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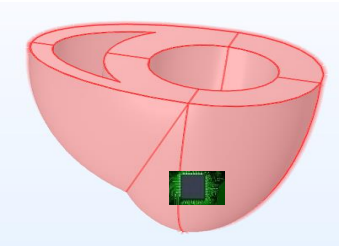
Total Artificial Heart



Prof. Dr. Mehdi Khan, MEE, MD (Cont), PhD

Professor: Hunan university of Arts and Science

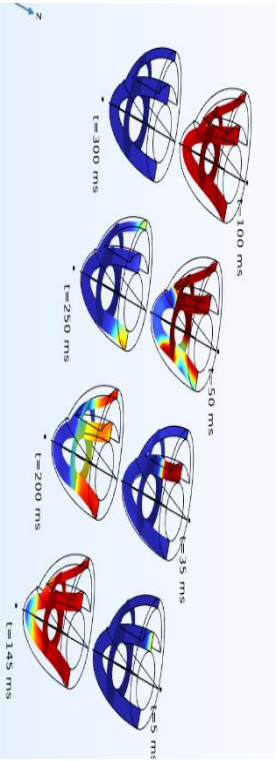
Senior consultant: Total Artificial Heart Transplant- United Christian Hospital, Peking Union Medical University

Senior consultant: RFIC, MMIC, ASIC, MCU, Nanotechnology, submm/mm for Radio Astronomy - Upplysning Robotics -- Chile (Claudio- **Professor** Universidad de Andes)

CTO : Upplysning Robotics → Biomedical devices & Radio Astronomy devices.

Patron: Journal of Medical, Electronics & Mechanical circulatory support.

Patron: International society of Medical, Electronics & Mechanical circulatory support.



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- MicroMed Heart Assist 5 (now the Reliant Heart HA5)

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Content

- Medical device Prototyping Headquarters
- Custom cuff fabrication
- Surgery →Custom cuff fabrication
- Dual MicroMed Heart Assist 5 TAH
- Cardiac replacement with dual continuous Flow pumps-experimental experience
- Right Pump thrombus remains problematic
- First Clinical experience with a continuous flow TAH
- Dual Thoratec HeartMate II
- BIVACOR Heart → One motor with maglevation
- 3-D printed the artificial heart
- Hemolysis Studies
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- BIVACOR Pulsatile output Characteristics
- BIVACOR Functionality
- Integrated left-to-right shunt for venous emboli protection
- Linear Mold 3-D Titanium Printing on the EOS Machine
- First Chronic BiVACOR TAH Implant, THI Cardiovascular Research Lab
- In Summary Old technique of TAH

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Upplysning Robotics SMC PVT LTD

Content

- Upplysning Robotics →Total Artificial Heart
- Total Artificial heart (TAH) Core structure
- Conference & Research Article
- TEAM
- Upplysning Robotics TAH Structure → CAD Simulation
- 3-D printed the artificial heart
- Linear Mold 3-D Titanium Printing on the EOS Machine
- TAH Mock flow loop to characterized performance, Upplysning Robotics→ Memma
- One motor →Maglevation cum hydraulic motor for TAH
- Contiguous mode Maglevation & Pulsatile mode (Hydraulic)
- MCU Diagram
- MCU Structure
- MCU Specification
- Partner
- Summary

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CORE TEAM

Dr. Muahmmad Khalid Pervaiz - CEO

Dr. Mehdi Khan -(CTO: Head of MCU and Mechanical Structure TAH, Motor design and Implantation within the Human Body)

Dr. Zhi-Cheng Jing -(Consultant: Head of cardiology)

Dr. He Lin - (Consultant: Head of Analog IC Design)

Dr. Lin Fujiang - (Consultant: Head of RFIC/MMIC IC Design)

Dr. Huang Dong - (Consultant: RFIC)

Dr. Meng Xu (ASIC / Analog)

Dr. Kishore (Consultant: Polymer material)

Dr. Xu Li (Consultant: Mems Bio sensor)

Dr. Pervaiz Chaudhry (Consultant: Cardiac Surgeon)

Bell Hu (Consultant: MCU IP integration testing debugging)

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Introduction

Definition- **M**echanical **C**irculatory **S**upport **(MCS)** Devices are mechanical pumps designed to assist or replace the function of either the left or the right ventricle or both ventricles of the heart.

UPPLYSNING ROBOTICS is the first company in Pakistan to perform total artificial heart TAH design and will transplant in animals for testing before moving on to human bodies in the third phase.

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Heart Failure

With an incidence of 1.1 million new cases each year, heart failure (HF) is a serious condition that affects more than 300,000 Australians and 11 million people in the US and Europe. Furthermore, HF incidence is expected to rise by 40% by 2040 based on current growth rates.

A ventricular assist device (VAD) or total artificial heart (TAH) might benefit 100,000 people right away, according to the US National Institutes of Health (NIH), and the European market is also sizable.

Patients with severe HF have a poor prognosis without treatment. For these people, drug therapy is a constrained and largely ineffectual alternative. They might benefit from a heart transplant, but there are only 4,000 donor hearts available each year in the world.

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Total Artificial Heart Therapy

Patients with end-stage HF who require support while waiting for a heart transplant or who are not candidates for a transplant may benefit from having a TAH implanted. The device can fully replace the function of the natural heart by removing the ventricles.

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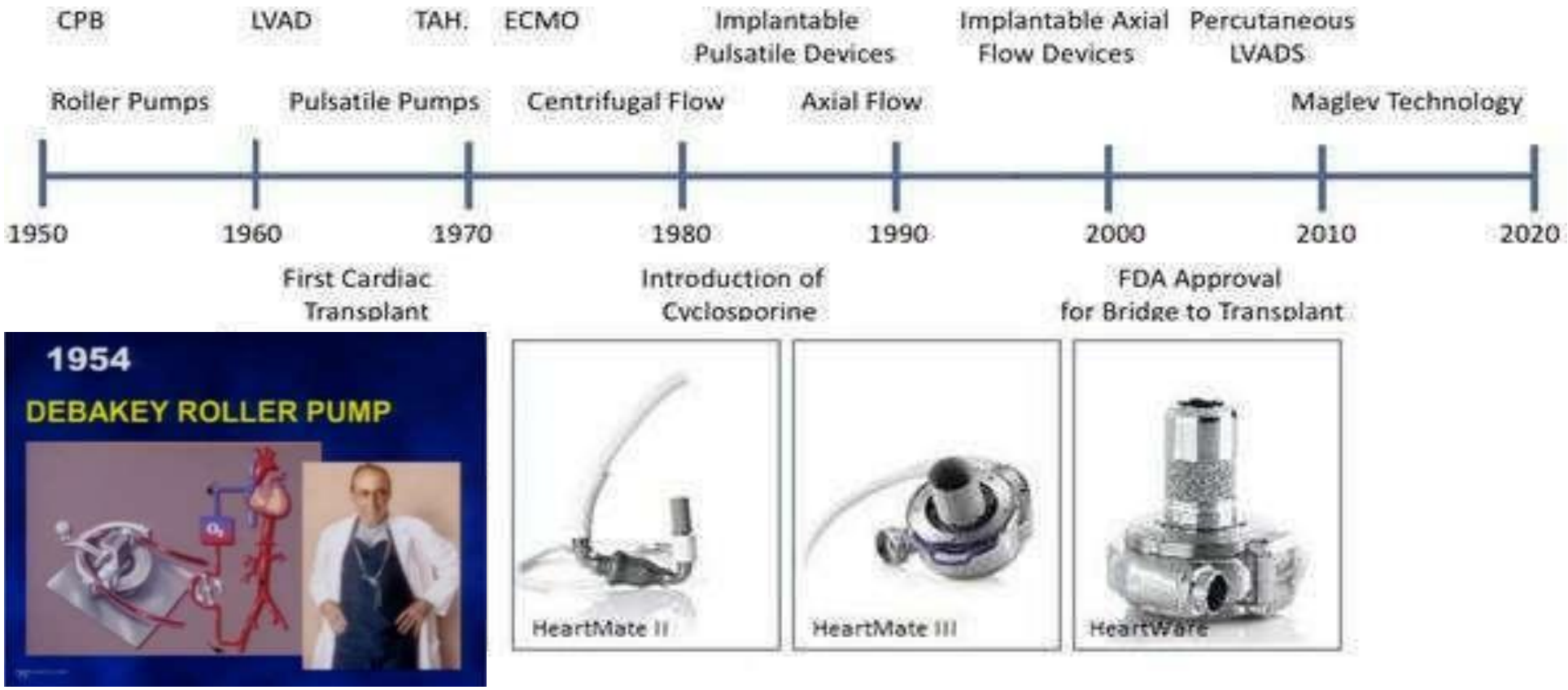
EVOLUTION



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Heart Failure in the U.S.

- Over 5 million living with heart failure in U.S.
- 50% with HF die within 5 years of diagnosis
- 400,000 deaths due to HF each year (U.S.)
- $34 Billion in healthcare costs / Year

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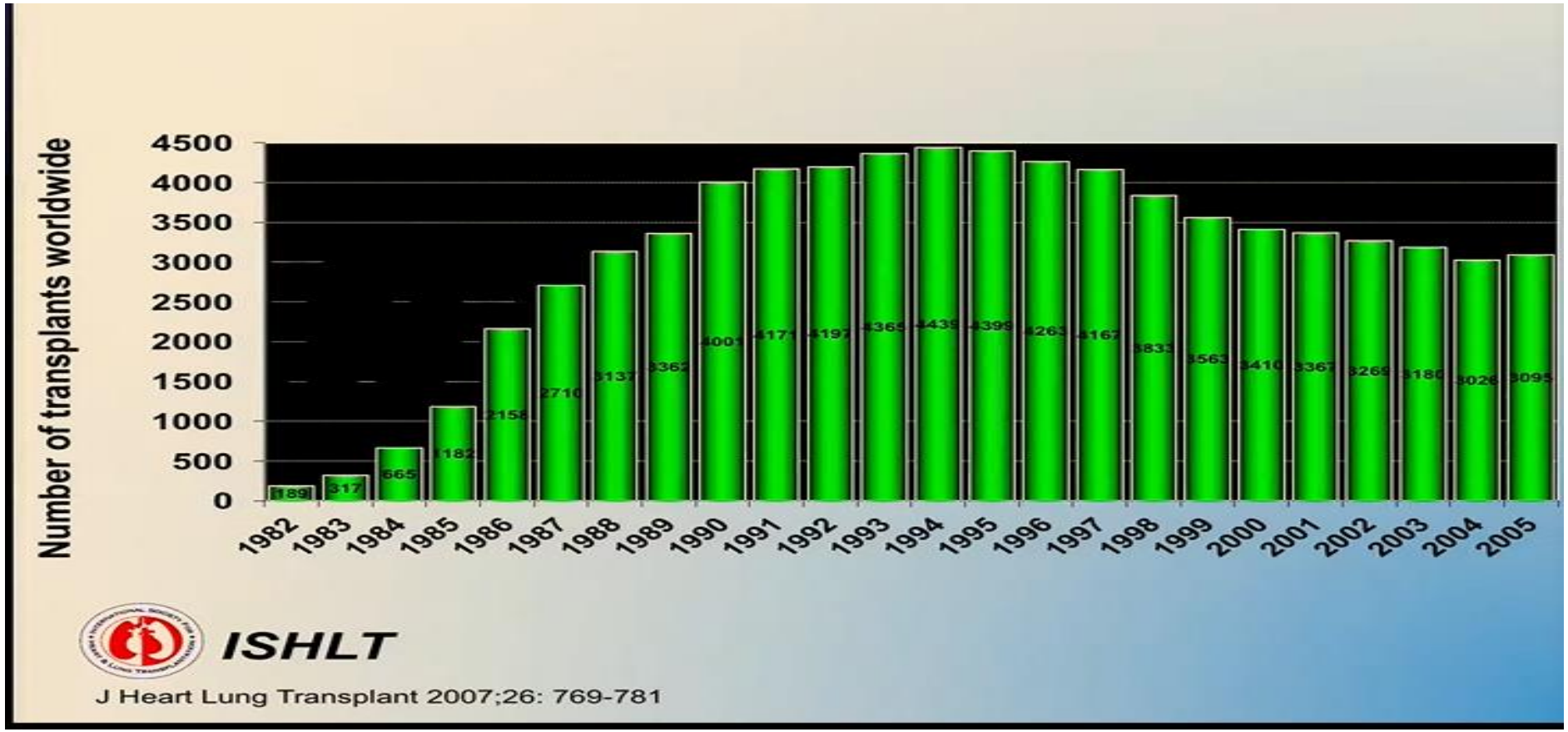
Number of transplants Worldwide



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Michael DeBakey MD and the pneumatic artificial heart

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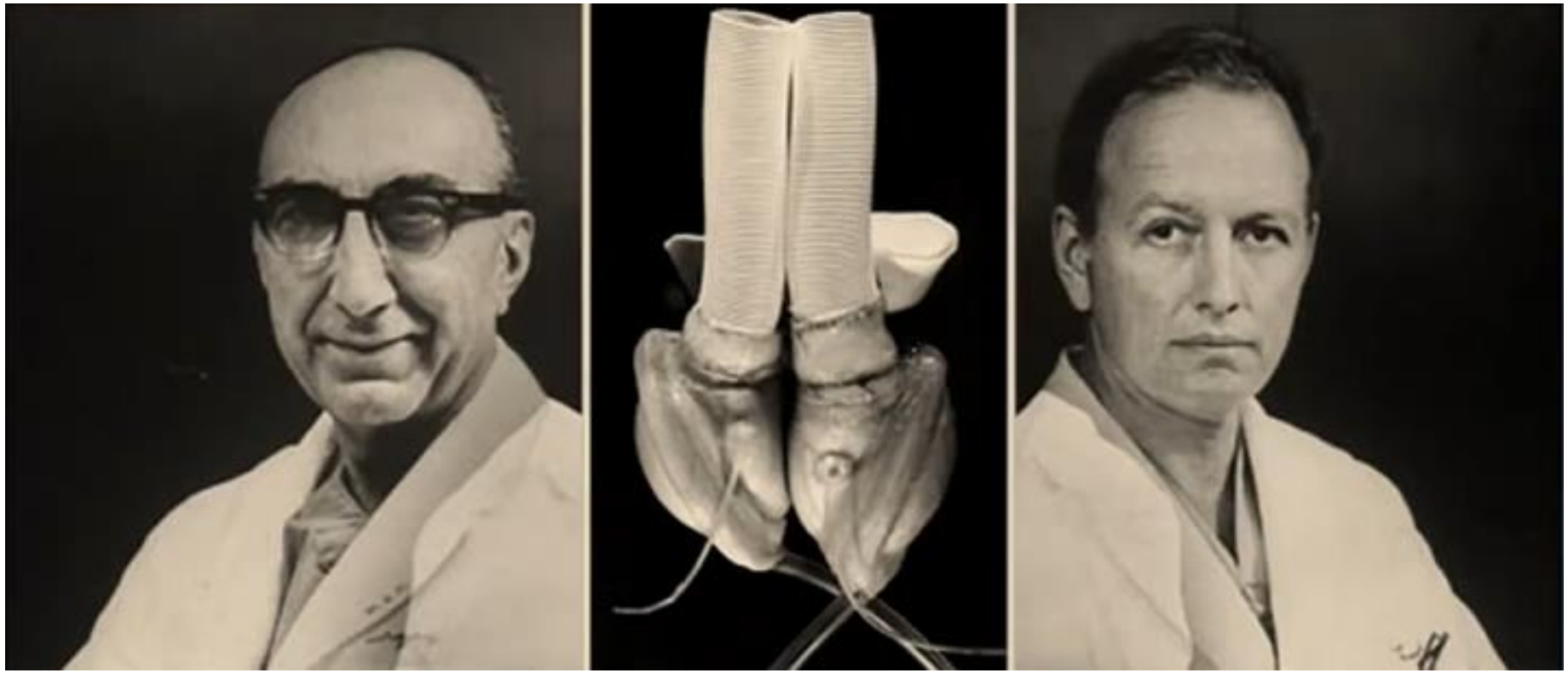
Michael DeBakey MD, Denton Cooley MD and the Pneumatic artificial heart



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Michael DeBakey MD, getting funding for the pneumatic artificial heart

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Cooley implanted the artificial heart while Debakey away

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Life

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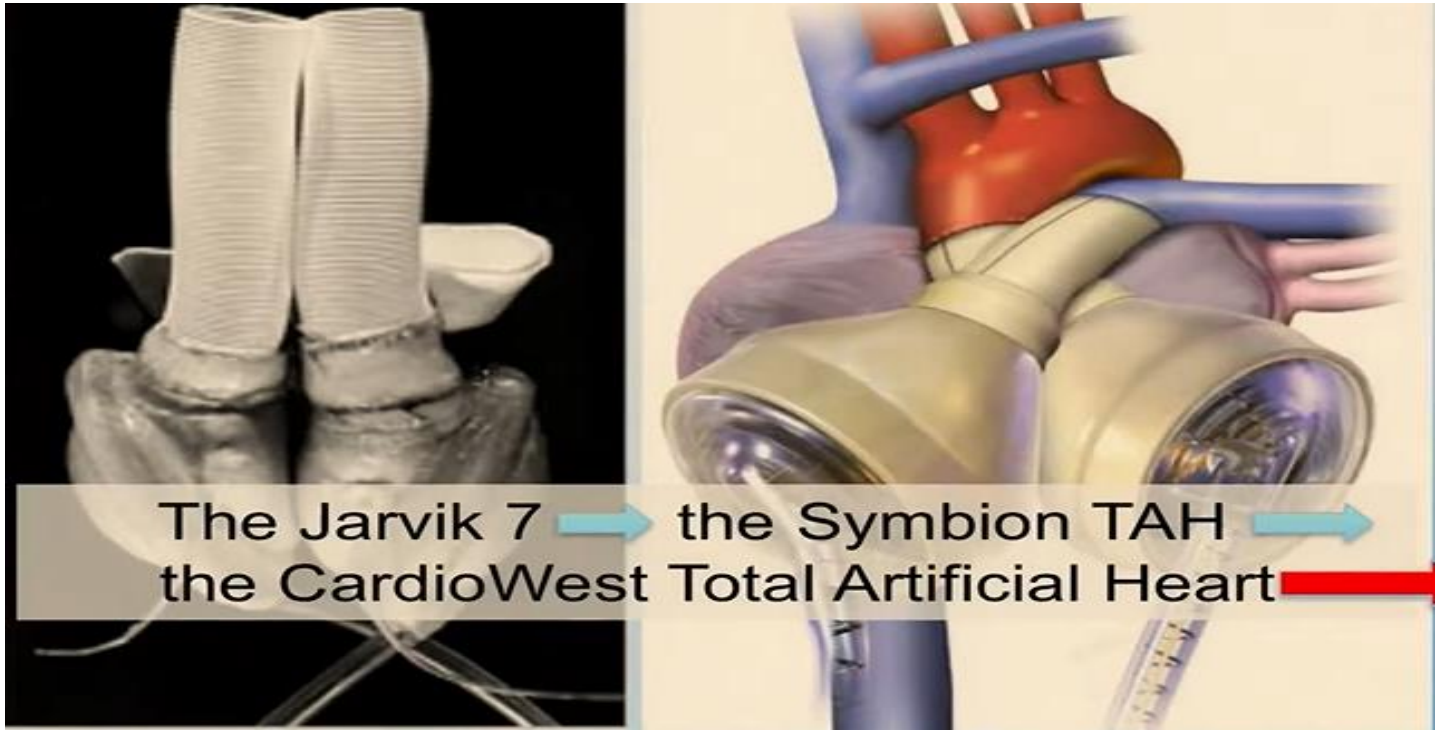
Direct descendant of the original DeBakey Pneumatic heart



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The SynCardia Temporary Total Artificial Heart

Over 1600 Patients implant, with 60% 1 year survival

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The SynCardia Temporary Total Artificial Heart

- 79% survival to transplant
- Average time from implant to transplant 60 days
- 60% one year survival
- 1 Patient > 5 years
- Limited durability of Freedom Driver necessitates

Exchange over 60 days or so

- Need for transcutaneous air hoses
- Limited durability of internal component

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The AbioCor Totally Implantable Artificial Heart

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G. H. ‘’Bud’’ Frazier M.D.

