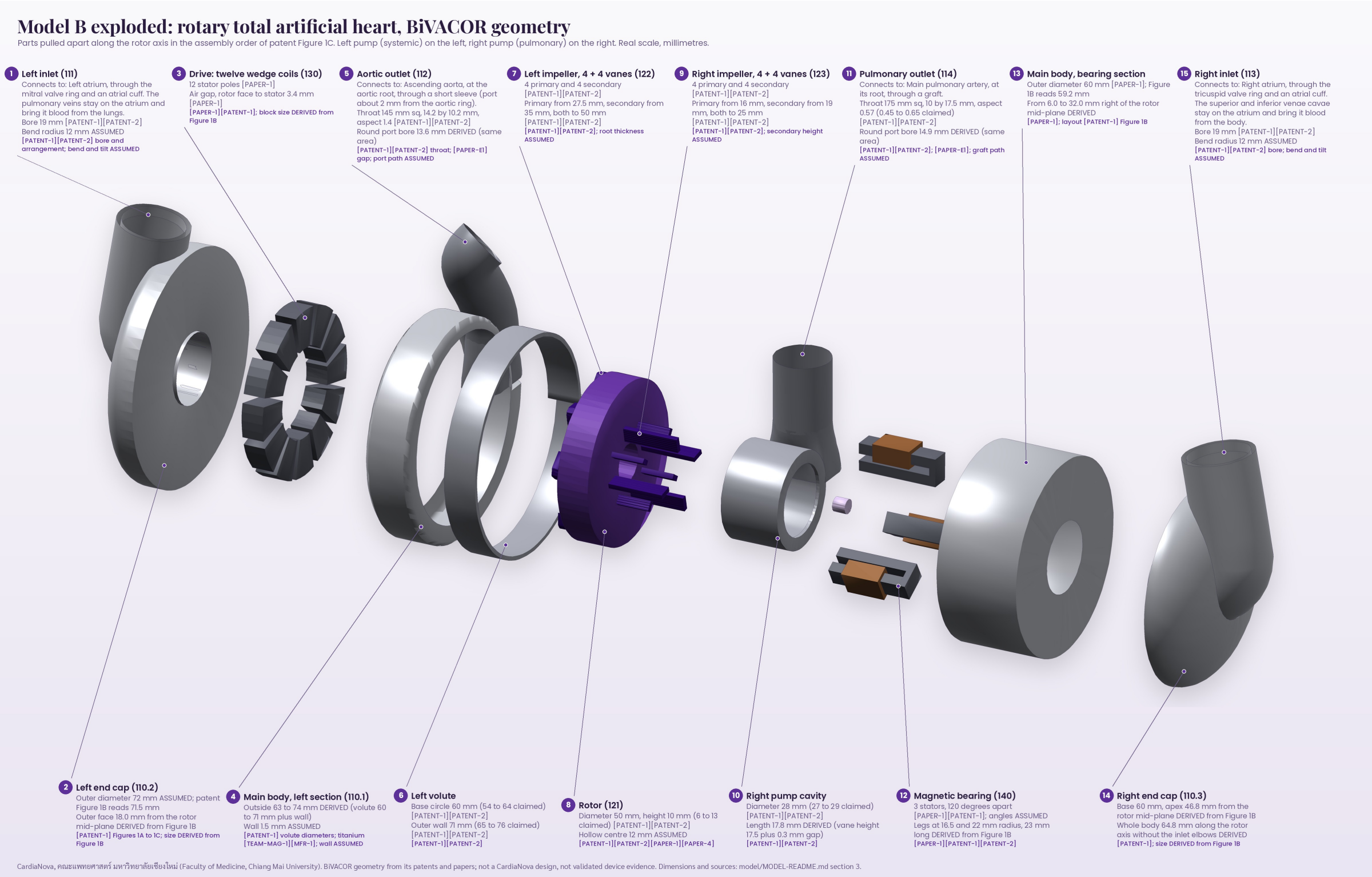


Model B, exploded and explained

Rotary total artificial heart at the BiVACOR geometry: every part, what it does, its size and where the number comes from



Not a CardiaNova design and not validated device evidence. Another team's device, drawn to its patents and papers so a CardiaNova geometry can be compared against it. No hardware was tested.

