body height, lower on the side, where run 29 read Figure 1.2.
- At the sourced anastomosis site the aorta lies about 6 mm from the right atrial appendage in this heart, so the 14 mm graft overlaps the appendage over its last 8 mm.
- One CT heart (Strocchi 2020 case 10: age 76, male, EF 41%), not an average, not Thai. The ascending aorta above the 35 mm CT stub is an assumed extension.

Sources

[HM3-IFU] Abbott. HeartMate 3 Left Ventricular Assist System Instructions for Use, document 100175565 revision A, 558 pages. Appendix A (Technical Specifications) and sections 1, 2 and 5 read; Figures 1.2, 2.1, 2.2 and 5.31 read as page images.

[PAPER-L1] Loforte A, Bottio T, Attisani M, et al. Conventional and alternative sites for left ventricular assist device inflow and outflow cannula placement. Ann Cardiothorac Surg. 2021;10(2):281 to 288. doi:10.21037/acs-2020-cfmcs-28.

[PAPER-L2] Worku B, Vinogradsky A, Ibrahim A, et al. Outcomes after HeartMate 3 left ventricular assist device implantation using a 10 mm outflow graft. ASAIO J. 2025;71(1):21 to 26. doi:10.1097/MAT.0000000000002249. Abstract.

[PAPER-N1] Netuka I. HeartMate 3 left ventricular assist system implantation technique: the devil is in the detail. Interact Cardiovasc Thorac Surg. 2018;27(6):946 to 949. doi:10.1093/icvts/ivy264.

[PAPER-O1] Odille F, Liu S, van Dam P, Felblinger J. Statistical variations of heart orientation in healthy adults. Computing in Cardiology. 2017;44. doi:10.22489/CinC.2017.225-058.

[PAPER-S1] [DATA-S1] Strocchi M, Augustin CM, Gsell MAF, et al. A publicly available virtual cohort of four-chamber heart meshes for cardiac electro-mechanics simulations. PLoS ONE 2020;15(6):e0235145; data doi:10.5281/zenodo.3890034, case 10, CC BY 4.0; modified (surfaces extracted, reoriented, simplified). Tags 12 and 13 are the venae cavae as the paper states; which of tags 7 to 11 is the appendage and which pulmonary vein was worked out from position.

Files: model/heart_models.py (geometry and part text), model/render_hq.py (these renders), model/MODEL-README.md section 2 (every dimension), report/29.md and report/34.md (what was done).

CardiaNova, คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่ (Faculty of Medicine, Chiang Mai University)

Design exploration, not validated device evidence. It cannot support any clinical or regulatory statement.