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The AbioCor Totally Implantable Artificial Heart

- >150 animal implants, THI CVRL
- 14 patients implant 2001-2002 (5 at THI)
- Longest survivor 15 months
- Only 4 patients lived longer than 9 months
- Causes of death
  - Infection
  - Stroke
  - Multi-system organ failure
  - Device failure

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Challengers with TAH development

- The AbioCor was too big
- It consumed too much power (38 watts)
- It was challenging to maintain balance between the Pulmonary and systemic circulation
- Limited durability beating 144 thousand Times/day (@ 100 bpm) … 52 million times/year… Longest survivor experienced pump failure at 15 months

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The AbioCor Totally Implantable Artificial Heart

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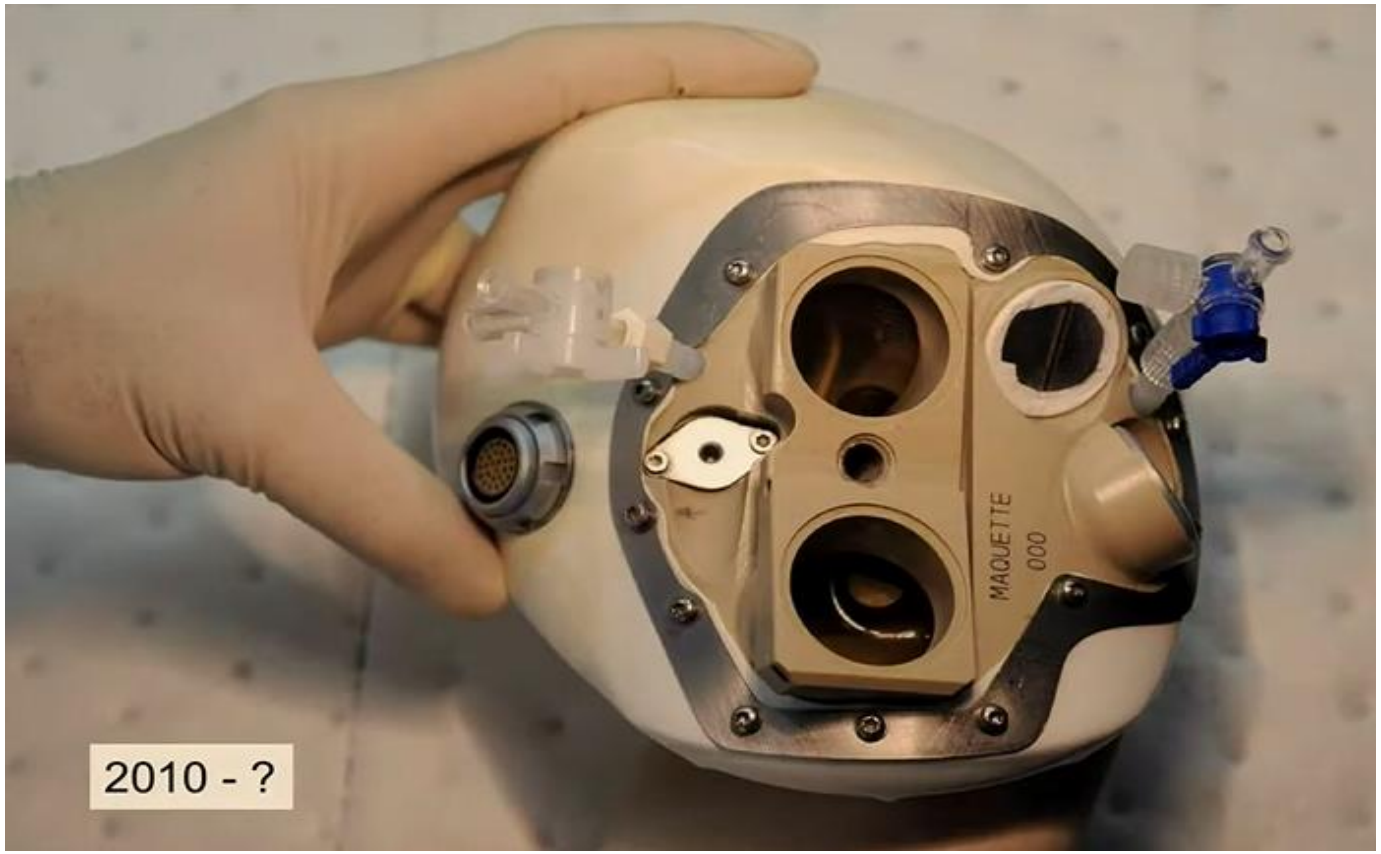
The CARMAT Totally Implantable Artificial heart



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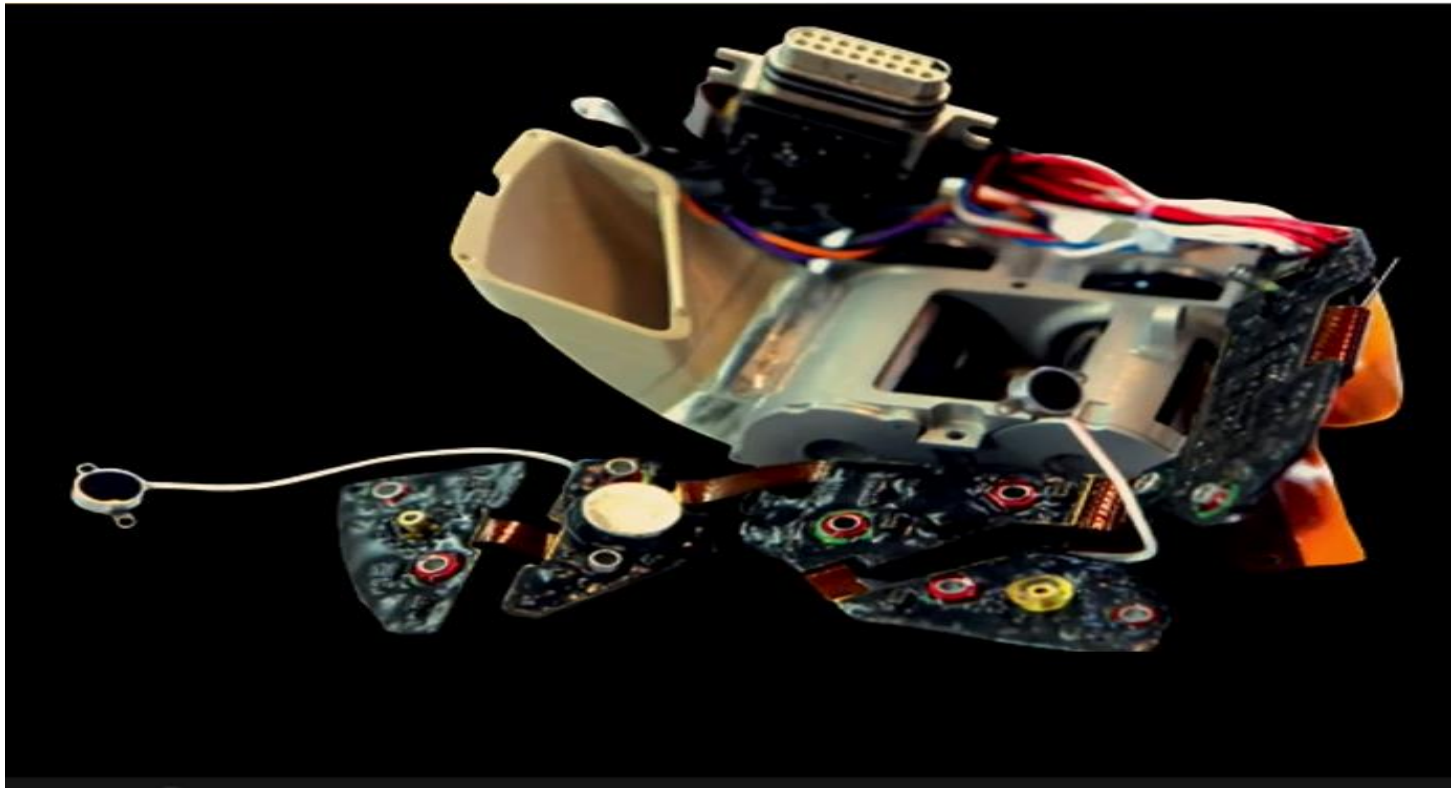
The CARMAT Totally Implantable Artificial heart



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The CARMAT Totally Implantable Artificial heart

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The CARMAT Totally Implantable Artificial heart

- 5 Patients Implanted 2015-2016
- Longest survivor 8.5 months
- Causes of death
  - Multi-system organ failure
  - Device failure
  - Postoperative complication

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The Future of the Artificial Heart ?

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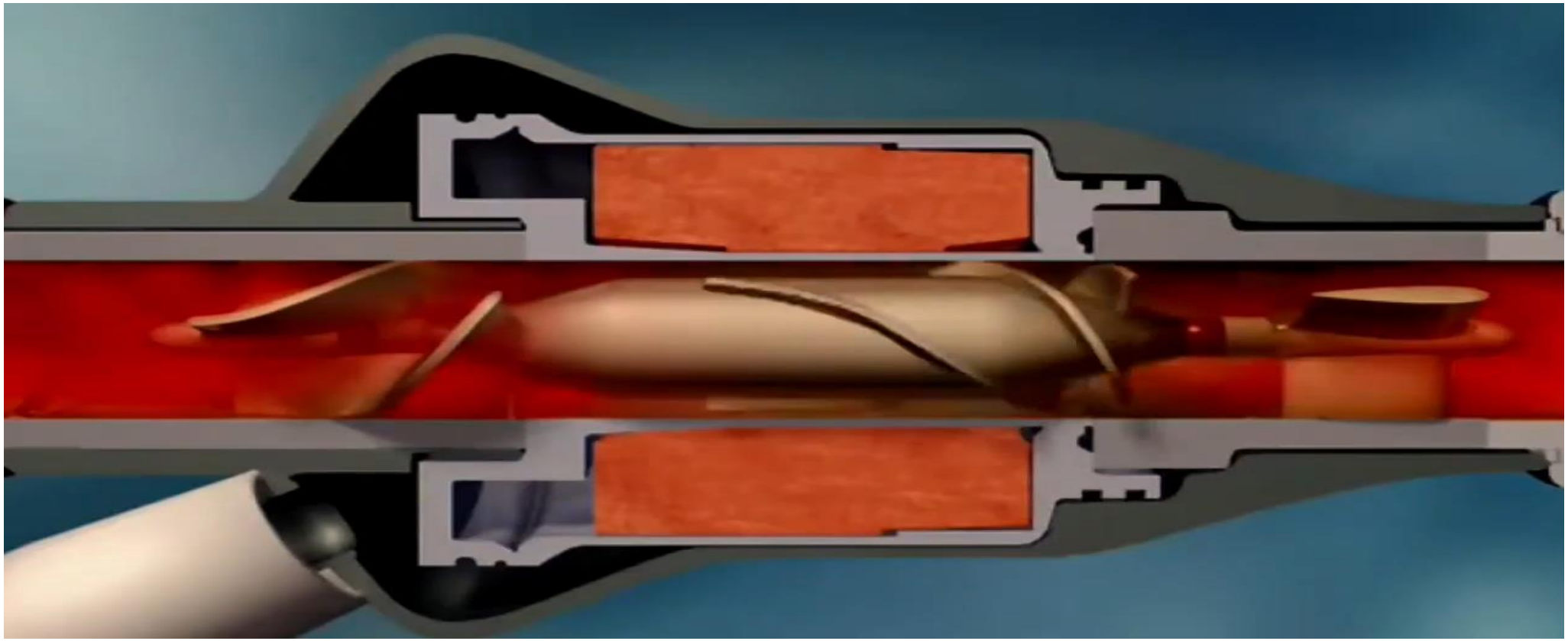

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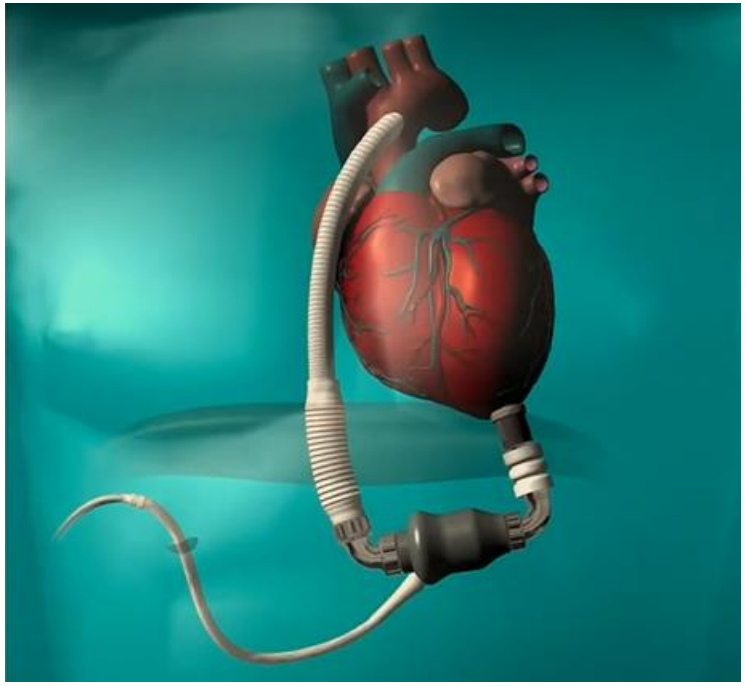
Thoratec HeartMate II



Taxas Heart Institute, Nov 2003

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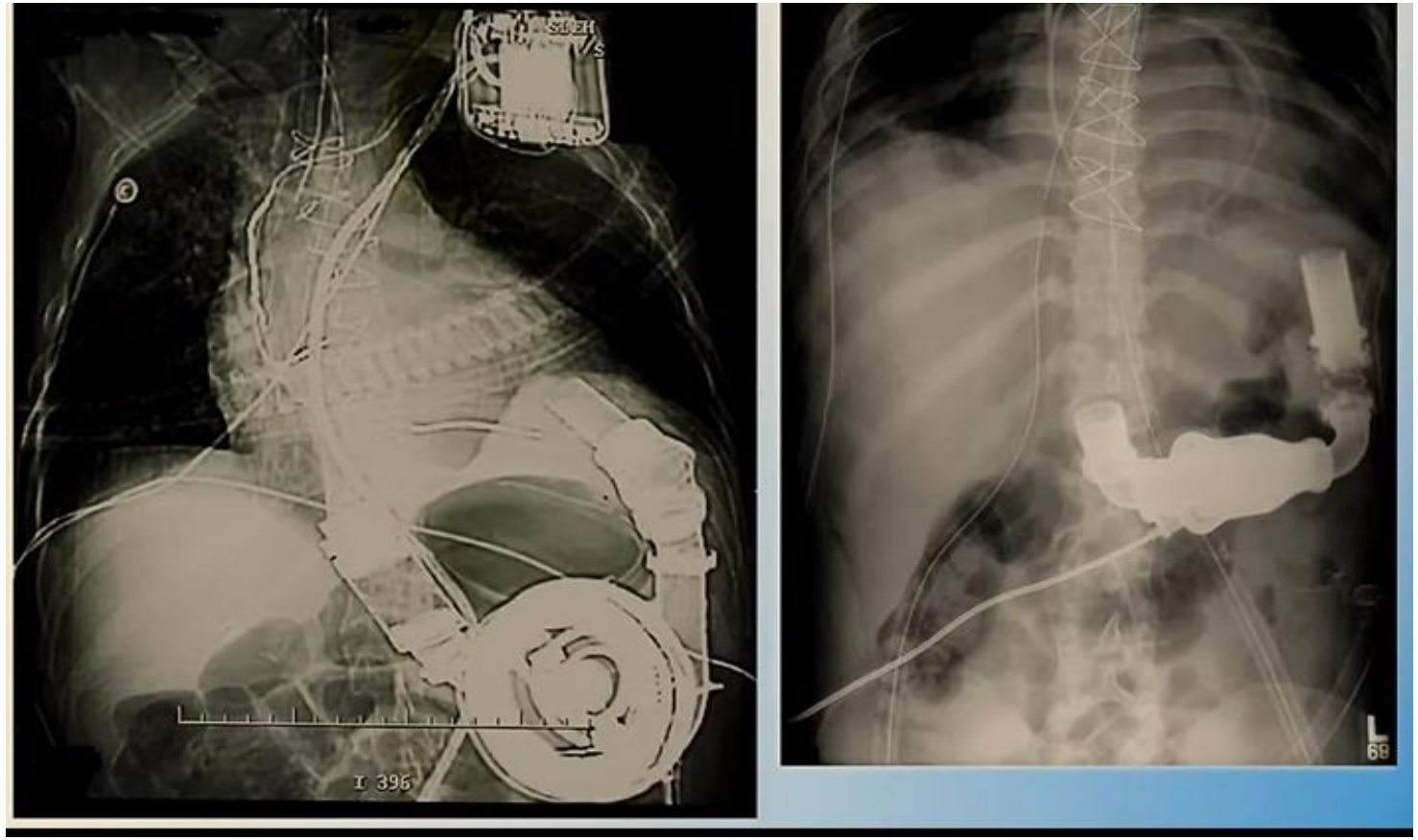
Evolution of LVADs from volume displacement to rotary design



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Continuous flow LVADs

- Smaller
- Easier to implant
- Quieter
- More Energy-efficient
- More durable!
  - >100 patients that have had a single HeartMate II
  - In place for 10 years or more

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The Rapid evolution of continuous-flow ventricular assist devices

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First efforts; Cardiac replacement with 2 jarvik FloMaker LVADs