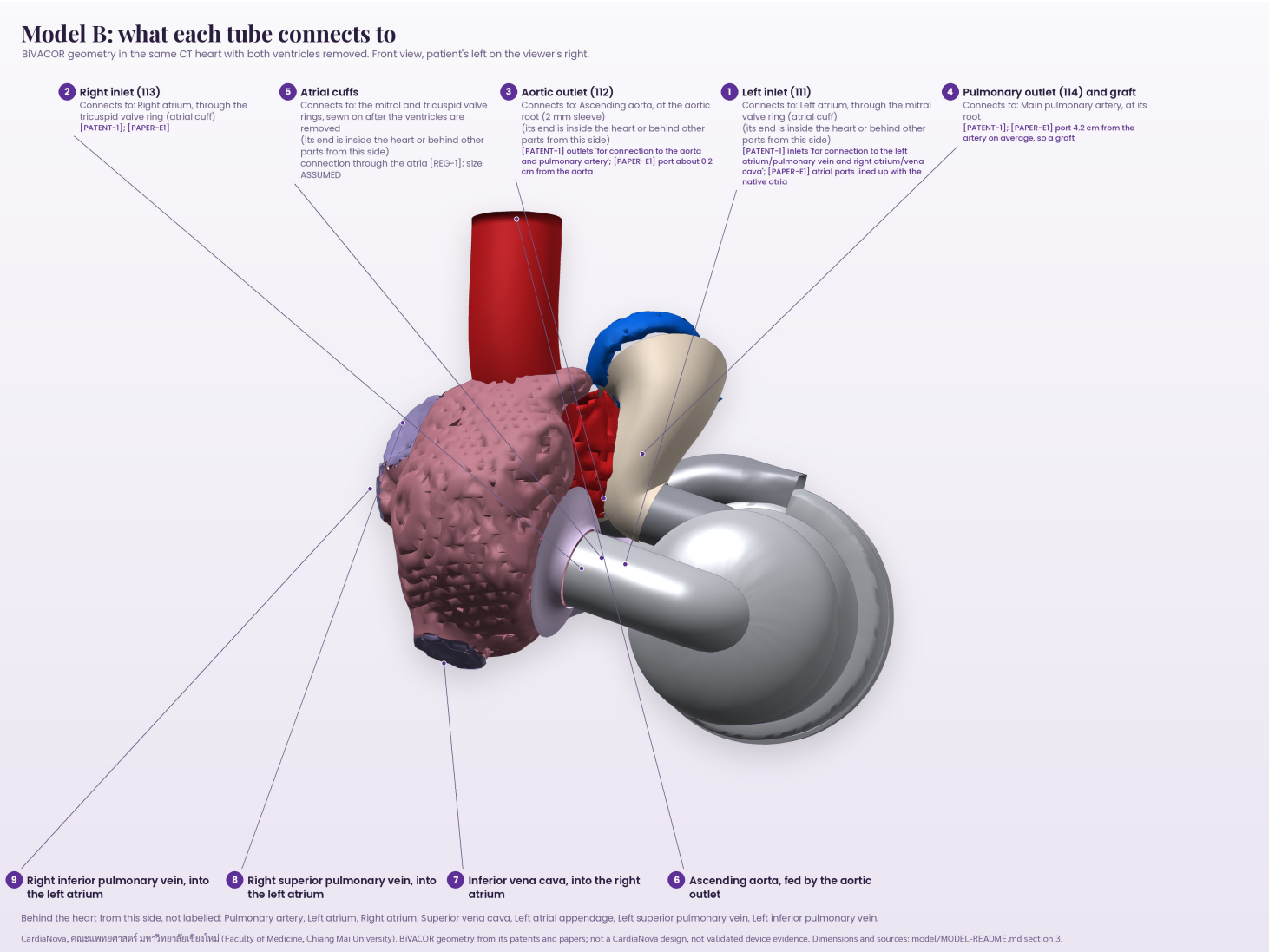
The fifteen parts

Numbers match the callouts on the exploded view. 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 on a sourced drawing. Full citations are on the last page; the complete dimension table is in model/MODEL-README.md and on the model web page.