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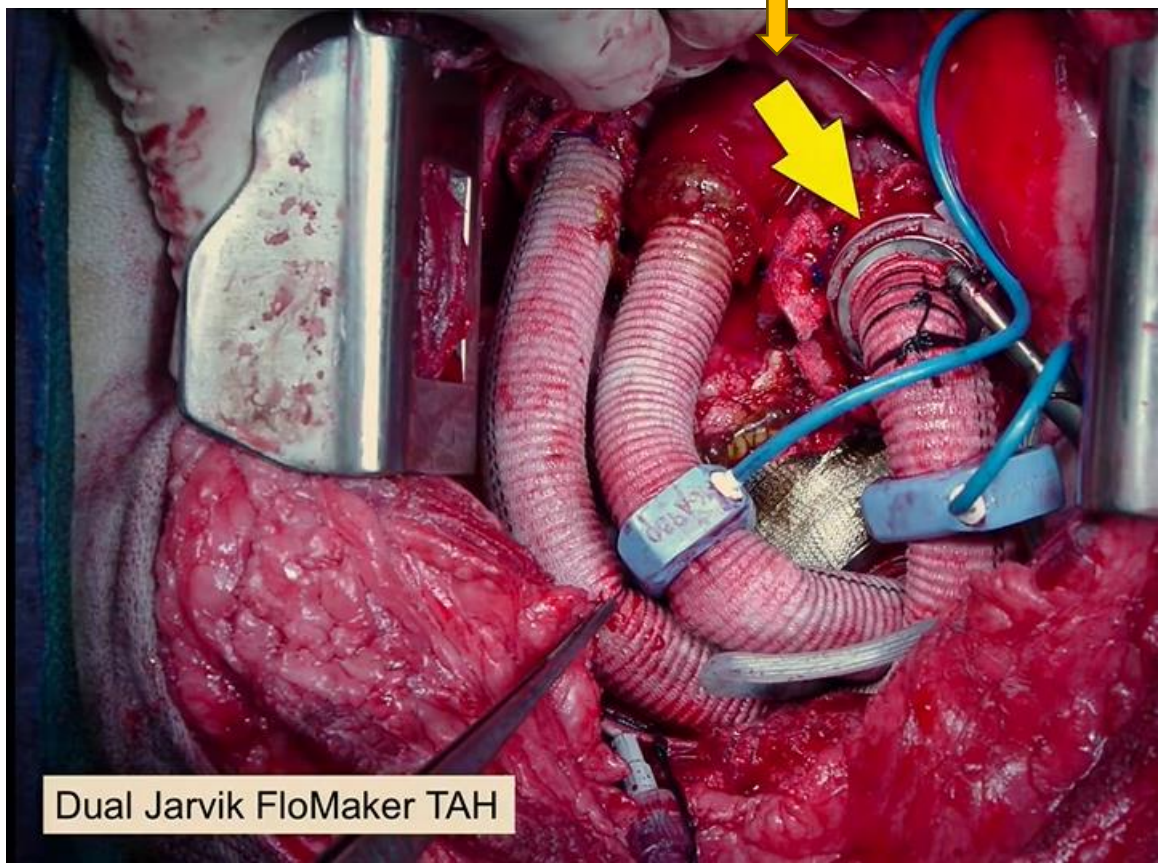
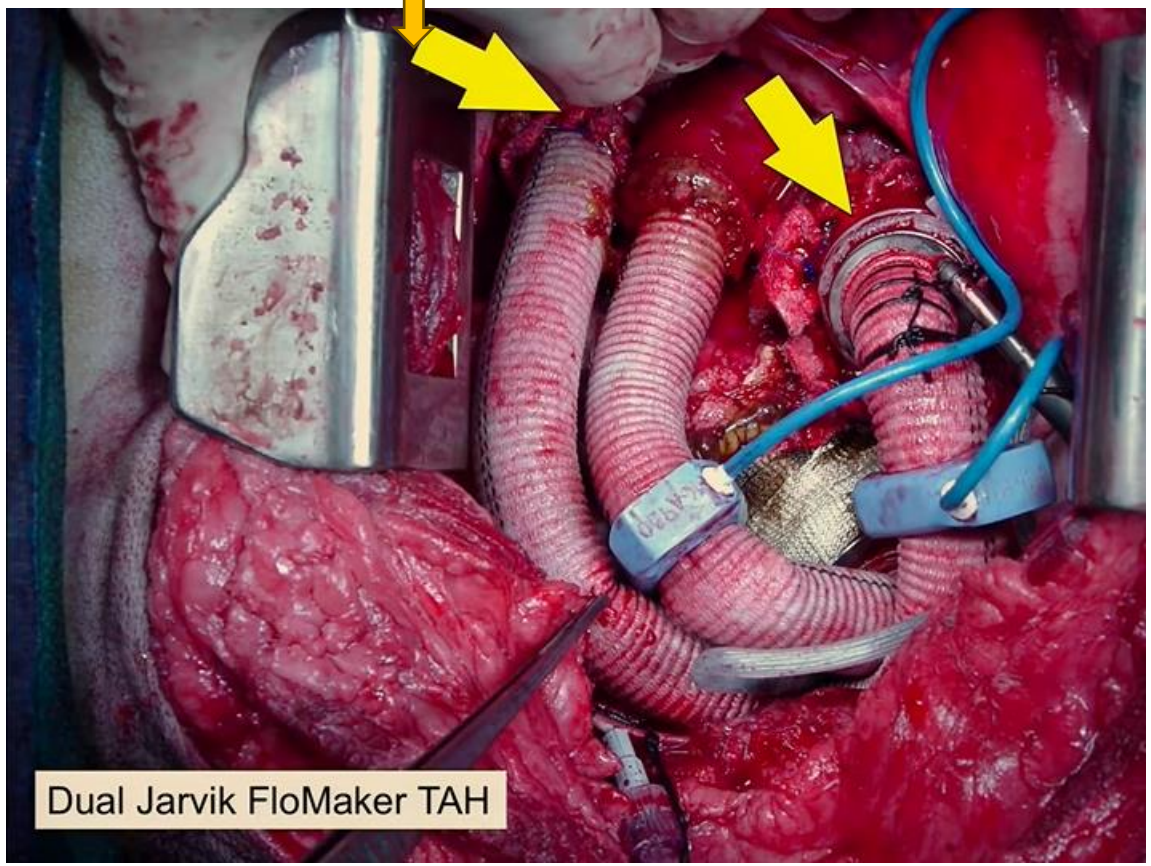
Left Atrium



Aorta



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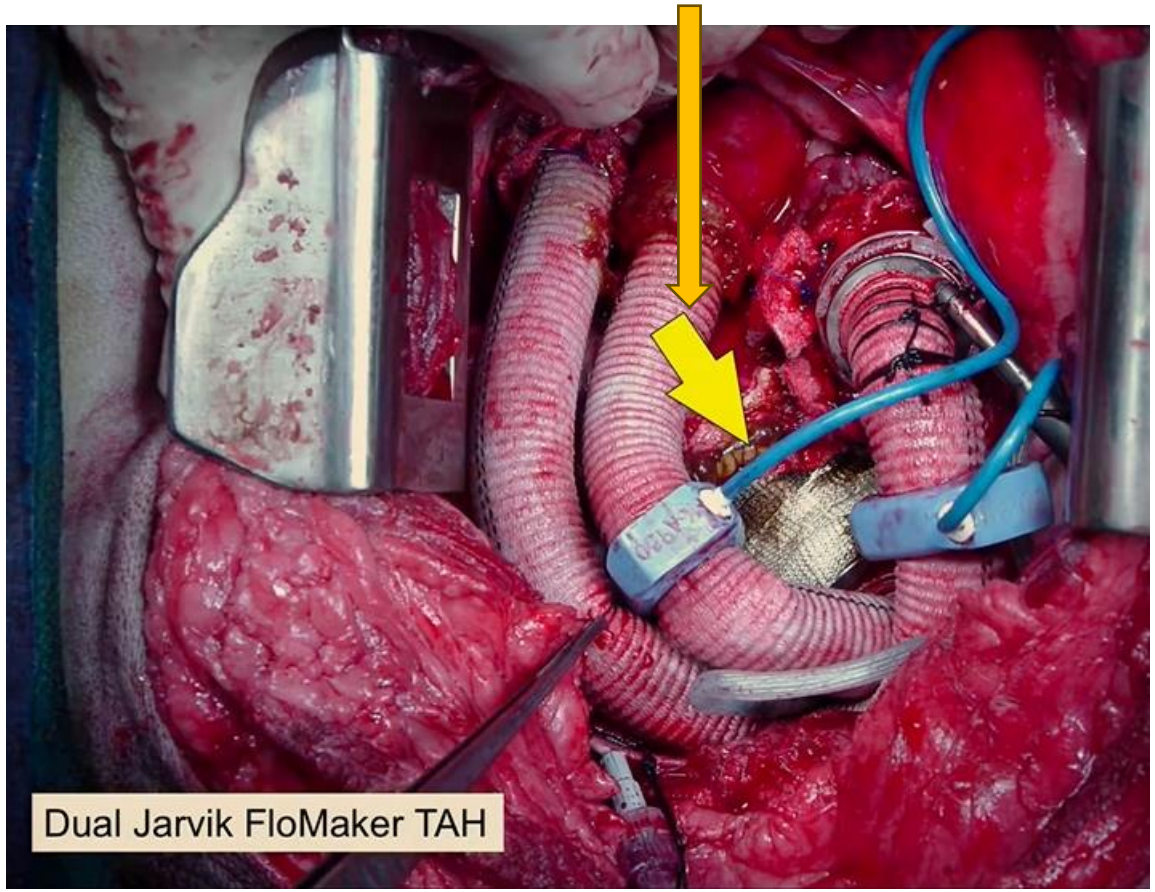
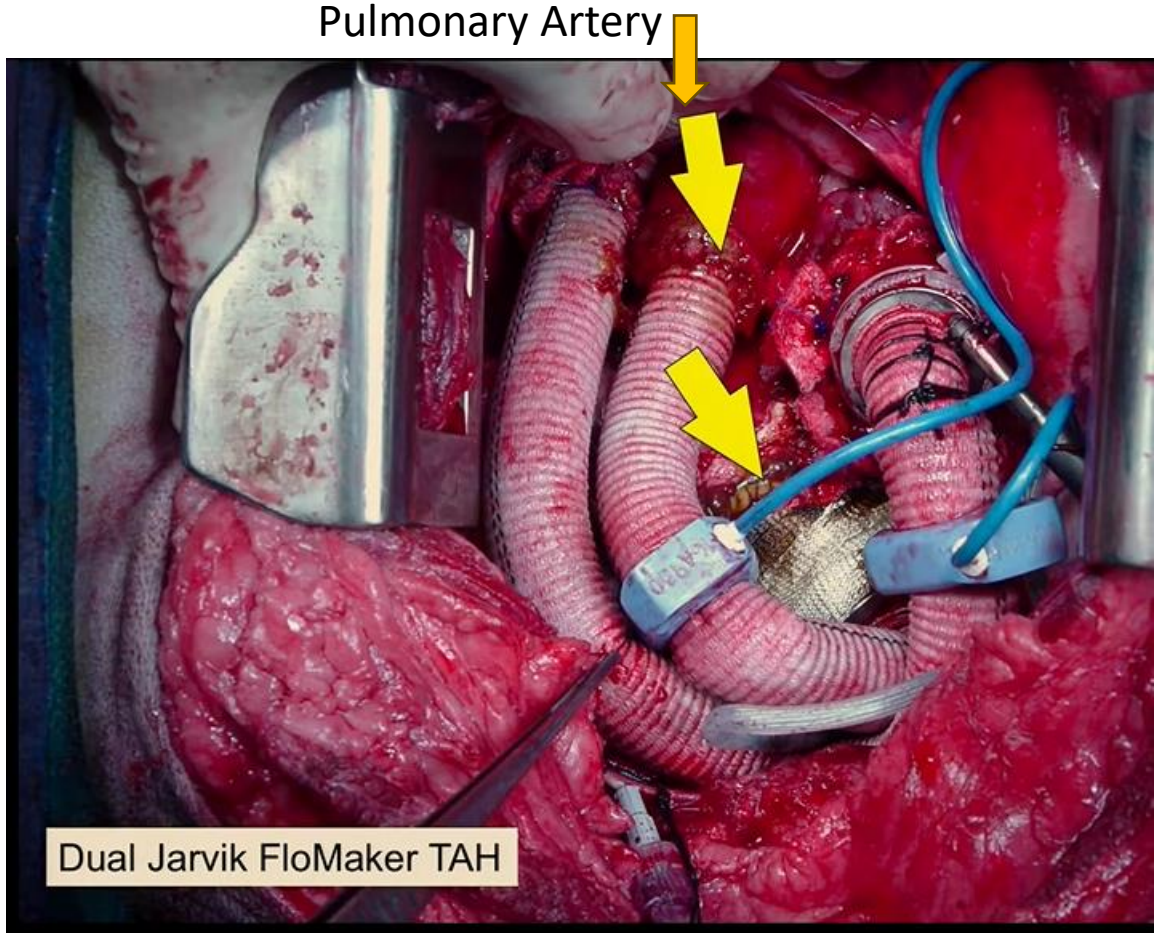
right Atrium



Pulmonary Artery



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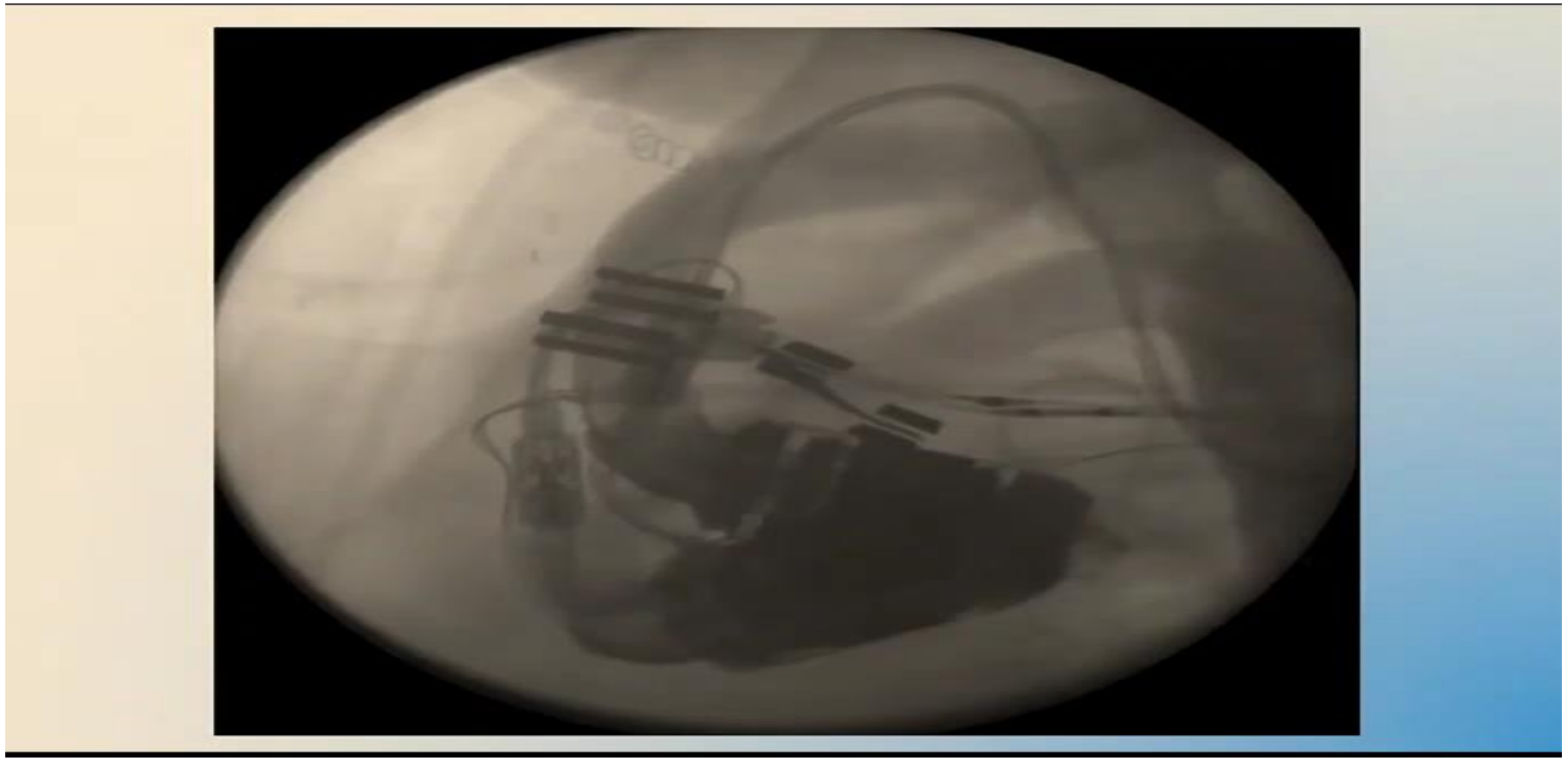

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MicroMed Heart Assist 5 (now the Reliant Heart HA5)

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MacGyver

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Medical device Prototyping Headquarters

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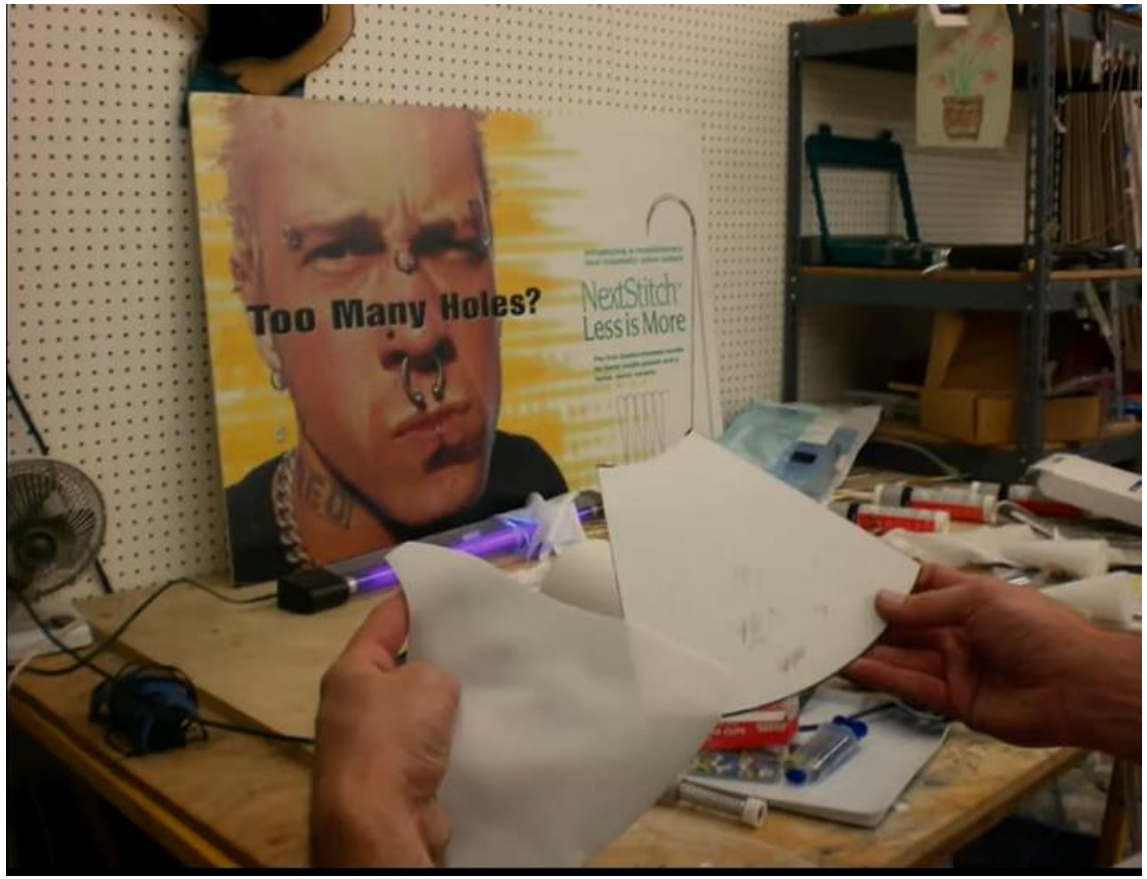