#	Part	What it does	Key numbers	Rests on
1	Left inlet (111)	Connects to: Left atrium, through the mitral valve ring and an atrial cuff. The pulmonary veins stay on the atrium and bring it blood from the lungs. Carries blood from the left atrium into the left pump. The patent claims the inlet is 'aligned with an axis of the cavity', so the channel enters the left cavity along the rotor axis, passes through the middle of the drive coils, and turns through the left end cap to open on the same side as the other three ports (patent Figure 1A). In the heart an atrial cuff joins it to the mitral ring.	Bore 19 mm [PATENT-1][PATENT-2] Bend radius 12 mm ASSUMED Opening tilted 10 degrees toward the device middle ASSUMED Opening 2.1 mm from its target and 6.8 degrees from the mitral ring normal in this heart DERIVED	[PATENT-1][PATENT-2] bore and arrangement; bend and tilt ASSUMED
2	Left end cap (110.2)	Closes the drive end of the housing. The drive coils sit between it and the left casing face, and the left inlet leaves through its centre.	Outer diameter 72 mm ASSUMED; patent Figure 1B reads 71.5 mm Outer face 18.0 mm from the rotor mid-plane DERIVED from Figure 1B Rim rounded at 4 mm radius ASSUMED	[PATENT-1] Figures 1A to 1C; size DERIVED from Figure 1B
3	Drive: twelve wedge coils (130)	An axial flux brushless DC motor. Twelve wedge shaped coils on stator cores face the eight drive magnets near the rotor rim across the air gap and turn the rotor. The left vanes spin inside that gap, which is why they are only 2 mm tall. The drive sits on the left pump side and the bearing on the right, so the magnetic pull of each on the rotor can be matched at the normal operating position [PATENT-1].	12 stator poles [PAPER-1] Air gap, rotor face to stator 3.4 mm [PAPER-1] Casing wall between vanes and coils 1.1 mm DERIVED (3.4 - 2 - 0.3) Coils drawn 14 to 26 mm radius, about 7 mm deep DERIVED; Figure 1B reads 12 to 28 mm	[PAPER-1][PATENT-1]; block size DERIVED from Figure 1B
4	Main body, left section (110.1)	The titanium housing around the left pump chamber and the rotor rim. Its outside follows the left volute, so it grows around the circumference and steps back at the aortic throat, like the raised volute in patent Figure 1A.	Outside 63 to 74 mm DERIVED (volute 60 to 71 mm plus wall) Wall 1.5 mm ASSUMED Rotor to cavity wall, radial 4 mm on average [PATENT-1][PATENT-2] Spans 8.4 mm left to 6.0 mm right of the rotor mid-plane DERIVED	[PATENT-1] volute diameters; titanium [TEAM-MAG-1][MFR-1]; wall ASSUMED
5	Aortic outlet (112)	Connects to: Ascending aorta, at the aortic root, through a short sleeve (port about 2 mm from the aortic ring). Blood leaves the left volute tangentially through a rectangular throat in the outer wall (claimed: 'outlet provided in a circumferential outer wall of the cavity'). A titanium port of the same area then turns toward the aorta. In the fitting study the aortic port lay almost on the native aorta, so here the port is carried to 2 mm from this heart's aortic ring.	Throat 145 mm sq, 14.2 by 10.2 mm, aspect 1.4 [PATENT-1][PATENT-2] Round port bore 13.6 mm DERIVED (same area) Gap to the aortic ring 2 mm [PAPER-E1] (mean 0.2 cm, range 0 to 0.5)	[PATENT-1][PATENT-2] throat; [PAPER-E1] gap; port path ASSUMED
6	Left volute	The spiral collector around the left impeller. Its passage widens around the circumference, collecting the flow that leaves the vane tips before the aortic throat. The patent defines it by its base circle and outer wall diameters at the throat.	Base circle 60 mm (54 to 64 claimed) [PATENT-1][PATENT-2] Outer wall 71 mm (65 to 76 claimed) [PATENT-1][PATENT-2] Cutwater angle 45 degrees [PATENT-1][PATENT-2], not drawn Unresolved: these diameters and the 145 mm sq throat give 56 mm sq for a 10.2 mm tall section, not 145; both drawn as stated	[PATENT-1][PATENT-2]
7	Left impeller, 4 + 4 vanes (122)	The systemic pump: blades on the drive face of the rotor. Four primary blades and four shorter secondary blades are swept back against the direction of rotation and thicken toward the tip. The patent notes that a taller vane reduces sensitivity to the rotor's axial position, and these are short, so the left output responds strongly when the rotor moves.	4 primary and 4 secondary [PATENT-1][PATENT-2] Primary from 27.5 mm, secondary from 35 mm, both to 50 mm [PATENT-1][PATENT-2] Height 2 mm (1.5 to 3 claimed) [PATENT-1][PATENT-2] Inlet angle 84, outlet 40 degrees from tangential [PATENT-1][PATENT-2] Tip thickness 7.5 mm [PATENT-1][PATENT-2]; root 1.5 mm ASSUMED; clipped at the 50 mm rim Pressure about 80 mmHg at 6 L/min (60 to 100 claimed) [PATENT-1][PATENT-2]	[PATENT-1][PATENT-2]; root thickness ASSUMED

#	Part	What it does	Key numbers	Rests on
8	Rotor (121)	The only moving part. One disc carries both impellers and is held by magnetic forces with no shaft and no contact, so the left and right pumps always turn at the same speed. Inside it are eight drive magnets near the rim facing the drive, and two annular bearing members on the bearing side facing the legs of the bearing stators.	Diameter 50 mm, height 10 mm (6 to 13 claimed) [PATENT-1][PATENT-2] Hollow centre 12 mm ASSUMED 8 drive magnets, 2 bearing rings [PAPER-1][PATENT-1]; sizes ASSUMED Axial gap to the casing 250 to 350 um, typically 300 [PATENT-2] Working clearance at least 240 um [PAPER-4][TEAM-MAG-1] Axial travel plus or minus 0.3 mm [PAPER-1]	[PATENT-1][PATENT-2][PAPER-1][PAPER-4]
9	Right impeller, 4 + 4 vanes (123)	The pulmonary pump, on the bearing face of the rotor. Straight, constant thickness radial blades, tall and small in diameter. The patent says the tall blades cut recirculation between the blades, and the small diameter limits the pressure made at the speed both pumps share, which suits the lungs.	4 primary and 4 secondary [PATENT-1][PATENT-2] Primary from 16 mm, secondary from 19 mm, both to 25 mm [PATENT-1][PATENT-2] Height 17.5 mm (15 to 20 claimed) [PATENT-1][PATENT-2]; secondary drawn at 60 percent ASSUMED Thickness 1.5 mm, blade angle 90 degrees [PATENT-1][PATENT-2] Pressure about 20 mmHg at 6 L/min (10 to 30 claimed) [PATENT-1][PATENT-2]	[PATENT-1][PATENT-2]; secondary height ASSUMED
10	Right pump cavity	The chamber around the right impeller, inside the ring of bearing stators. The patent gives the cavity diameter for the 24 to 25 mm right rotor and the right volute's base circle as the same 28 mm, so it is drawn round with a tangential throat.	Diameter 28 mm (27 to 29 claimed) [PATENT-1][PATENT-2] Length 17.8 mm DERIVED (vane height 17.5 plus 0.3 mm gap) Wall 1 mm ASSUMED	[PATENT-1][PATENT-2]
11	Pulmonary outlet (114)	Connects to: Main pulmonary artery, at its root, through a graft. Leaves the right cavity tangentially through a tall rectangular throat that runs between two bearing stators, becomes a round port, and continues as a graft to the pulmonary artery root. In the fitting study the pulmonary port sat on average 4.2 cm from the pulmonary artery, which is why a graft is needed.	Throat 175 mm sq, 10 by 17.5 mm, aspect 0.57 (0.45 to 0.65 claimed) [PATENT-1][PATENT-2] Round port bore 14.9 mm DERIVED (same area) Graft 43.5 mm long in this heart DERIVED Fitting study: port to artery mean 4.2 cm, range 1 to 7 [PAPER-E1]	[PATENT-1][PATENT-2]; [PAPER-E1]; graft path ASSUMED
12	Magnetic bearing (140)	Three U shaped stators stand around the small right cavity with both legs facing the rotor's bearing members; each carries its coil on the outer leg. Three eddy current sensors measure the rotor's axial position and the bearing current sets it. Moving the rotor toward one cavity raises that side's output and lowers the other's (Kurita 2014), which is how one rotor balances the two circulations without valves. Placing the large bearing beside the small right cavity lets its legs sit close to the rotor [PATENT-1].	3 stators, 120 degrees apart [PAPER-1][PATENT-1]; angles ASSUMED Legs at 16.5 and 22 mm radius, 23 mm long DERIVED from Figure 1B 3 eddy current sensors [PAPER-1] Axial travel plus or minus 0.3 mm [PAPER-1] A 200 um shift: flow change 2 to 3 L/min left, 0.5 to 1.5 L/min right, narrowest claimed ranges [PATENT-1][PATENT-2]	[PAPER-1][PATENT-1][PATENT-2]
13	Main body, bearing section	The narrower titanium section around the bearing stators and the right cavity. Kurita 2014 gives the device as approximately 60 mm across, and patent Figure 1B scaled by the rotor reads this section at 59.2 mm.	Outer diameter 60 mm [PAPER-1]; Figure 1B reads 59.2 mm From 6.0 to 32.0 mm right of the rotor mid-plane DERIVED Wall 1 mm DERIVED	[PAPER-1]; layout [PATENT-1] Figure 1B
14	Right end cap (110.3)	The dome that closes the bearing end. The right inlet channel crosses its face, as the curved channel on the right end does in patent Figure 1A.	Base 60 mm, apex 46.8 mm from the rotor mid-plane DERIVED from Figure 1B Whole body 64.8 mm along the rotor axis without the inlet elbows DERIVED	[PATENT-1]; size DERIVED from Figure 1B
15	Right inlet (113)	Connects to: Right atrium, through the tricuspid valve ring and an atrial cuff. The superior and inferior venae cavae stay on the atrium and bring it blood from the body. Carries blood from the right atrium. It enters the right cavity along the rotor axis through the middle of the bearing ring, then turns across the dome to the port side, where an atrial cuff joins it to the tricuspid ring.	Bore 19 mm [PATENT-1][PATENT-2] Bend radius 12 mm ASSUMED Opening 2.1 mm from its target and 6.8 degrees from the tricuspid ring normal in this heart DERIVED	[PATENT-1][PATENT-2] bore; bend and tilt ASSUMED