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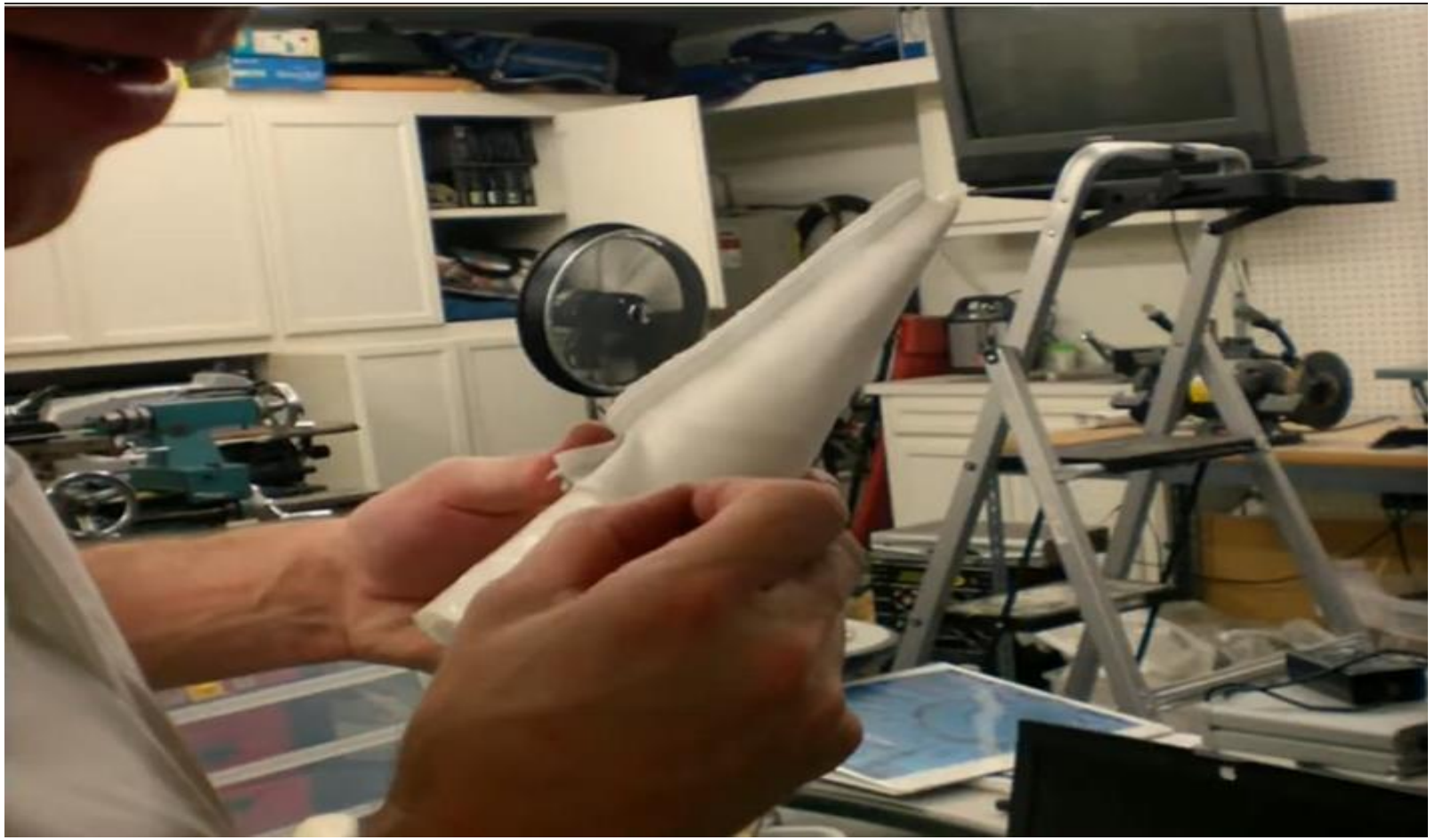

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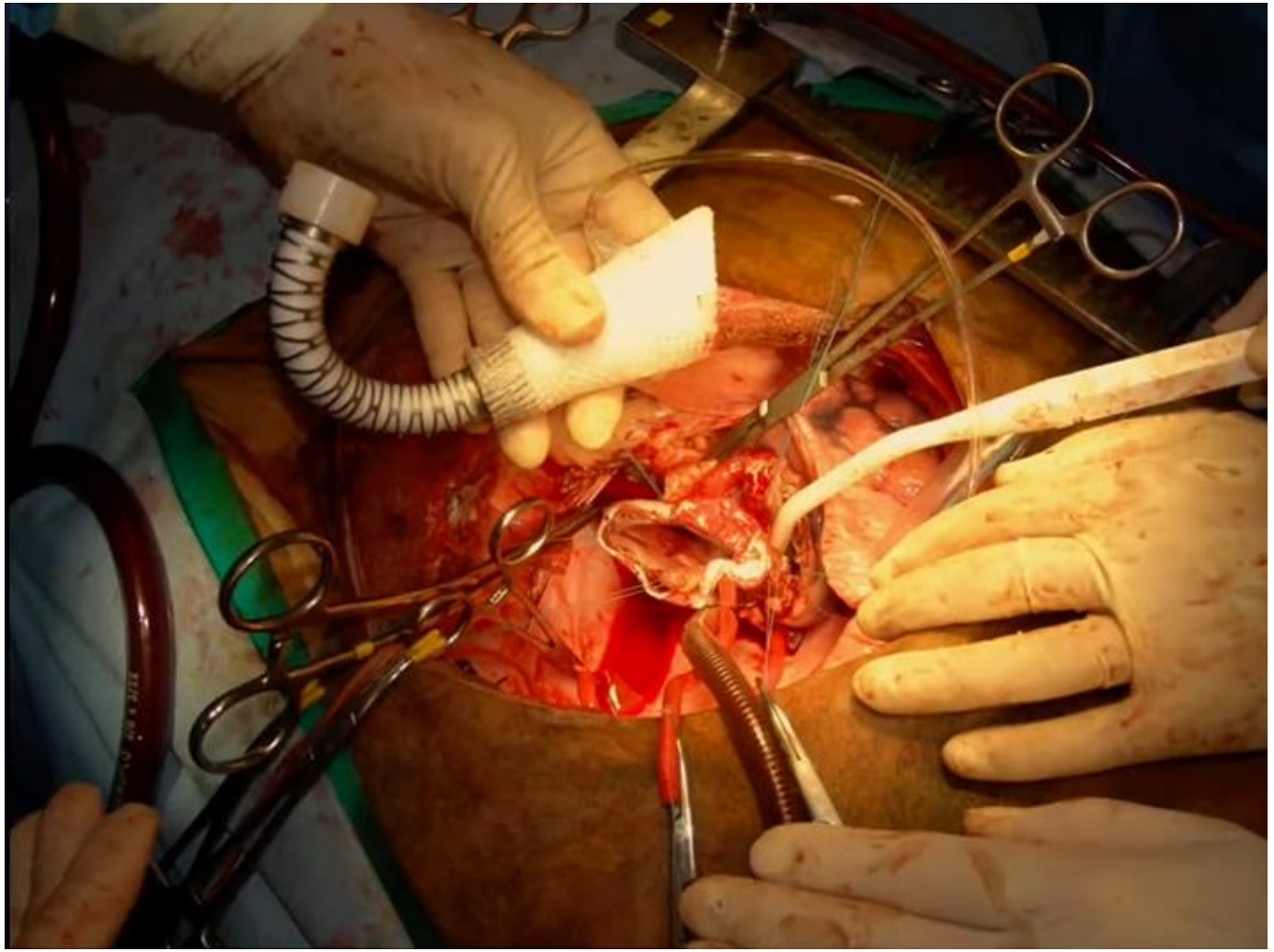

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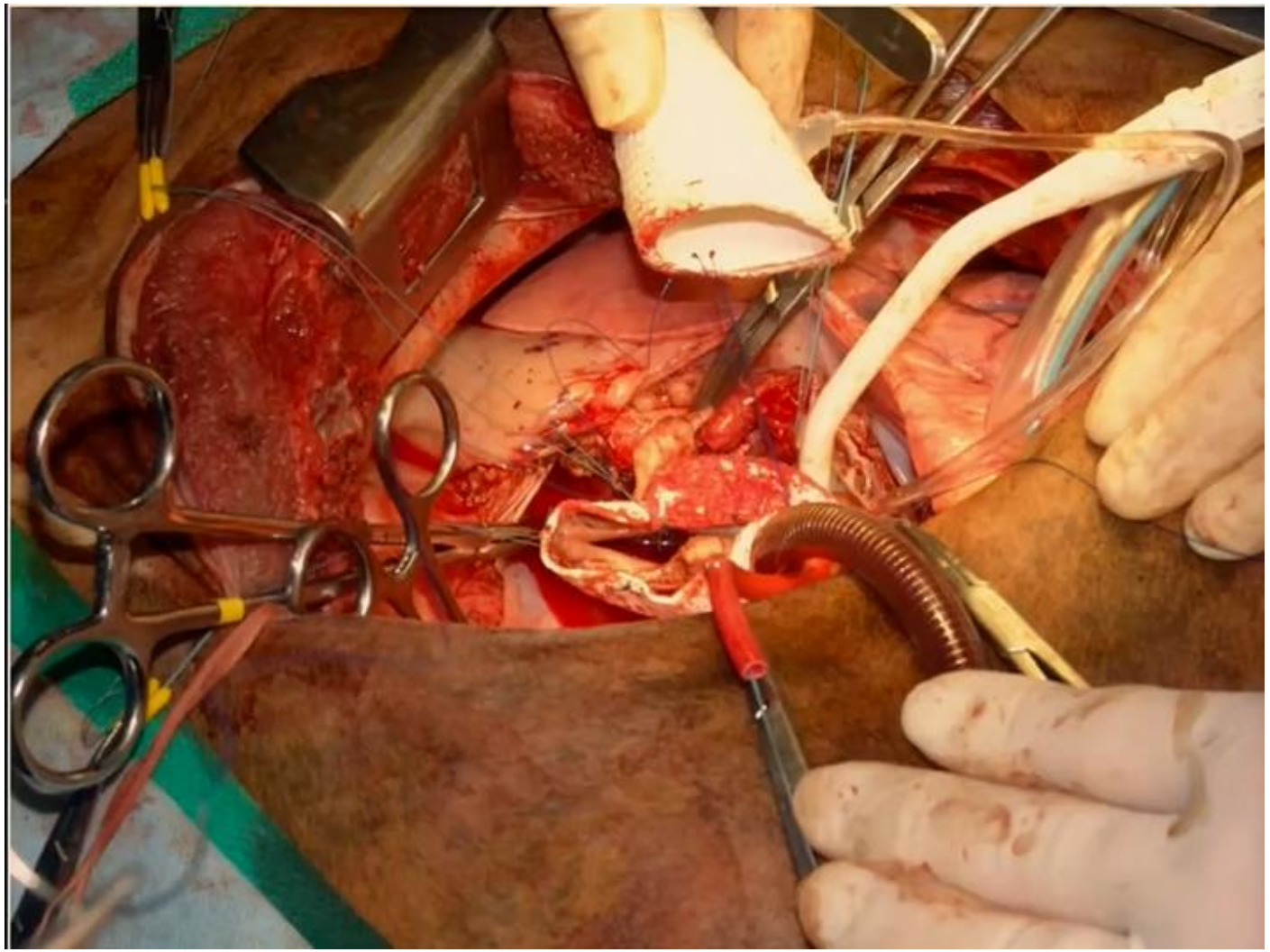

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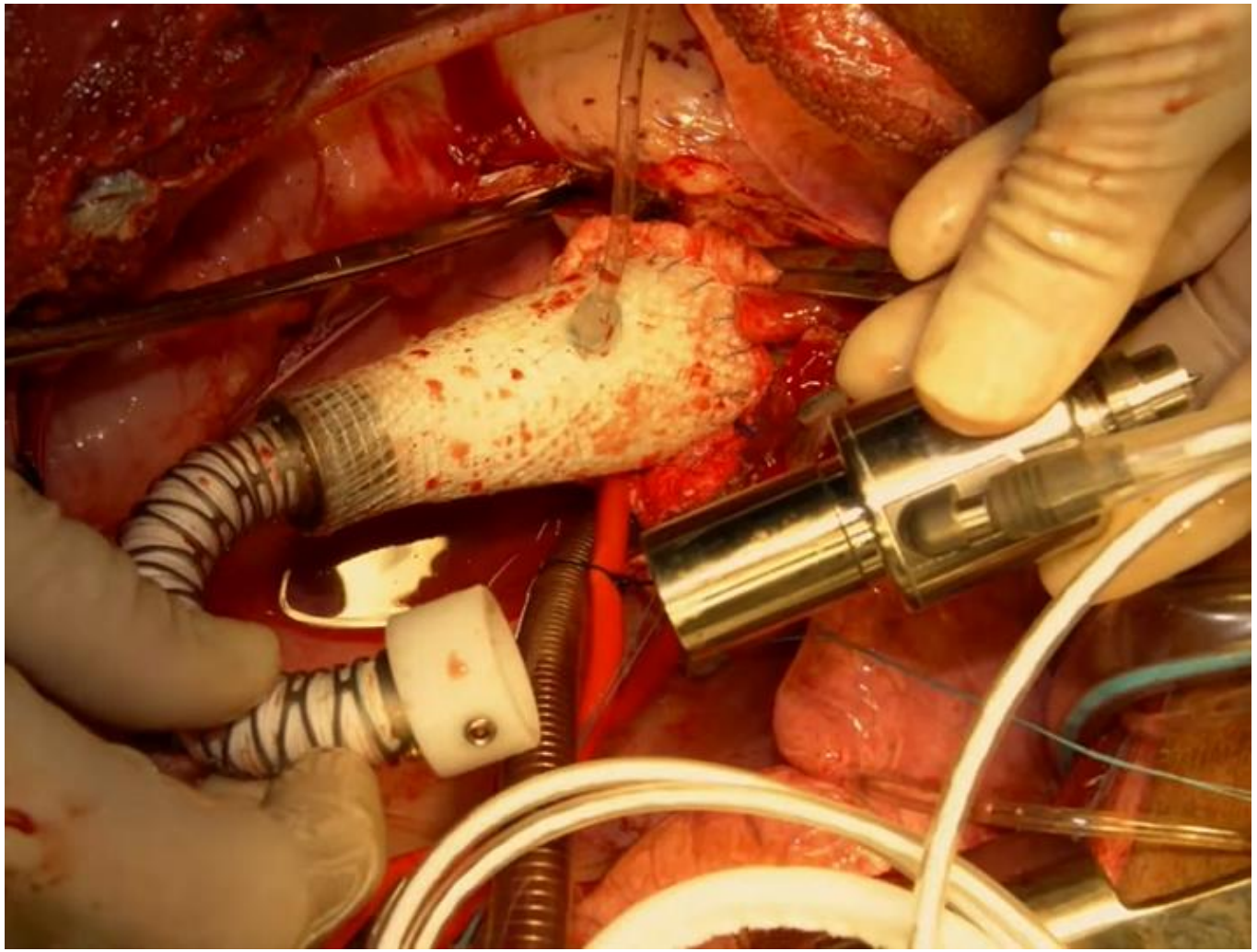

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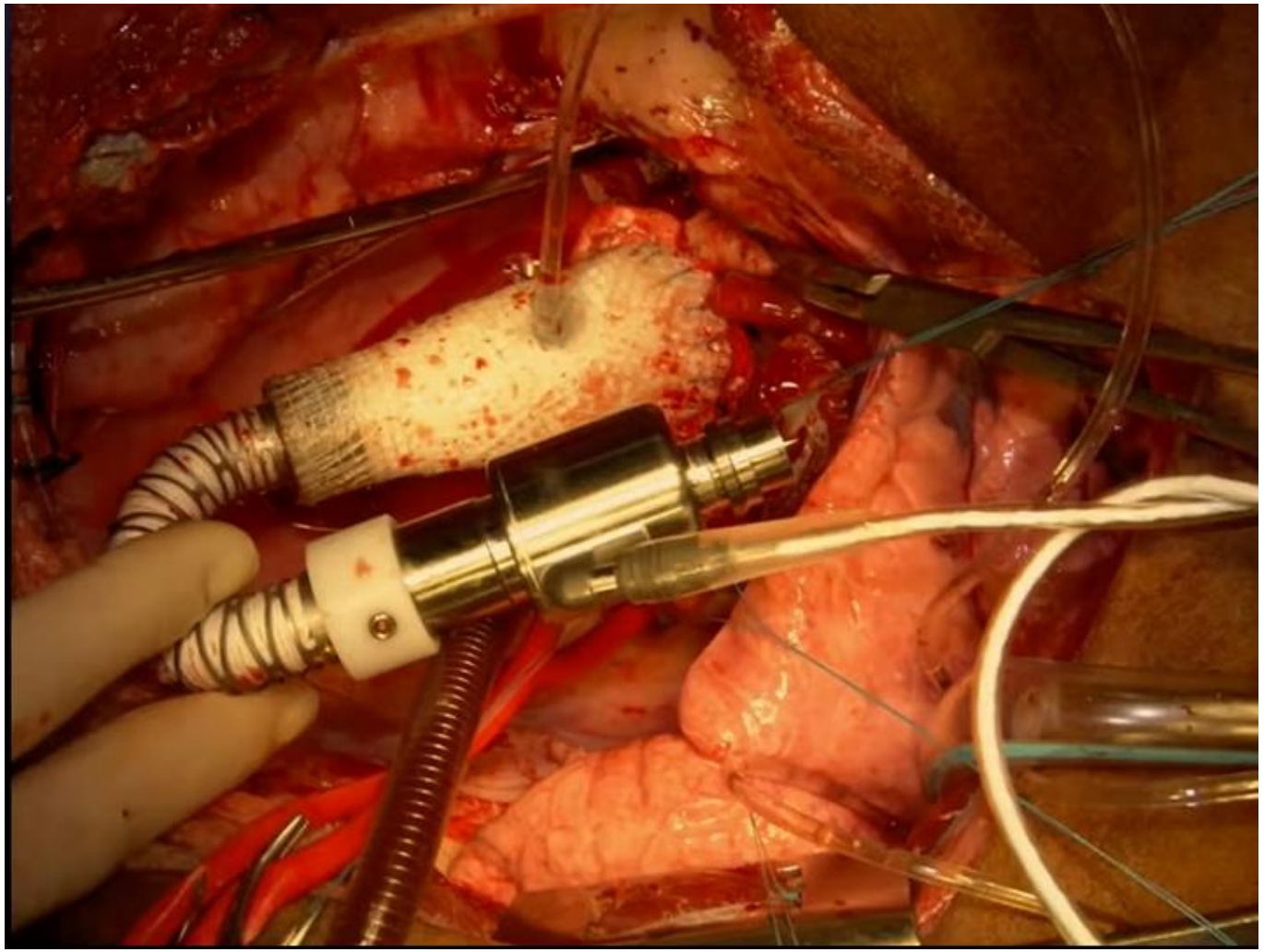

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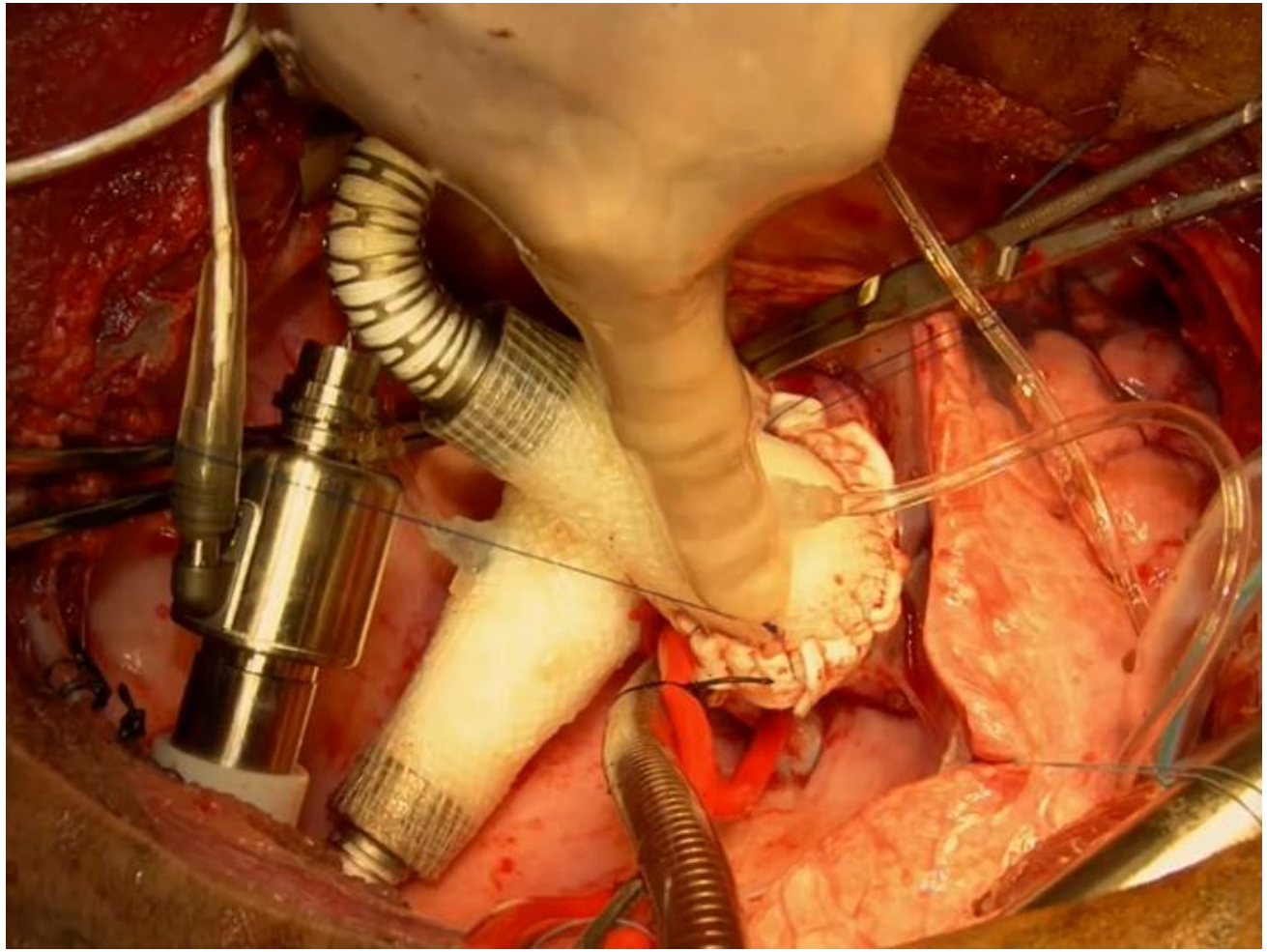