Every tube and what it connects to

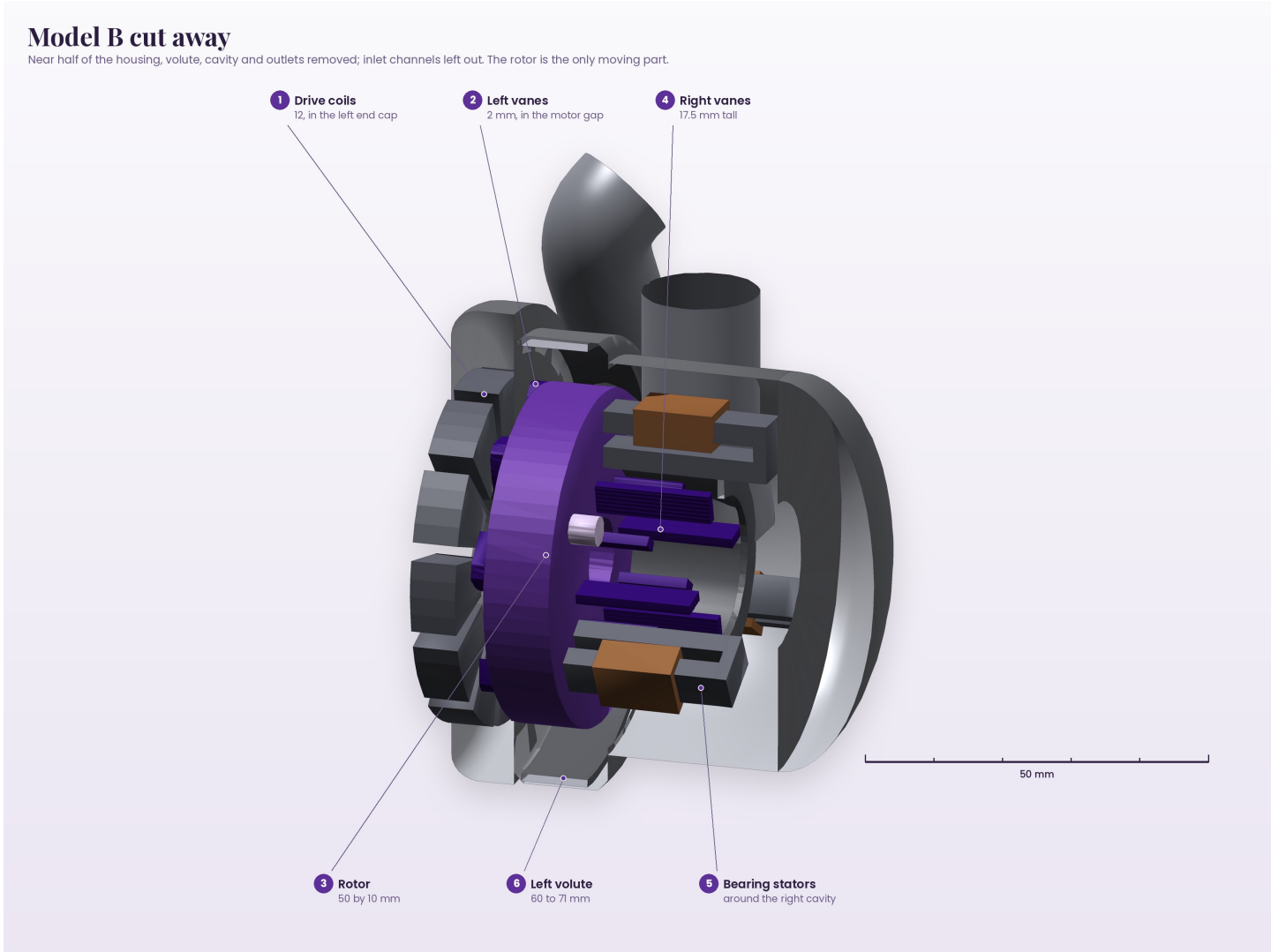