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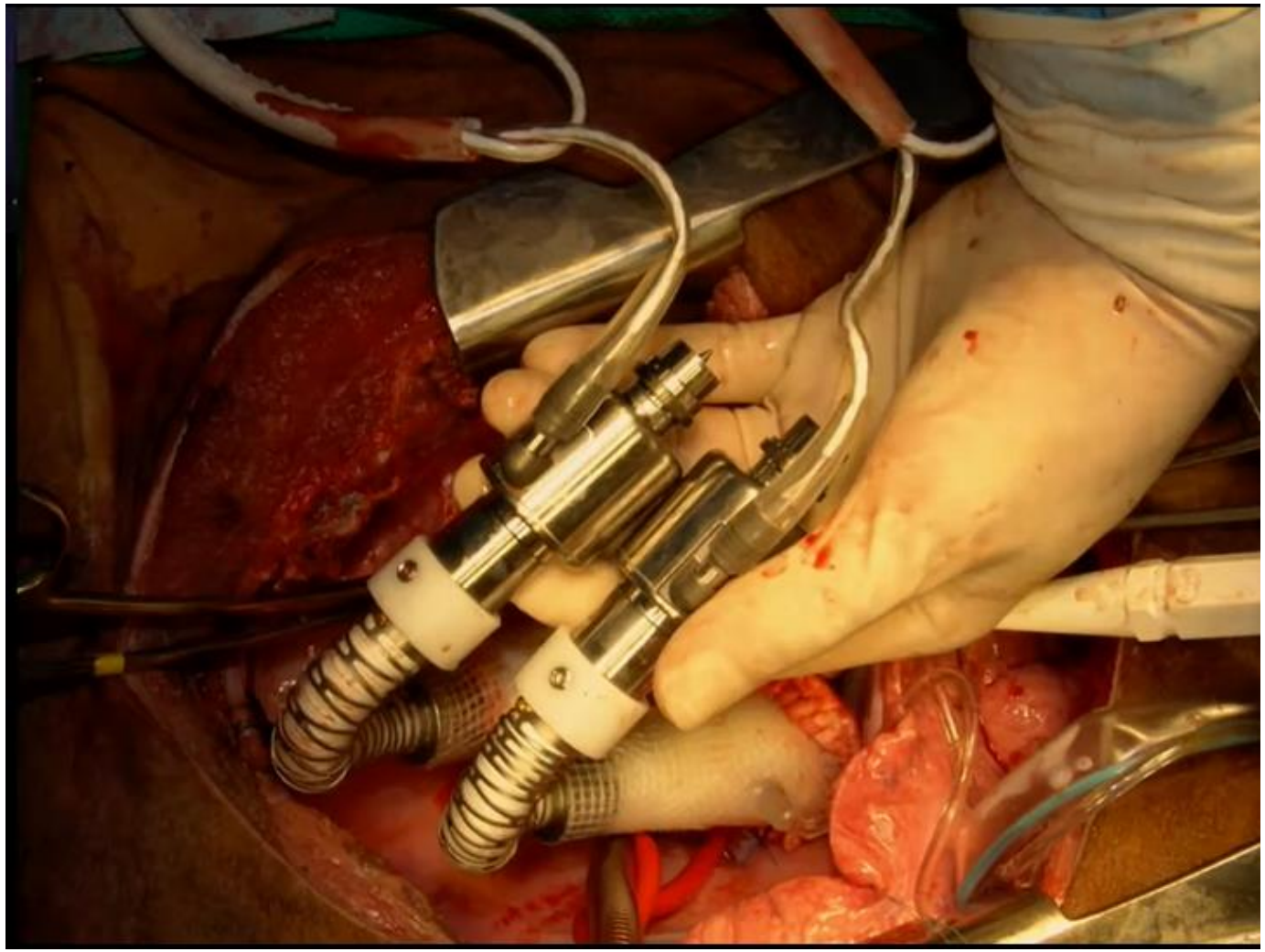

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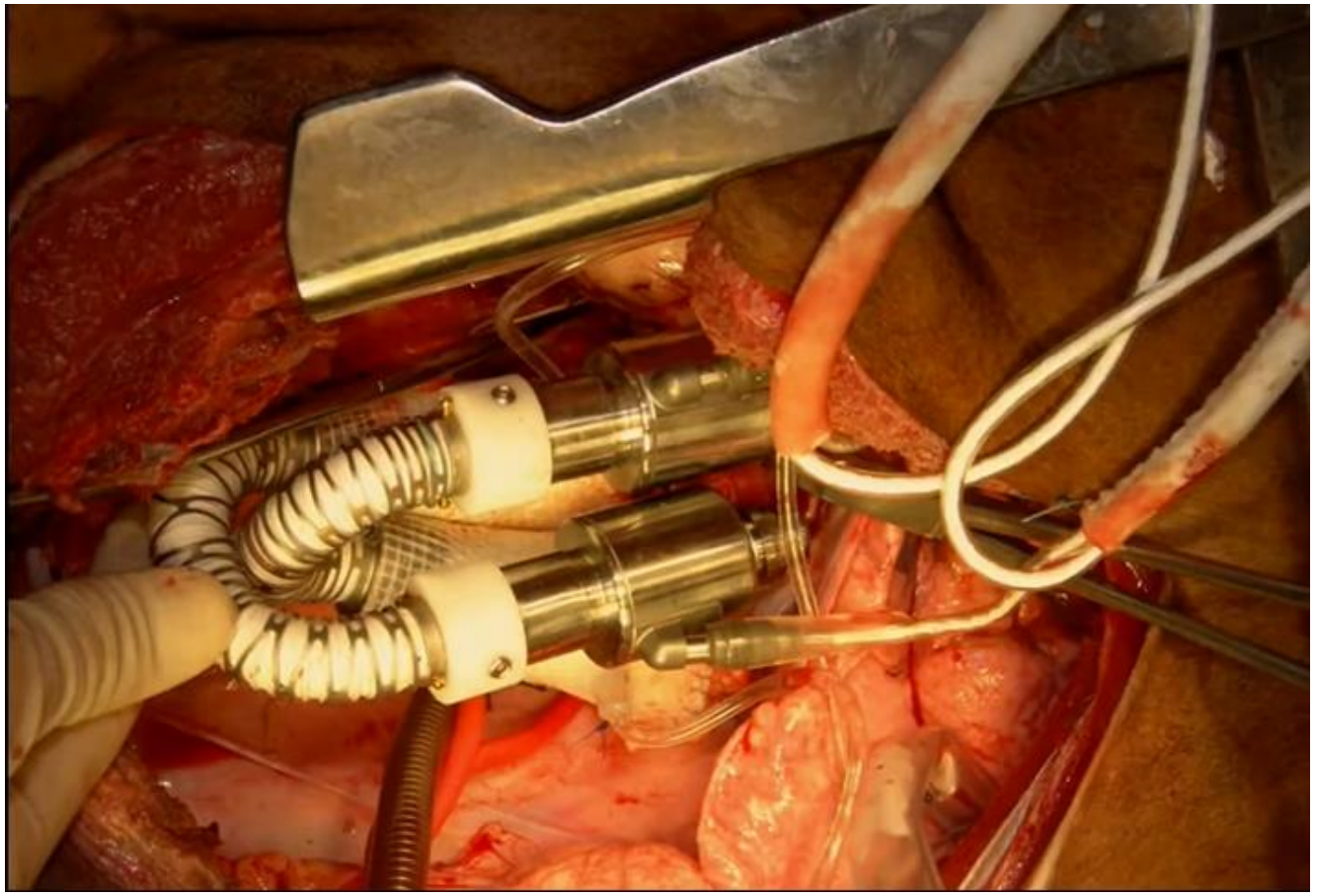
Dual MicroMed Heart Assist 5 TAH



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Upplysning Robotics SMC PVT LTD

Cardiac replacement with dual continuous Flow pumps-experimental experience

- Coriente-X calves n=68 5-7 months Old, 160-180lbs
- Complete heart excision and replacements with:
    - MicroMed Heart Assist 5 45
    - Jarvik FloMaker 4
    - HeartWare HVAD 5
    - HeartMate II 6
    - HeartMate III 8

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Upplysning Robotics SMC PVT LTD

Cardiac replacement with dual continuous Flow pumps-experimental experience

- Hearts Completely excised
- Left and right arterial pressure lines
- Systemic and pulmonary outflow Doppler flow probes
- Systemic and pulmonary arterial lines

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Upplysning Robotics SMC PVT LTD

Cardiac replacement with dual continuous Flow pumps-experimental experience

- 30 calves survived > one week
- 8 animals were able to exercise on a motorized treadmill
- 3 animals survived the 90 day duration of the study

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Upplysning Robotics SMC PVT LTD

Cardiac replacement with dual continuous Flow pumps-experimental experience

- Flows generally 8-11 liters/minute
- Left flows slightly greater than right flows
- Total power generally < 15 watts
- Requires 2 microprocessor controlled external controllers,
  Each of which must be adjusted to maintain appropriate hemodynamics

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Upplysning Robotics SMC PVT LTD

Cardiac replacement with dual continuous Flow pumps-experimental experience

- Right pump thrombus remains problematic
- Left pump thrombus never seen
- Infection frequently seen
- Balance between the left and right pumps facilitated by automaticity of continuous flow pumps.
- Infrequent adjustments of left and right pump speed needed
- Animals outgrow the device after 90 days (weight gain of >60 lbs)

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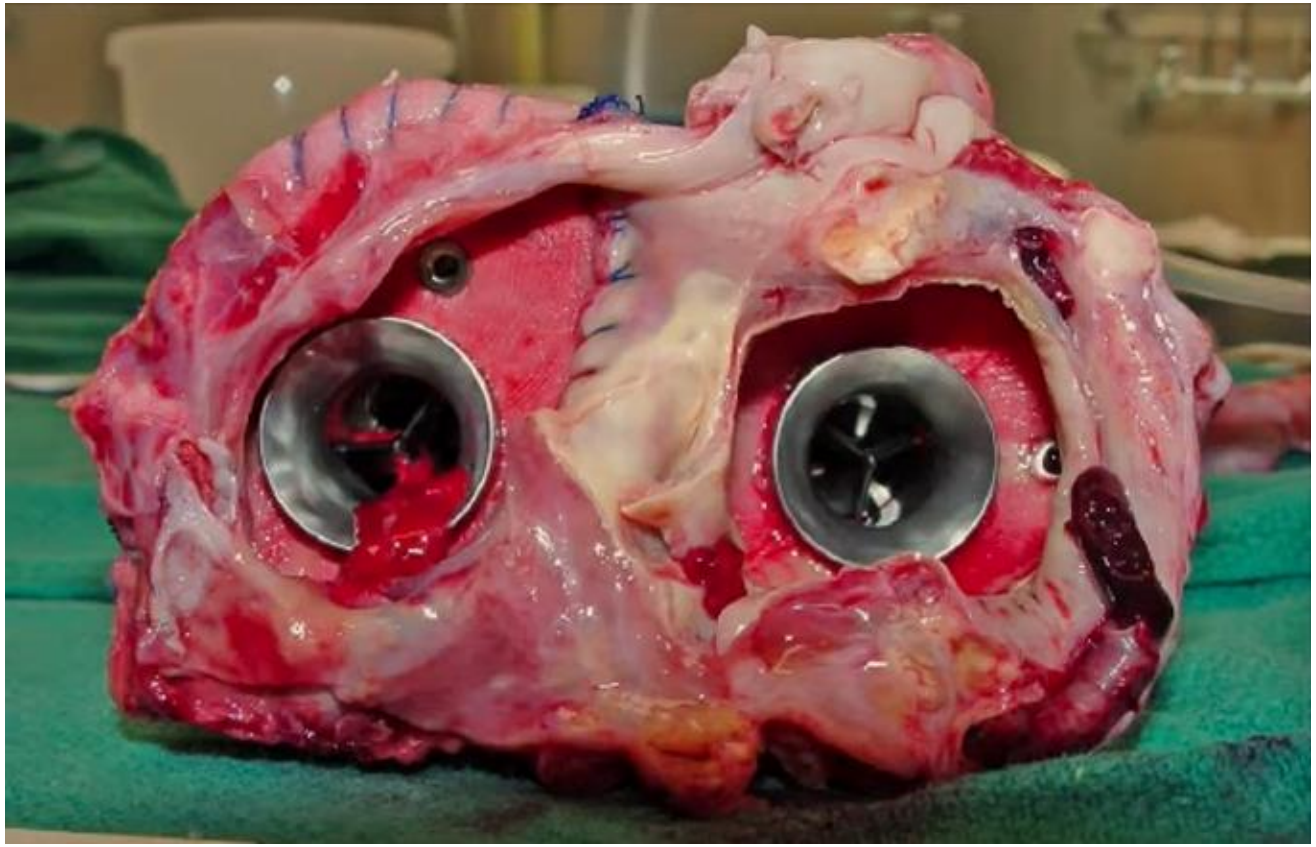
Right Pump thrombus remains problematic



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Cardiac replacement with dual continuous Flow pumps-experimental experience

- The continuous flow TAH is considerably smaller than previous Pulsatile devices
- Power consumption is decreased
- Durability should be improved
- Perhaps it was worth considering as a desperation strategy In a patient facing imminent death without other options

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First Clinical experience with a continuous flow TAH

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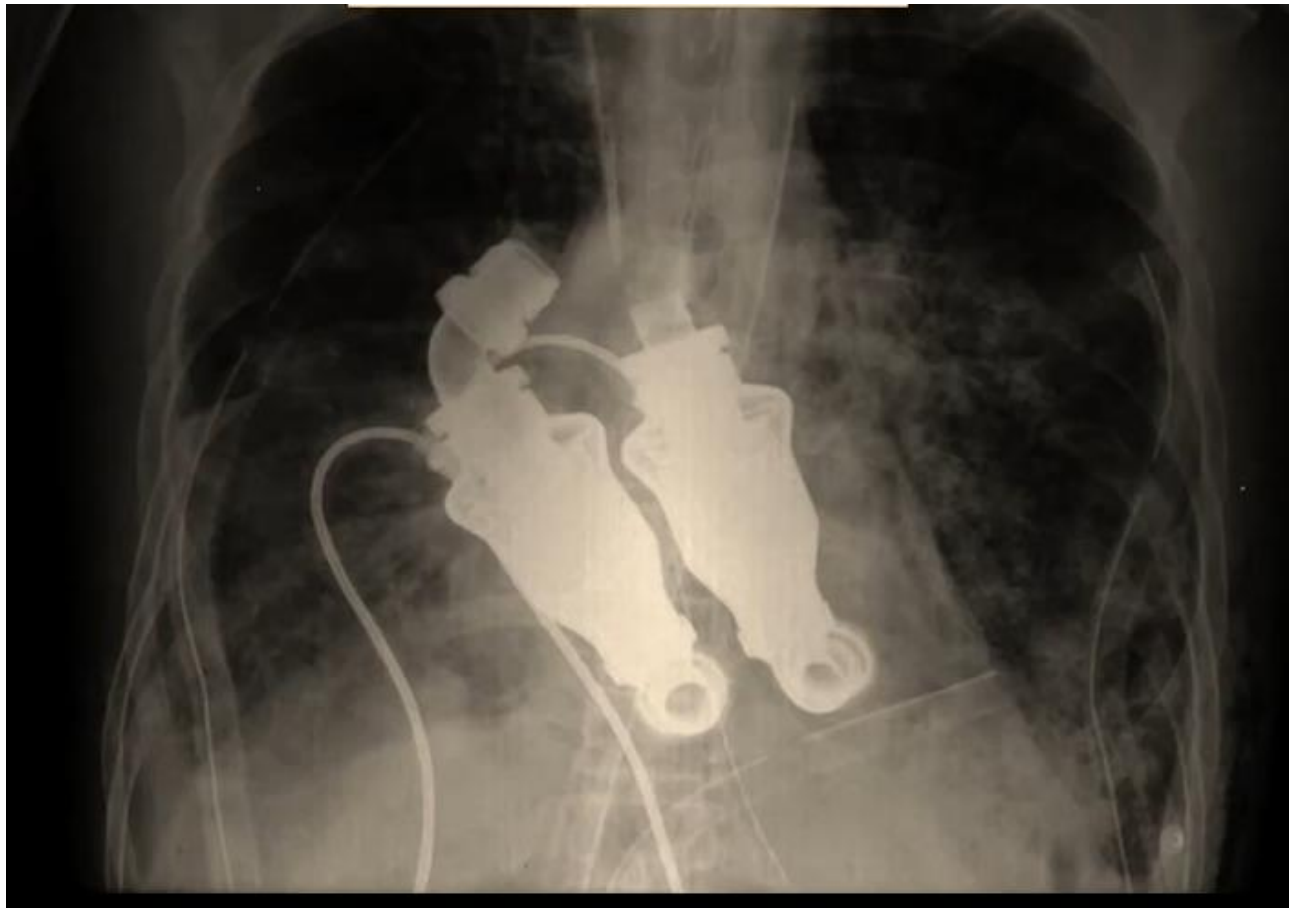
Dual Thoratec HeartMate II



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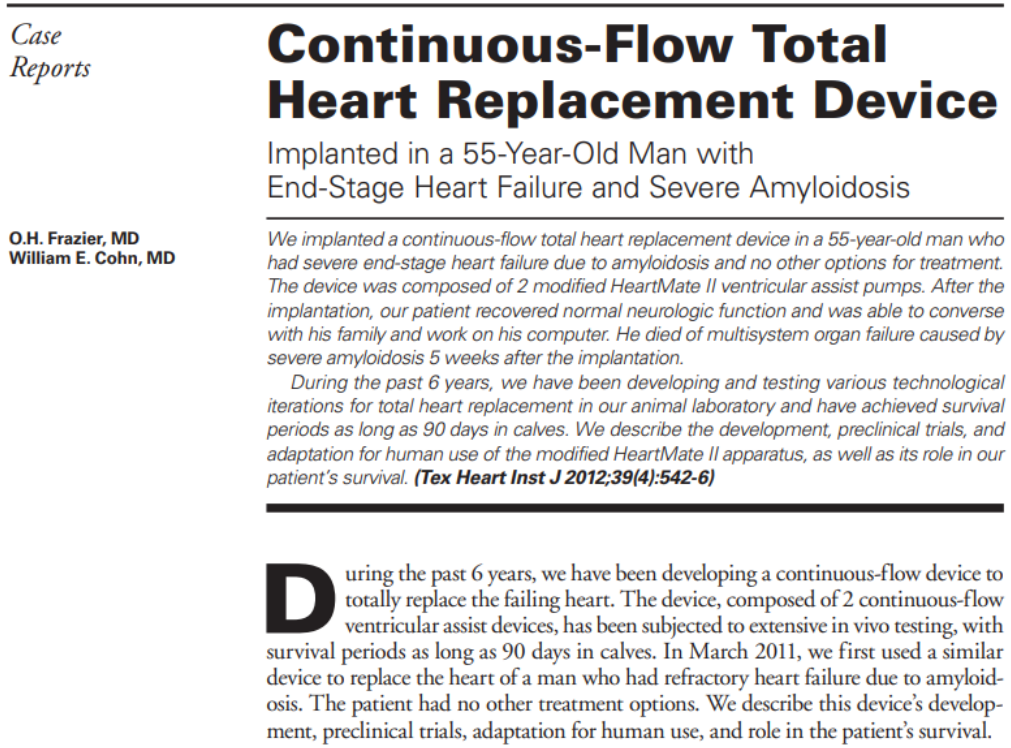
Texas Heart Institute, Journal, 2012:39(4):542-6



Case Reports

Continuous-Flow Total Heart Replacement Device

Implanted in a 55-Year-Old Man with End-Stage Heart Failure and Severe Amyloidosis

O.H. Frazier, MD
William E. Cohn, MD

We implanted a continuous-flow total heart replacement device in a 55-year-old man who had severe end-stage heart failure due to amyloidosis and no other options for treatment. The device was composed of 2 modified HeartMate II ventricular assist pumps. After the implantation, our patient recovered normal neurologic function and was able to converse with his family and work on his computer. He died of multisystem organ failure caused by severe amyloidosis 5 weeks after the implantation.