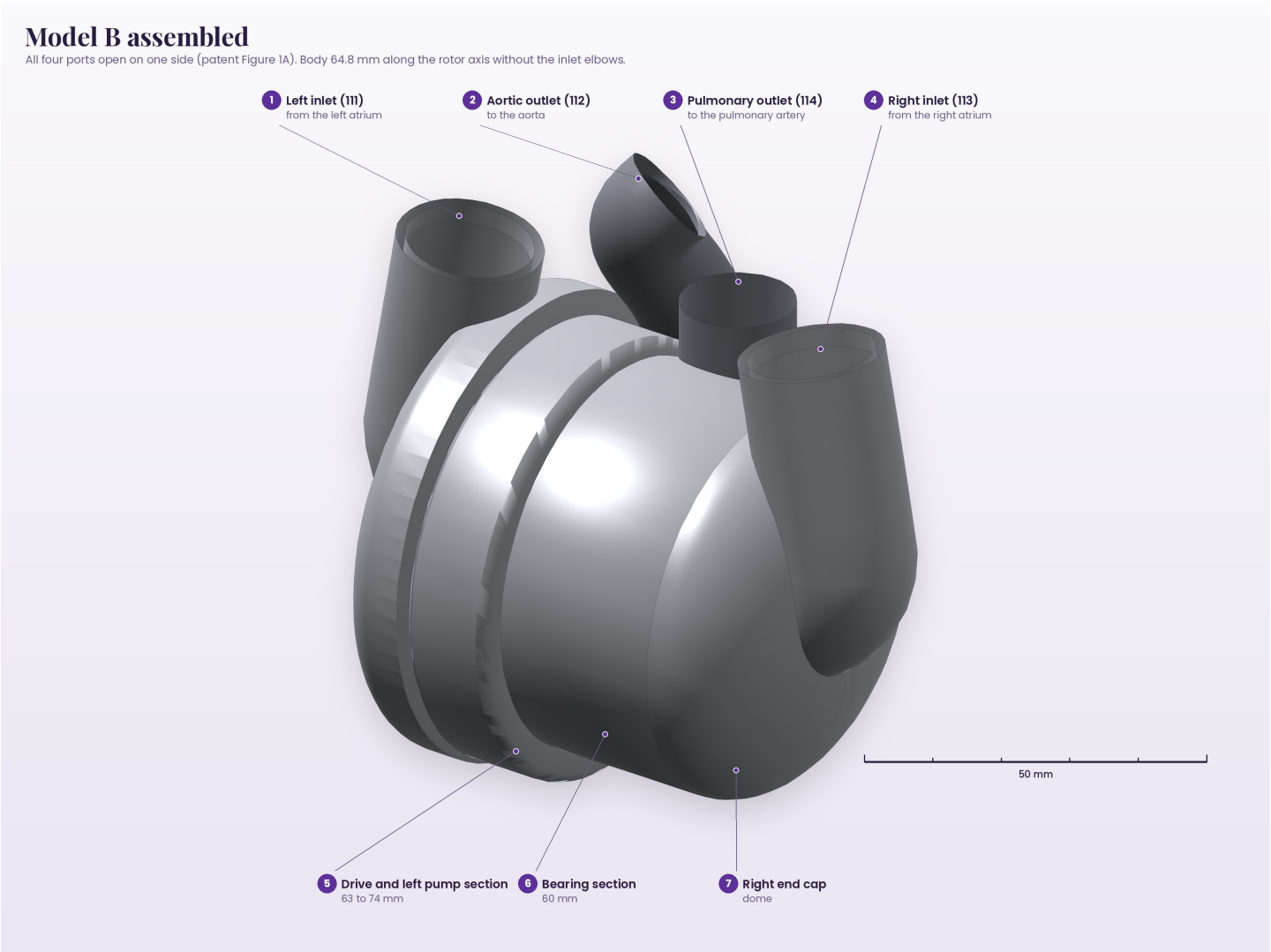