During the past 6 years, we have been developing and testing various technological iterations for total heart replacement in our animal laboratory and have achieved survival periods as long as 90 days in calves. We describe the development, preclinical trials, and adaptation for human use of the modified HeartMate II apparatus, as well as its role in our patient's survival. ***(Tex Heart Inst J 2012;39(4):542-6)***

During the past 6 years, we have been developing a continuous-flow device to totally replace the failing heart. The device, composed of 2 continuous-flow ventricular assist devices, has been subjected to extensive in vivo testing, with survival periods as long as 90 days in calves. In March 2011, we first used a similar device to replace the heart of a man who had refractory heart failure due to amyloidosis. The patient had no other treatment options. We describe this device's development, preclinical trials, adaptation for human use, and role in the patient's survival.

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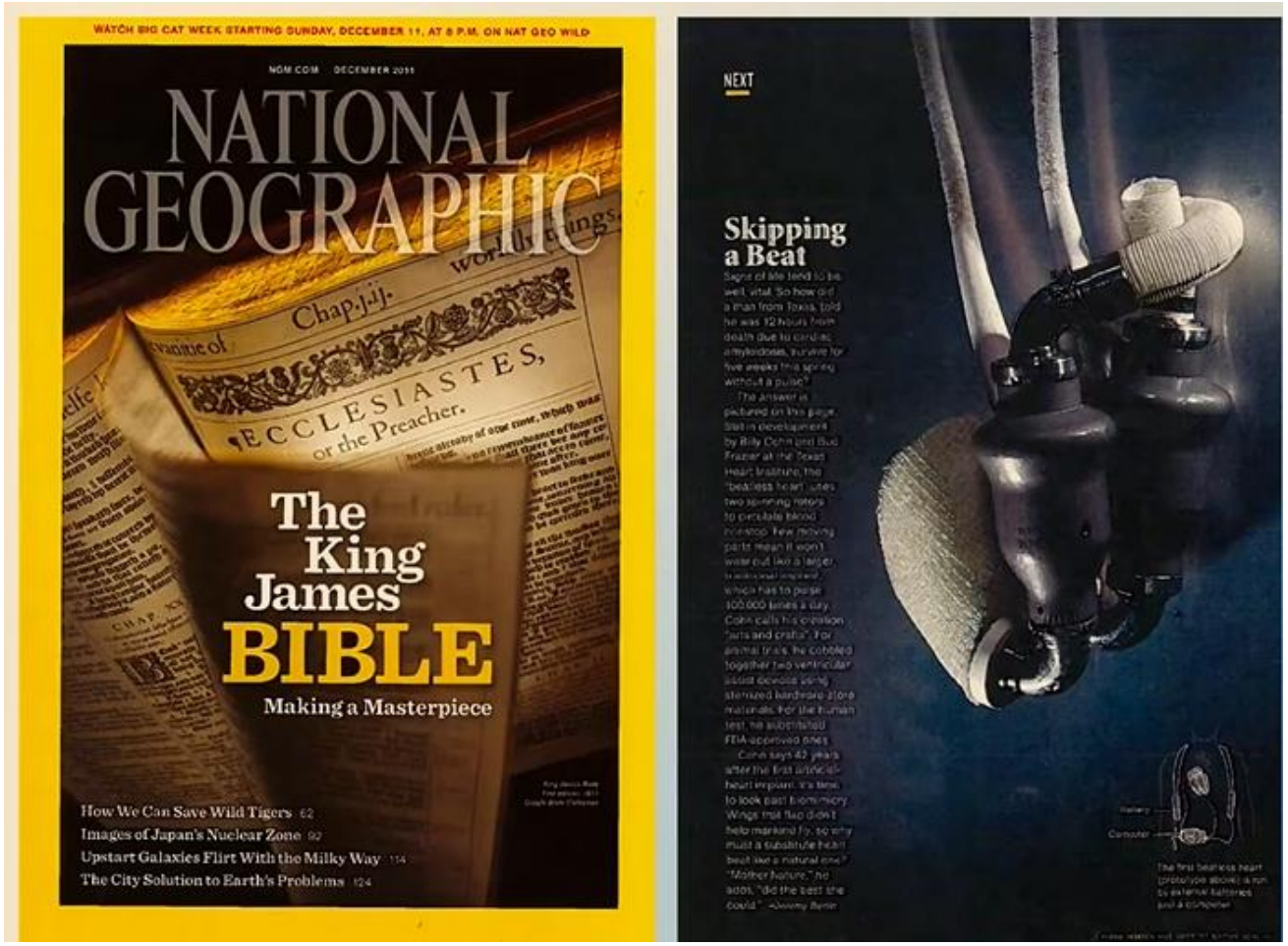

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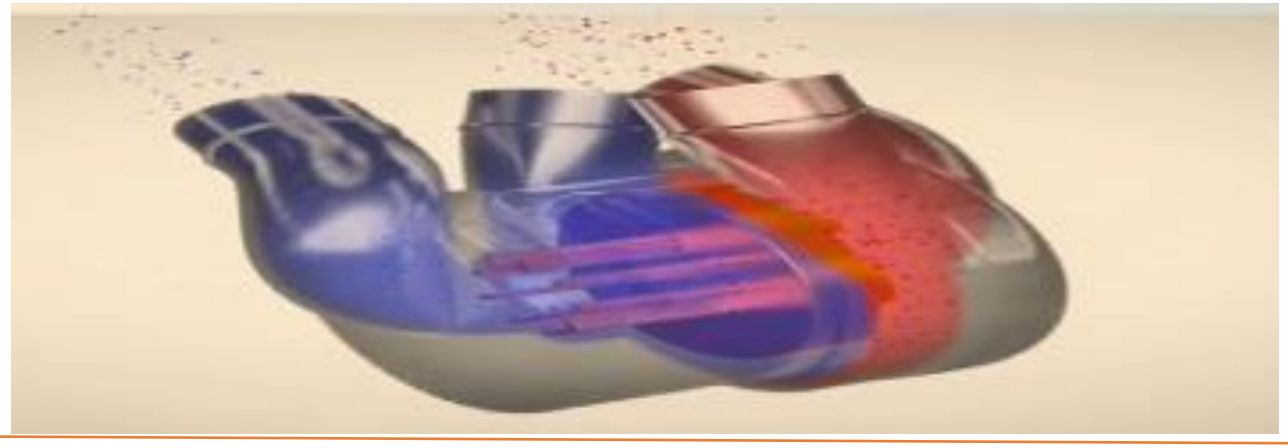
BIVACOR Heart → One motor with maglevation



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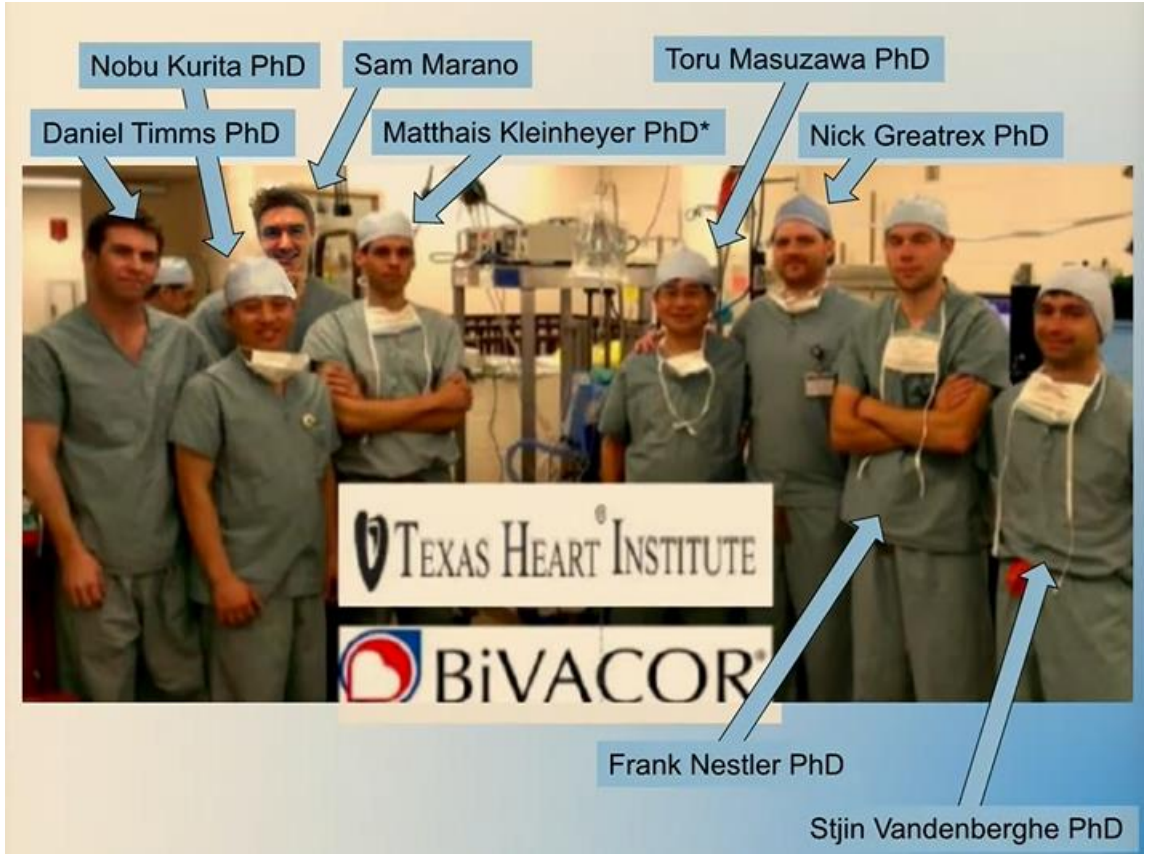

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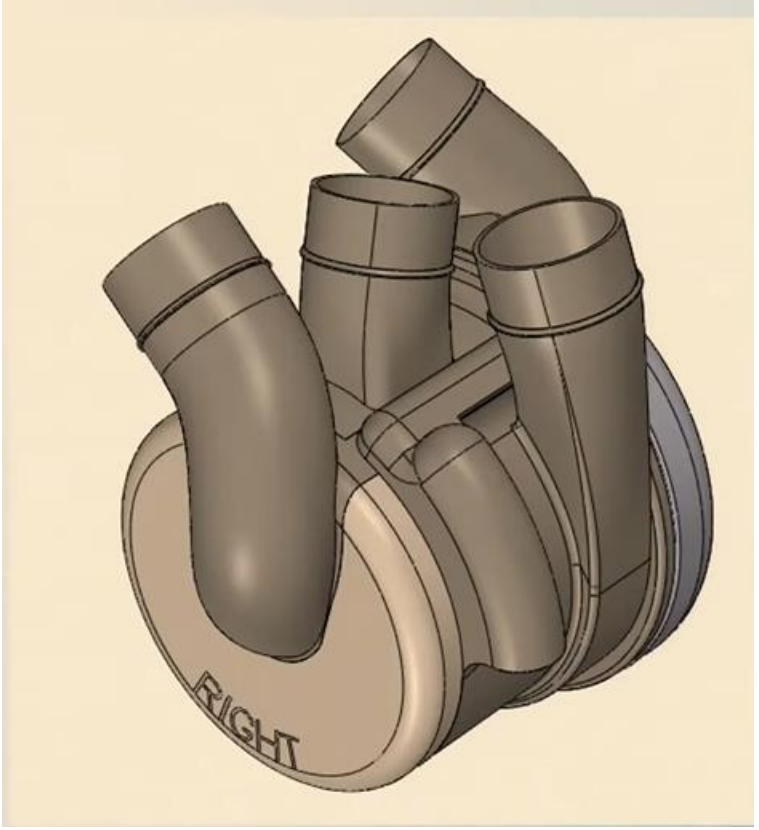
3-D printed the artificial heart



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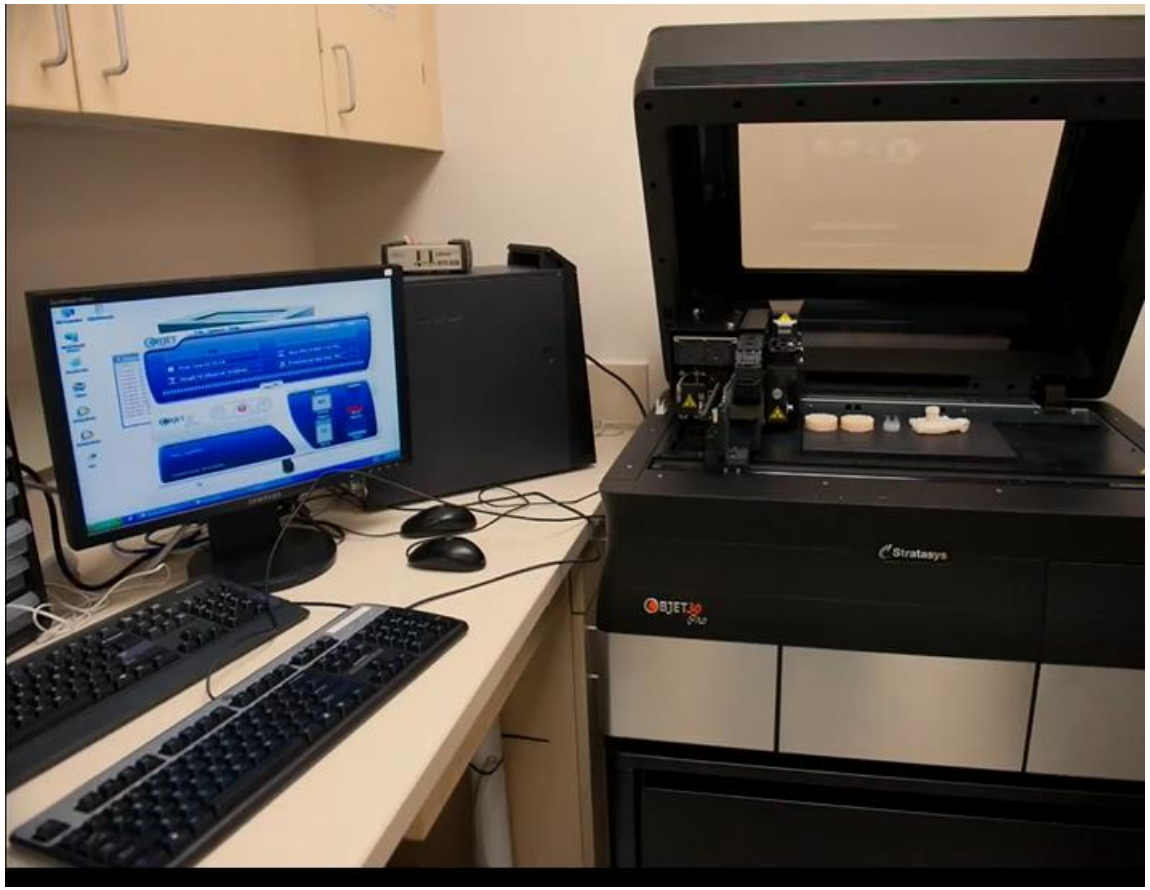

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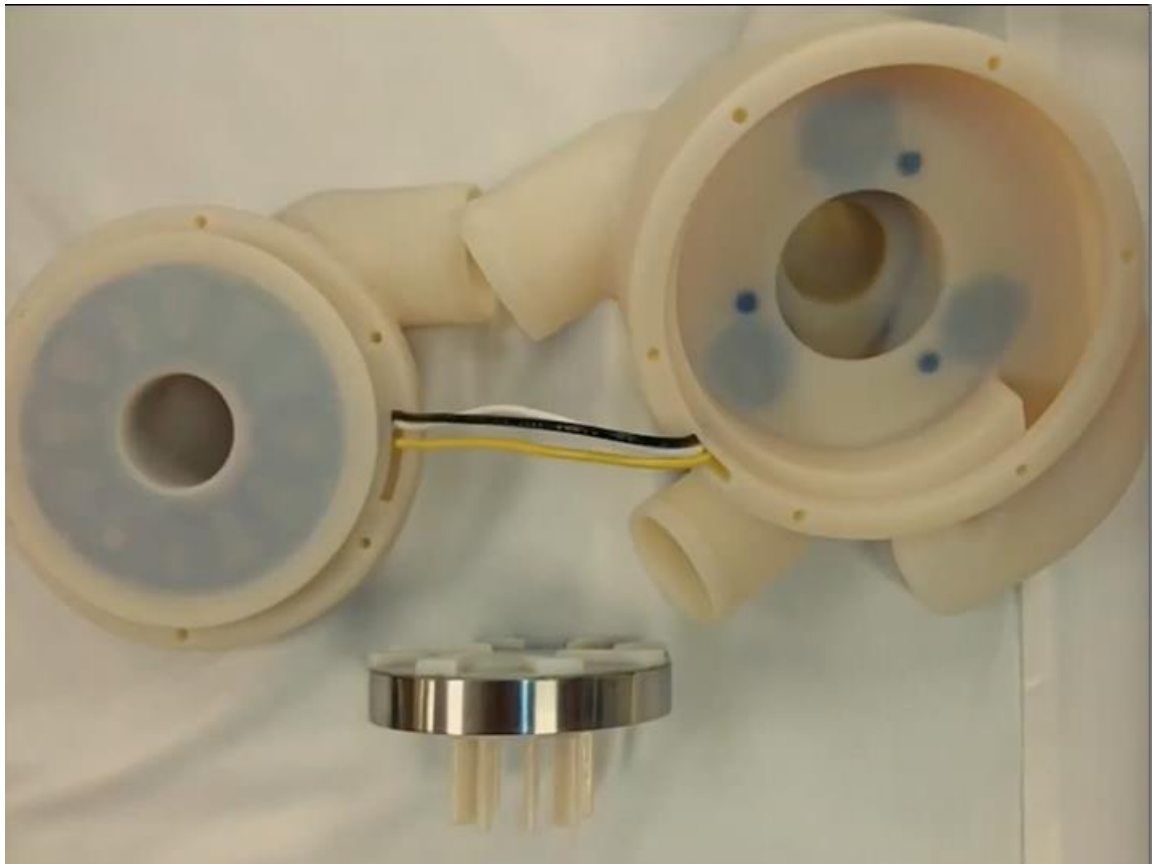

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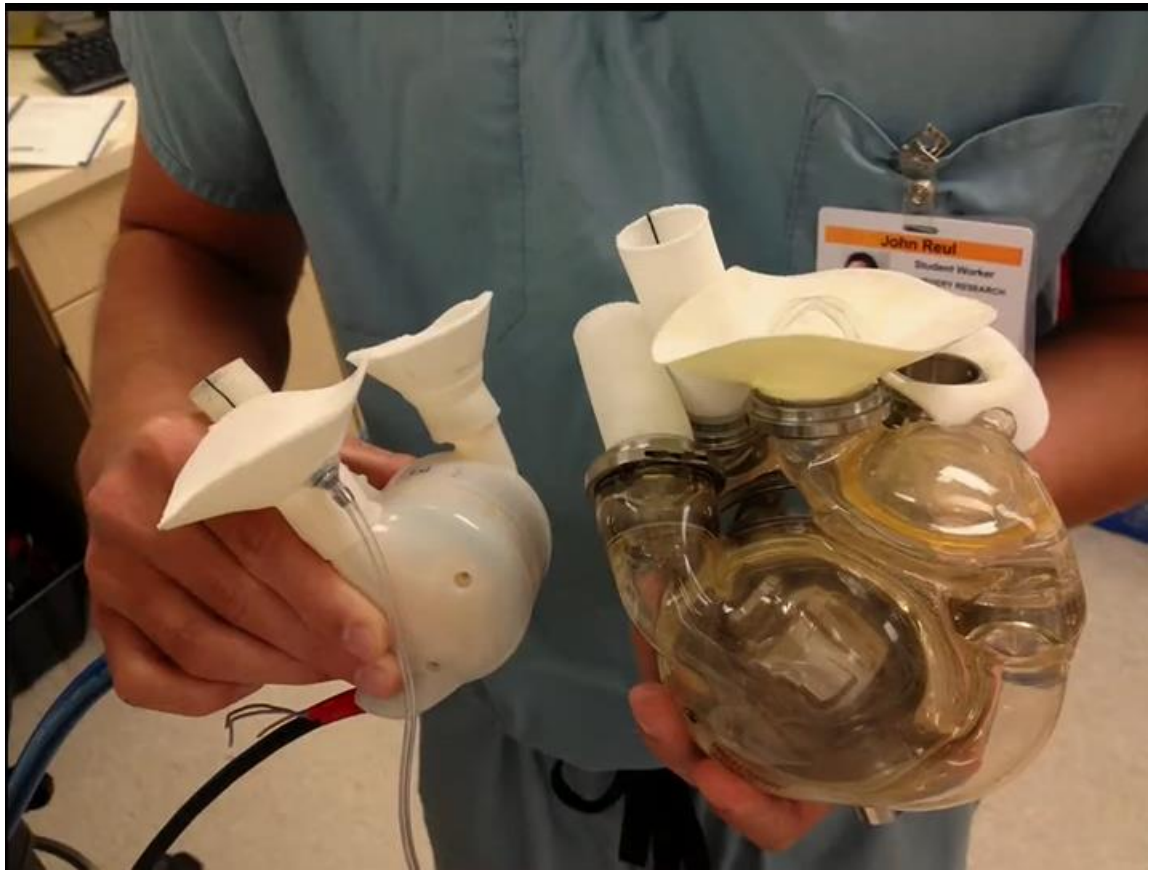

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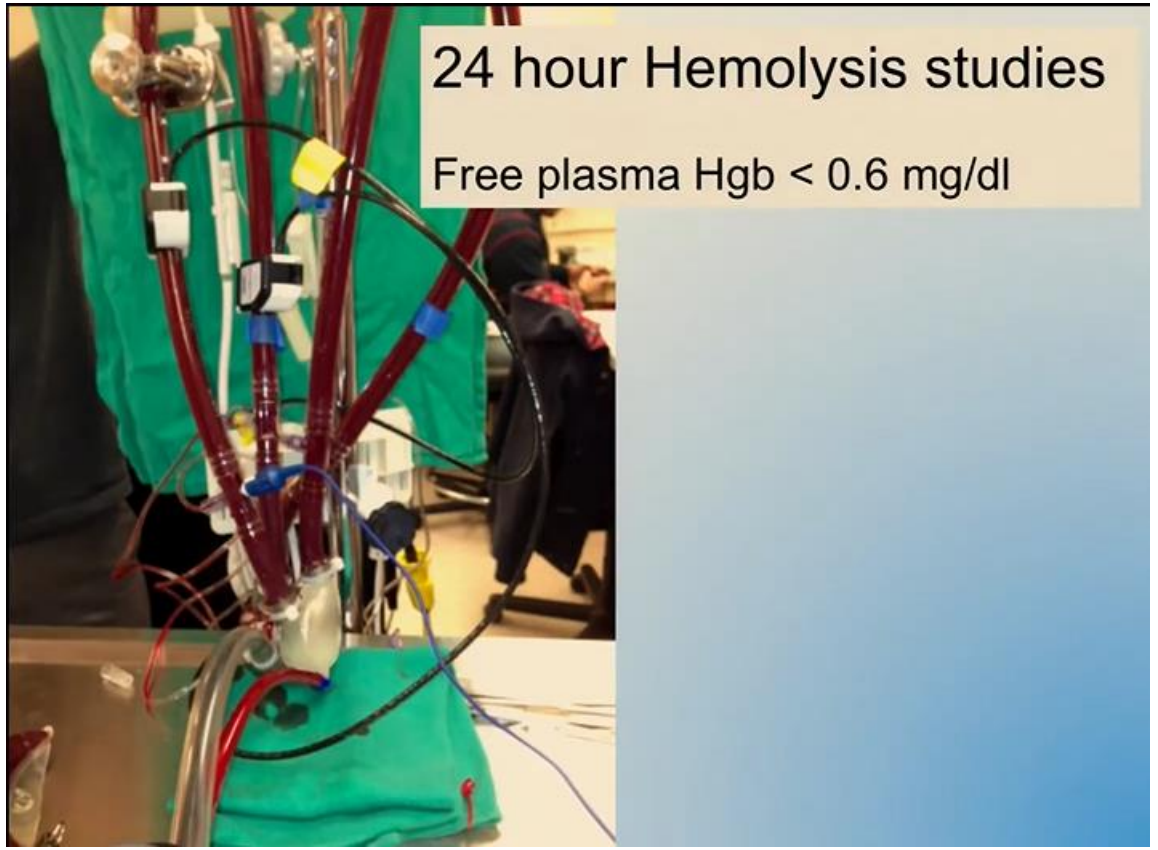

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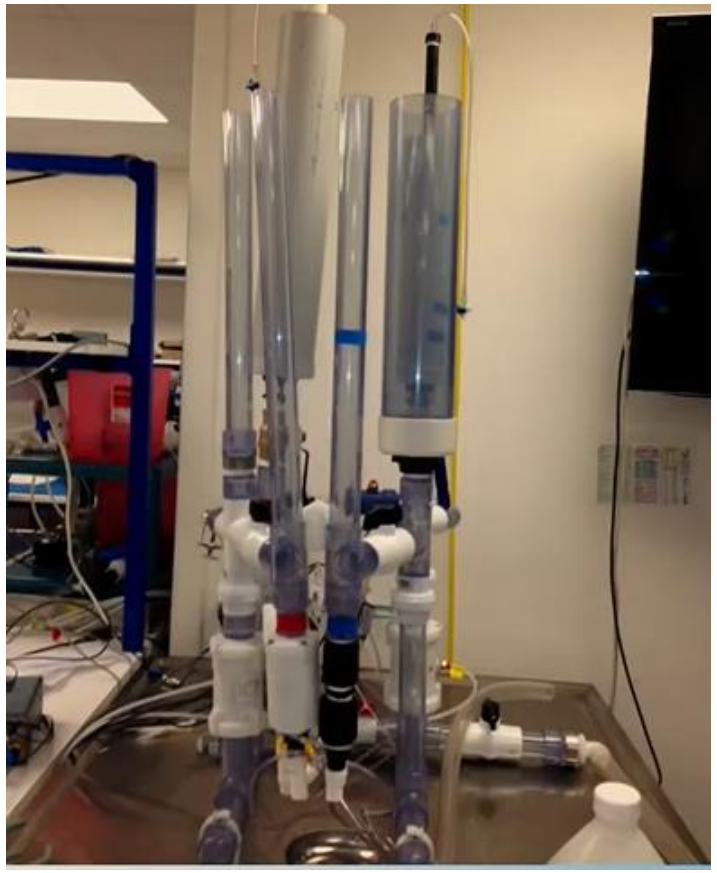
TAH Mock flow loop to characterized performance



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Do mammals need a pulse?

- Flow is continuous at the capillary level
- Gas exchange, exercise tolerance, end-organ function and Histology… has been normal in our > 70 experiments
- Wash out beyong atherosclerotic lesions is reduced
- G.I. Bleeding Maybe related to decrease pulsatility
- Pulsatility will certainly improve pump wash out!
- Creating a pulse may be of some merit…

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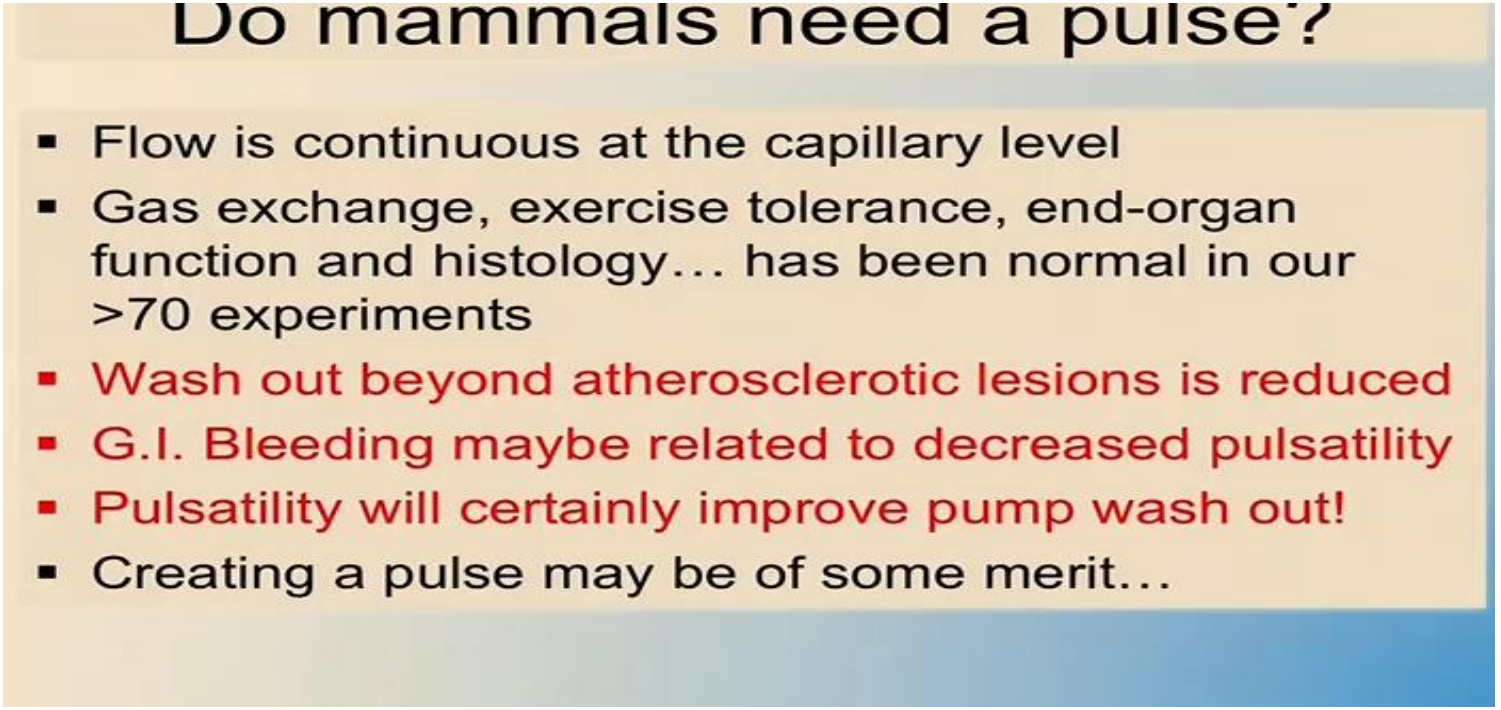
Refine drive Algorithm for pulsatile mode



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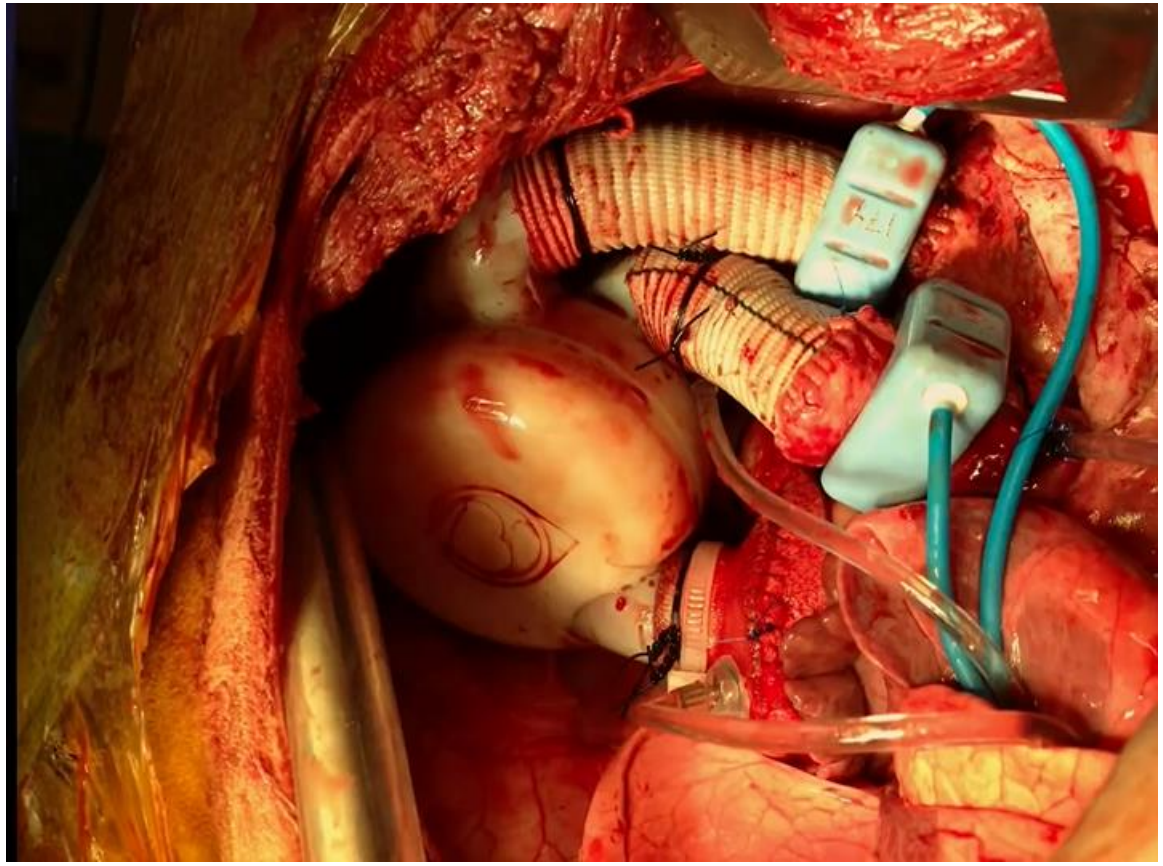

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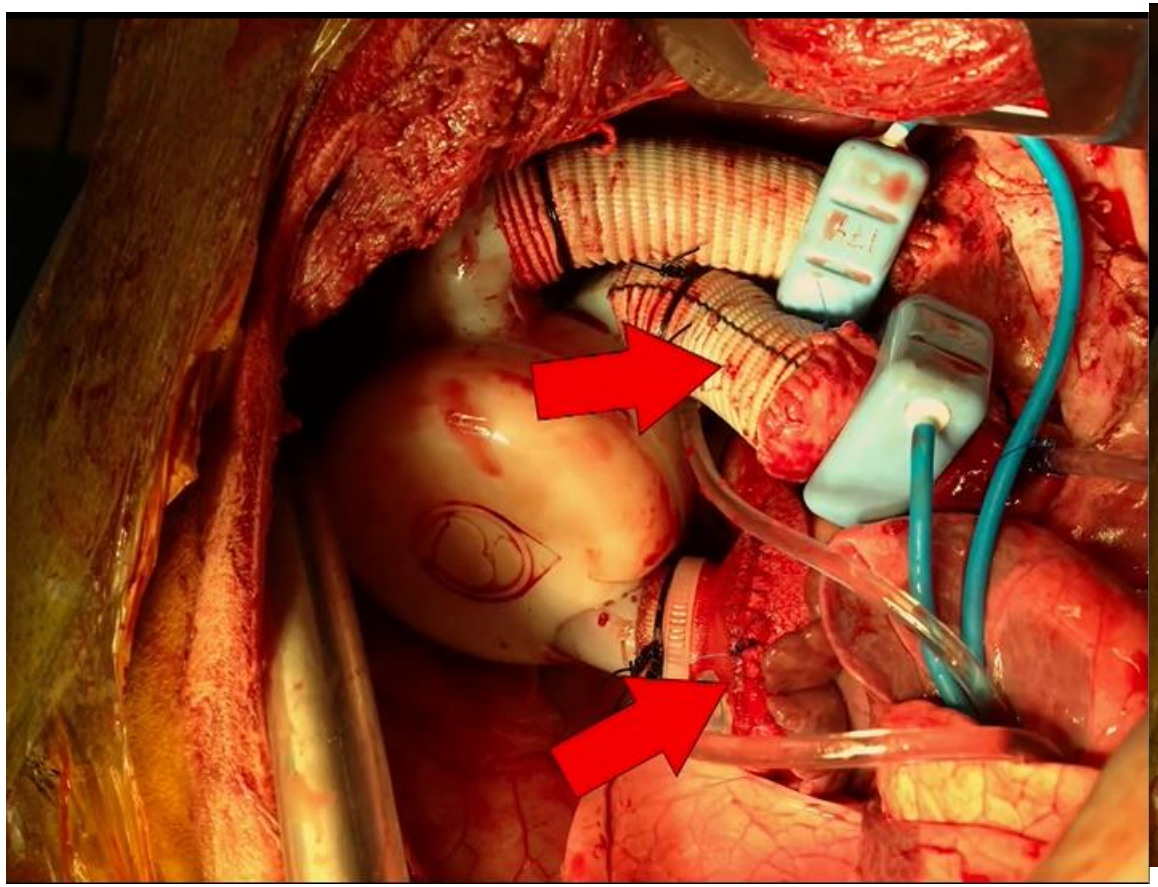