Tube	Connects to	Rests on
Left inlet (111)	Left atrium, through the mitral valve ring (atrial cuff)	[PATENT-1] inlets 'for connection to the left atrium/pulmonary vein and right atrium/vena cava'; [PAPER-E1] atrial ports lined up with the native atria
Right inlet (113)	Right atrium, through the tricuspid valve ring (atrial cuff)	[PATENT-1]; [PAPER-E1]
Aortic outlet (112)	Ascending aorta, at the aortic root (2 mm sleeve)	[PATENT-1] outlets 'for connection to the aorta and pulmonary artery'; [PAPER-E1] port about 0.2 cm from the aorta
Pulmonary outlet (114) and graft	Main pulmonary artery, at its root	[PATENT-1]; [PAPER-E1] port 4.2 cm from the artery on average, so a graft
Atrial cuffs	the mitral and tricuspid valve rings, sewn on after the ventricles are removed	connection through the atria [REG-1]; size ASSUMED

Vessel stub	Blood flow	Rests on
Ascending aorta	fed by the aortic outlet	[DATA-S1] root; extension ASSUMED
Pulmonary artery	fed by the pulmonary graft	[DATA-S1]
Left atrium	feeds the left inlet	[DATA-S1]
Right atrium	feeds the right inlet	[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 stub	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

Closed and cut open



How blood moves through it

Left side (to the body). Left atrium, atrial cuff, left inlet (1) along the rotor axis, onto the left impeller (7) in the motor gap, out into the left volute (6), through the 145 mm sq throat and the aortic outlet (5), into the aorta.

Right side (to the lungs). Right atrium, atrial cuff, right inlet (15) through the middle of the bearing ring, onto the tall right impeller (9), around the 28 mm cavity (10), through the 175 mm sq throat and the pulmonary outlet (11), along the graft into the pulmonary artery.

Balance. Both impellers are on one rotor, so they always share a speed. The magnetic bearing (12) moves the rotor along its axis by about plus or minus 0.3 mm [PAPER-1]; moving it toward one cavity raises that side's output and lowers the other's [PAPER-1]. In the patents' narrowest claimed ranges a 200 um shift changes flow by 2 to 3 L/min on the left and 0.5 to 1.5 L/min on the right [PATENT-1] [PATENT-2]. That is how the device matches left and right output without valves or a second motor.

The rotor

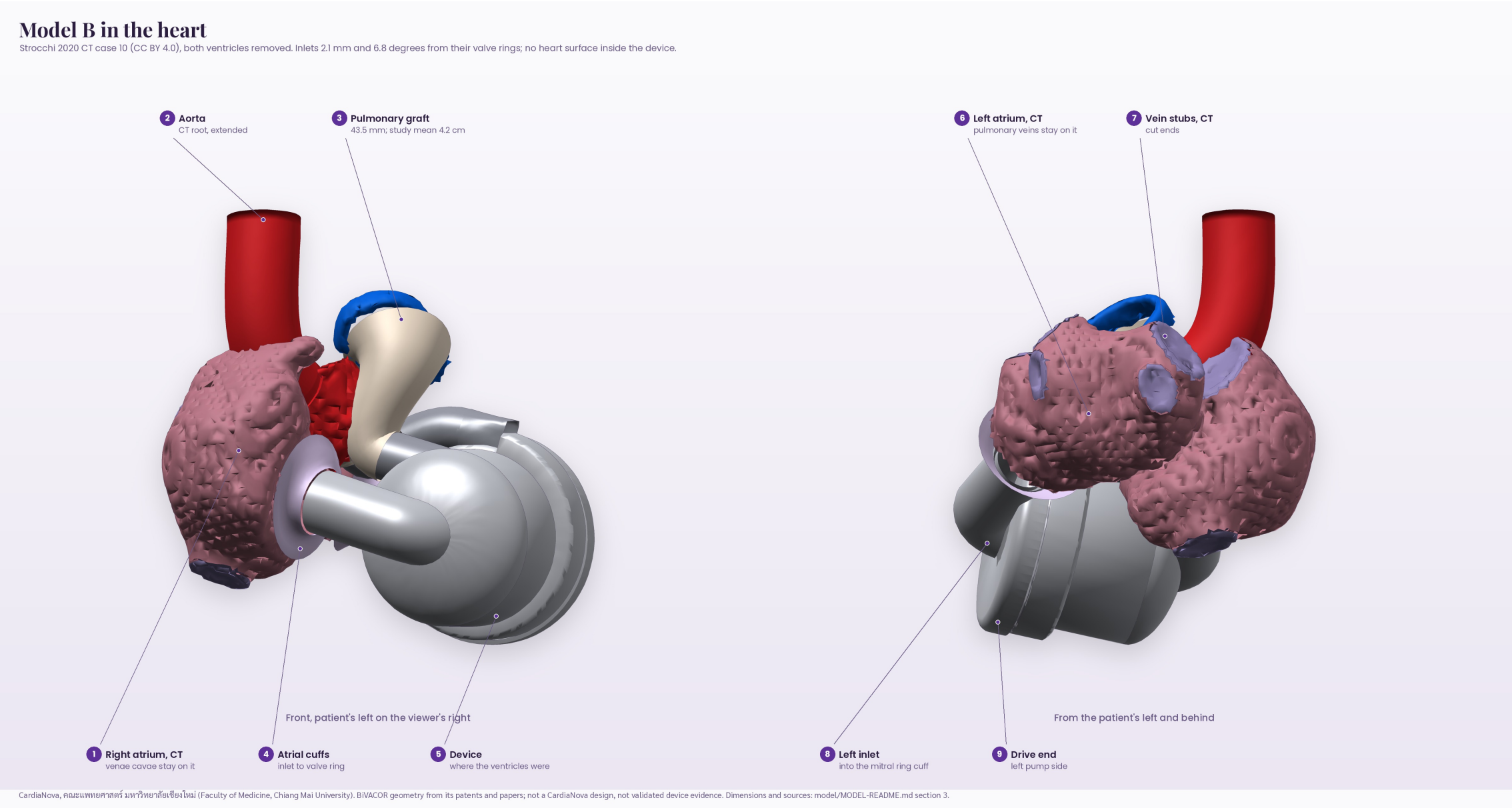
Model B rotor: the single moving part

50 by 10 mm disc, magnetically levitated with no shaft. Two impellers on one rotor: left for the body, right for the lungs. Axial gap 250 to 350 um, below drawing resolution.



CardiaNova, คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่ (Faculty of Medicine, Chiang Mai University). BiVACOR geometry from its patents and papers; not a CardiaNova design, not validated device evidence. Dimensions and sources: model/MODEL-README.md section 3.

In the heart



Placement checks

Check	Result
Inlet openings to their valve ring targets	2.1 and 2.1 mm
Inlet directions to the ring normals	6.8 and 6.8 degrees
Heart surface points inside the device body	0 in each of 5 surfaces
Internal part vertices outside the housing	0 of 6112
Aortic port to aortic ring	2 mm, set from [PAPER-E1] mean 0.2 cm (0 to 0.5)
Pulmonary graft length	43.5 mm; [PAPER-E1] mean 4.2 cm (1 to 7)
Body length along the rotor axis, without inlet elbows	64.8 mm

Placement is by rule, not a free fit: ports toward the atria (mean of the mitral and tricuspid ring normals), rotor axis from the mitral toward the tricuspid ring, inlet openings centred 8 mm short of their rings (ASSUMED cuff length), aortic port carried to the aortic root. The pulmonary graft agreeing with [PAPER-E1] is a check, not a validation.

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

Assumed

- Where each port opens, read from patent Figure 1A by eye; the inlet bend radius and tilt; port lengths.
- The rotor's turning sense, which sets the side the outlets leave on; chosen so they face the great arteries.
- Rotor bore, wall thicknesses, magnet and coil block sizes, sensor and stator angles.
- Graft and cuff sizes and paths; the ascending aorta past the 35 mm CT stub.

Unresolved

- Left throat: 60 to 71 mm volute diameters and a 145 mm sq throat at aspect ratio 1.4 cannot be one rectangular section (56 against 145 mm sq).
- Kurita 2014 gives approx 60 mm across and 70 mm height for the 2014 build; what the height measures is not defined.
- One CT heart (Strocchi 2020 case 10: age 76, male, EF 41%), not an average, not Thai.

Sources

[PATENT-1] Timms D; BiVACOR Inc. Heart pump. US 10,543,301 B2, granted 28 January 2020.

[PATENT-2] Timms D; BiVACOR Inc. Heart pump. US 11,833,341 B2, granted 5 December 2023.

[PAPER-1] Kurita N, Timms D, Greatrex N, Kleinheyer M, Masuzawa T. Optimization design of magnetically suspended system for the BiVACOR total artificial heart. ISMB14, Linz, 2014, pp 437 to 440.

[PAPER-4] McNamee AP, Timms D, Nestler F, et al. In vitro hemocompatibility of the BiVACOR total artificial heart in continuous and pulsatile flow. Artif Organs. 2026;50(1):84 to 93. doi:10.1111/aor.70009.

[PAPER-E1] Emmanuel S, Jansz P, McGiffin D, et al. Anatomical human fitting of the BiVACOR total artificial heart. Artif Organs. 2022;46(1):50 to 56. doi:10.1111/aor.14077. Abstract only.

[PAPER-SF1] Narayanaswamy K, Petz J, Bierewirtz T, et al. Anatomical compatibility of a novel total artificial heart: an in-silico study. Artif Organs. 2025;49(2):196 to 206. doi:10.1111/aor.14878. Method only.

[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 (ventricles removed, surfaces extracted, simplified).

Files: model/heart_models.py (geometry), model/render_hq.py (these renders), model/MODEL-README.md section 3 (every dimension), model/MODEL-B-REFERENCES.md and model/refs/ (the primary documents), report/31.md to report/34.md (what was done).

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