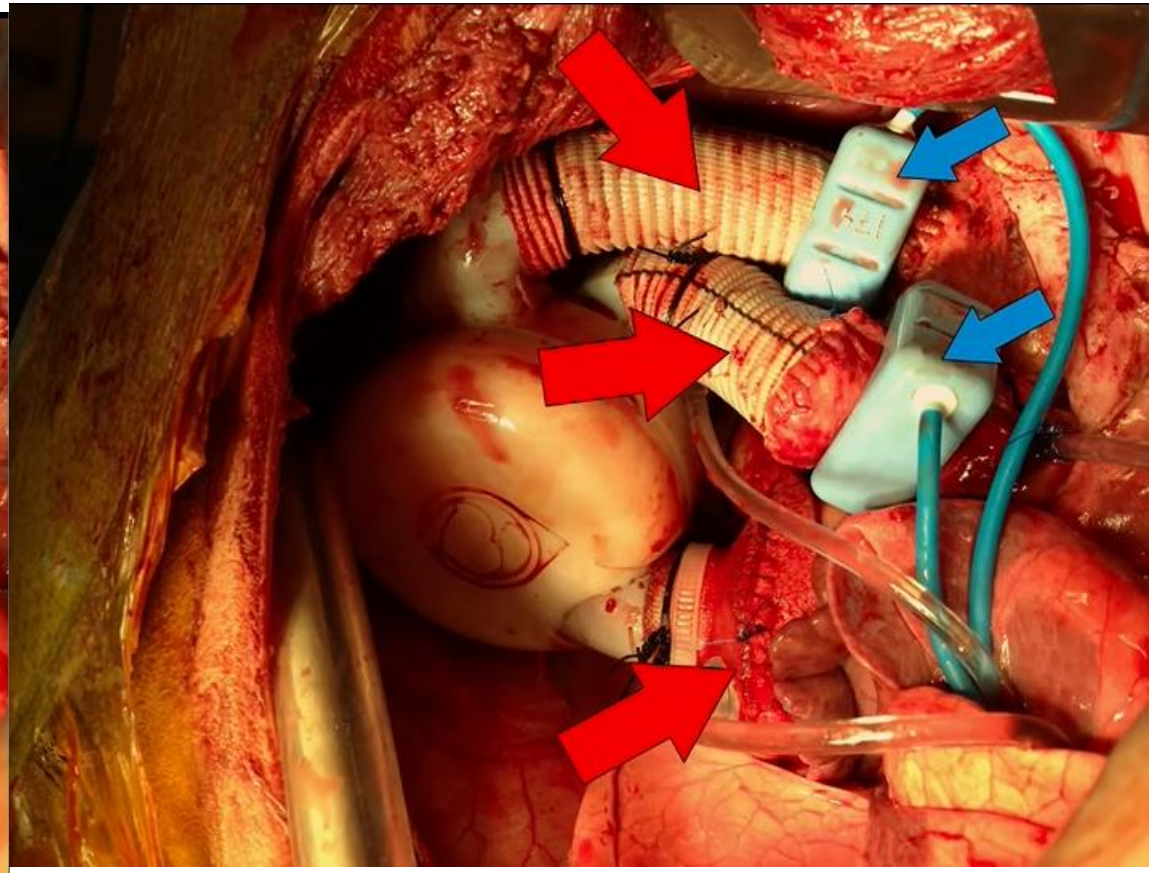

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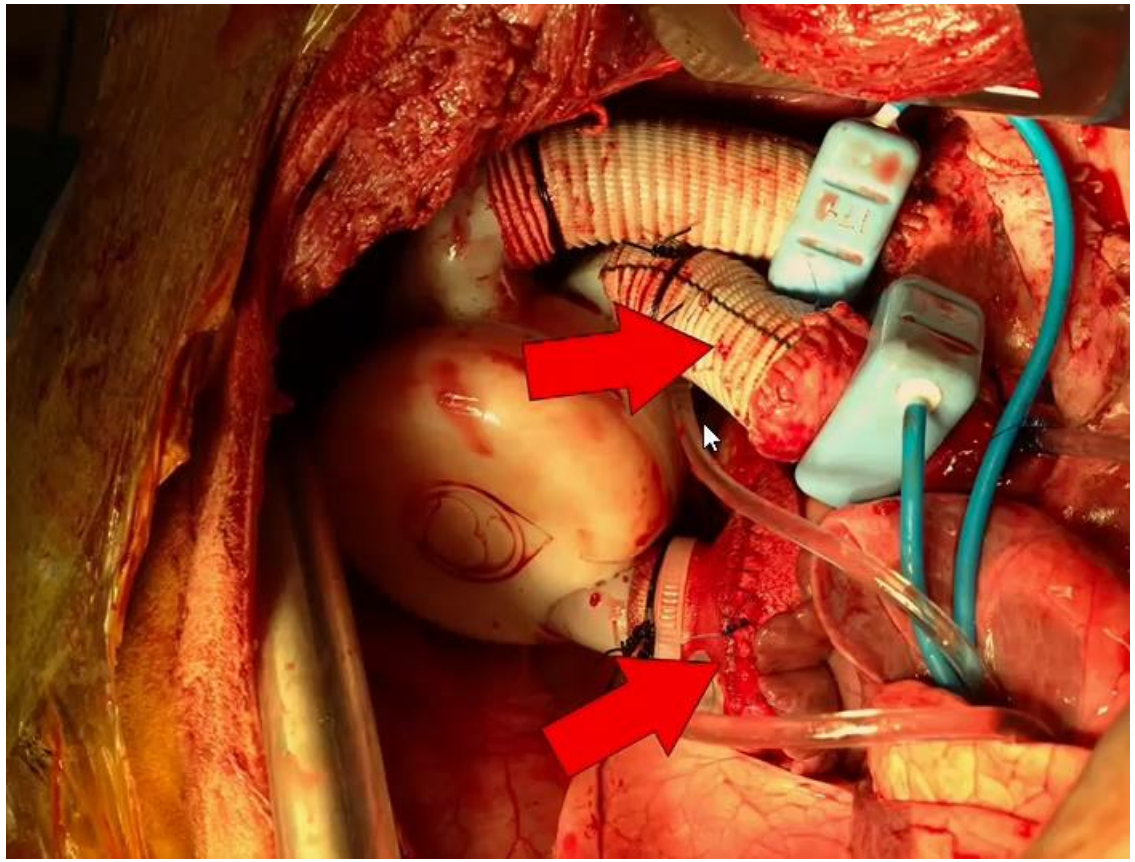

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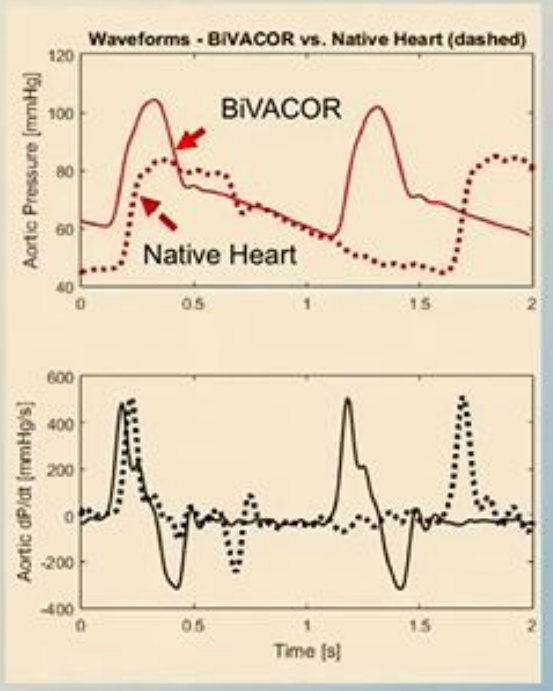
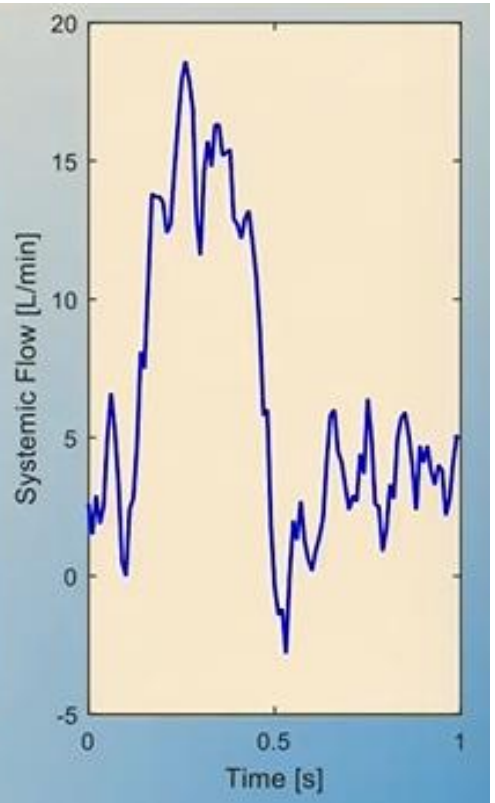
BIVACOR Pulsatile output Characteristics

- BiVACOR induced pulse resembles the native pulse (pre-implant)
  - Flow pulses 0 – 20 L/min
  - Pulse pressure of 120/80 mmHg
  - Arterial dP/dt of >500 mmHg/s
  - 60 – 120 bpm
  - Motor power 7.8 W
- Manageable increase in motor power consumption with pulsatility (+1W)
- Clinically insignificant hemolysis (15-20mg/dL) @16hrs after bypass





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BIVACOR Functionality

- 10 l/min on left and right for <10 watts
- Max output of 23l/min
- Pulsatile output if felt desirable
- Autonomous moment-to-moment balancing between Systemic and pulmonary circulation
- Magnetic levitation- no mechanical wear
- One moving part-mechanistic simplicity
- Wide blood gaps (4mm radial) so no hemolysis
- Programed left-to-right shunt for venous emboli protection
- 6cm x 6cm – smallest contained TAH

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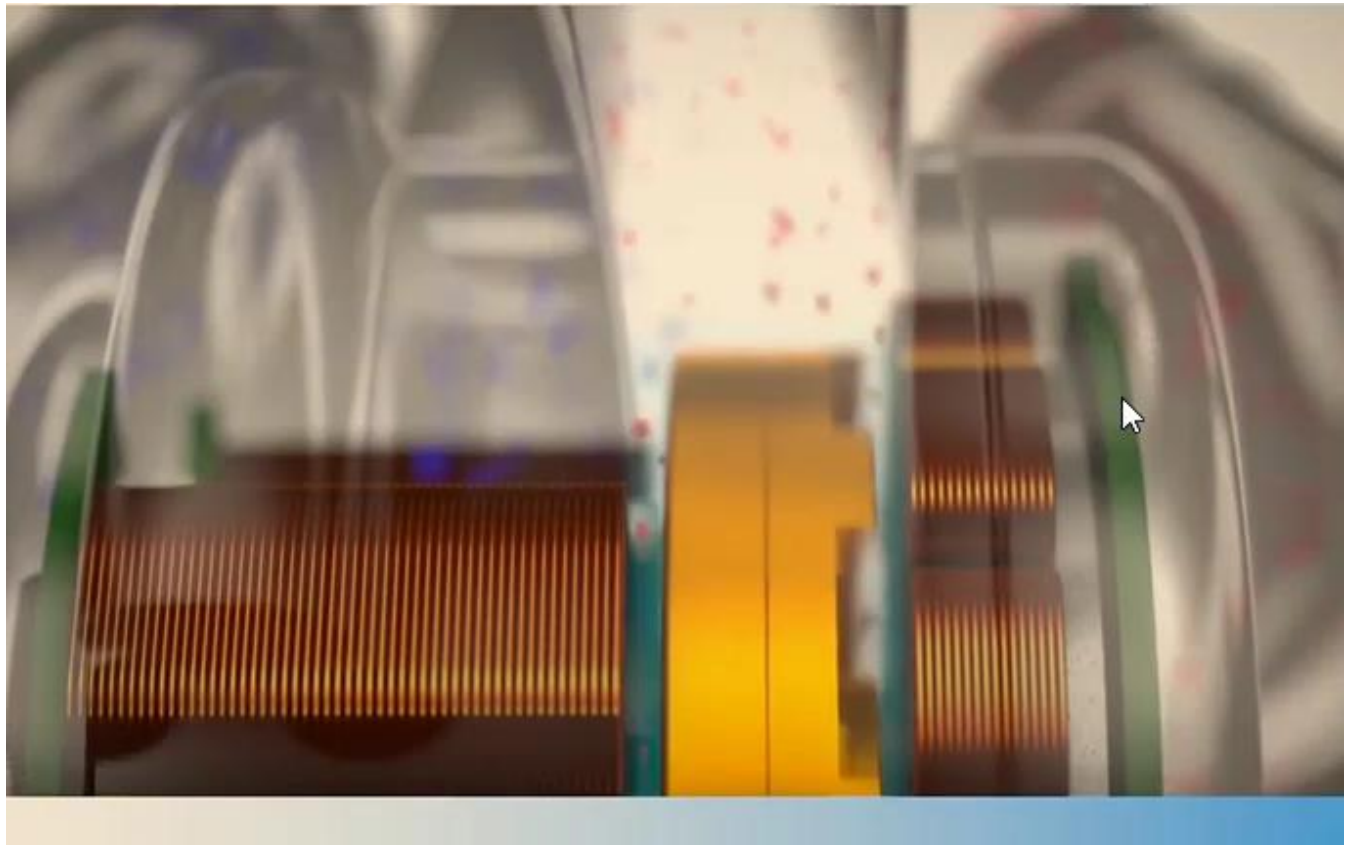
Integrated left-to-right shunt for venous emboli protection



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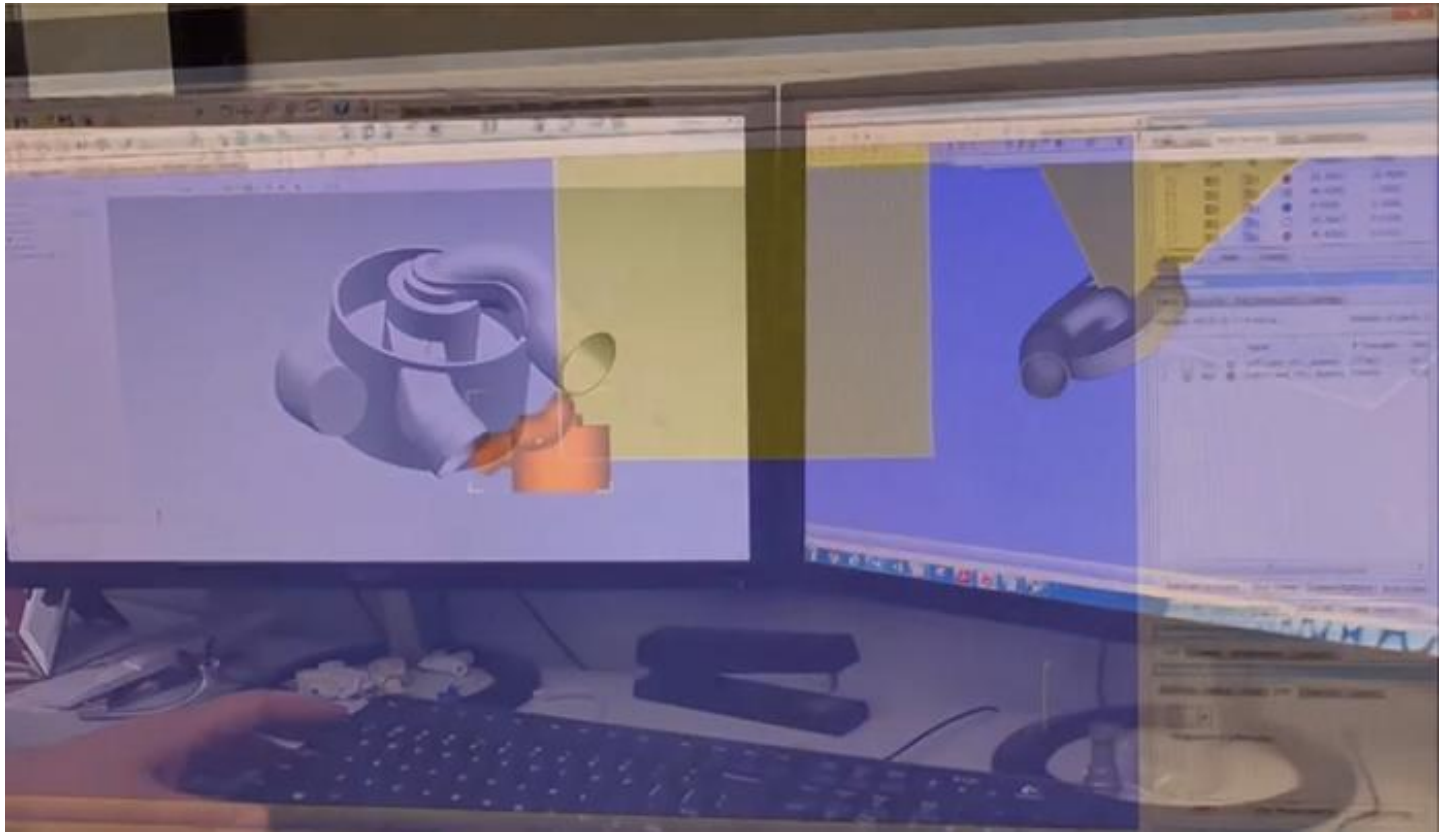
Linear Mold 3-D Titanium Printing on the EOS Machine



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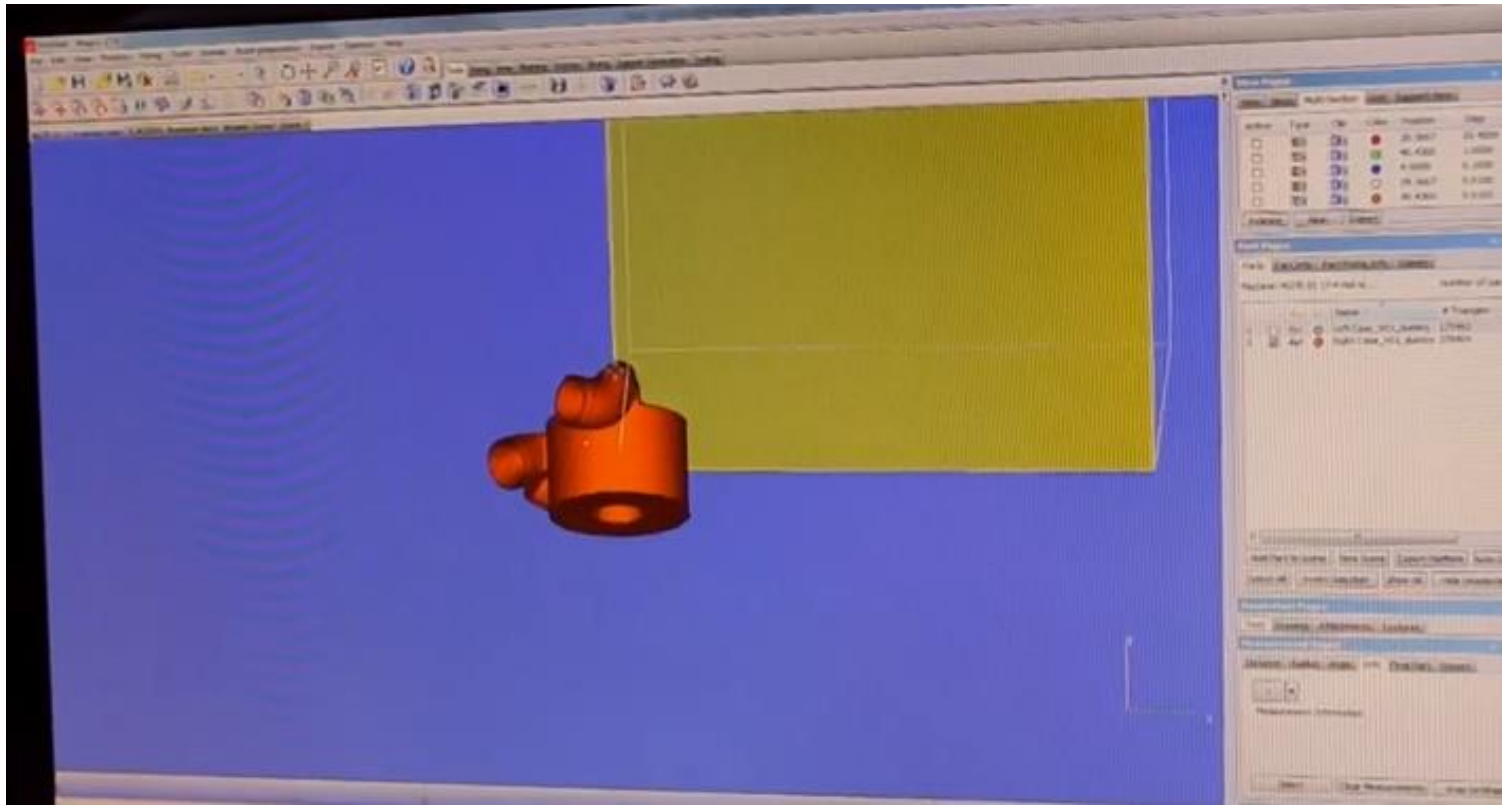

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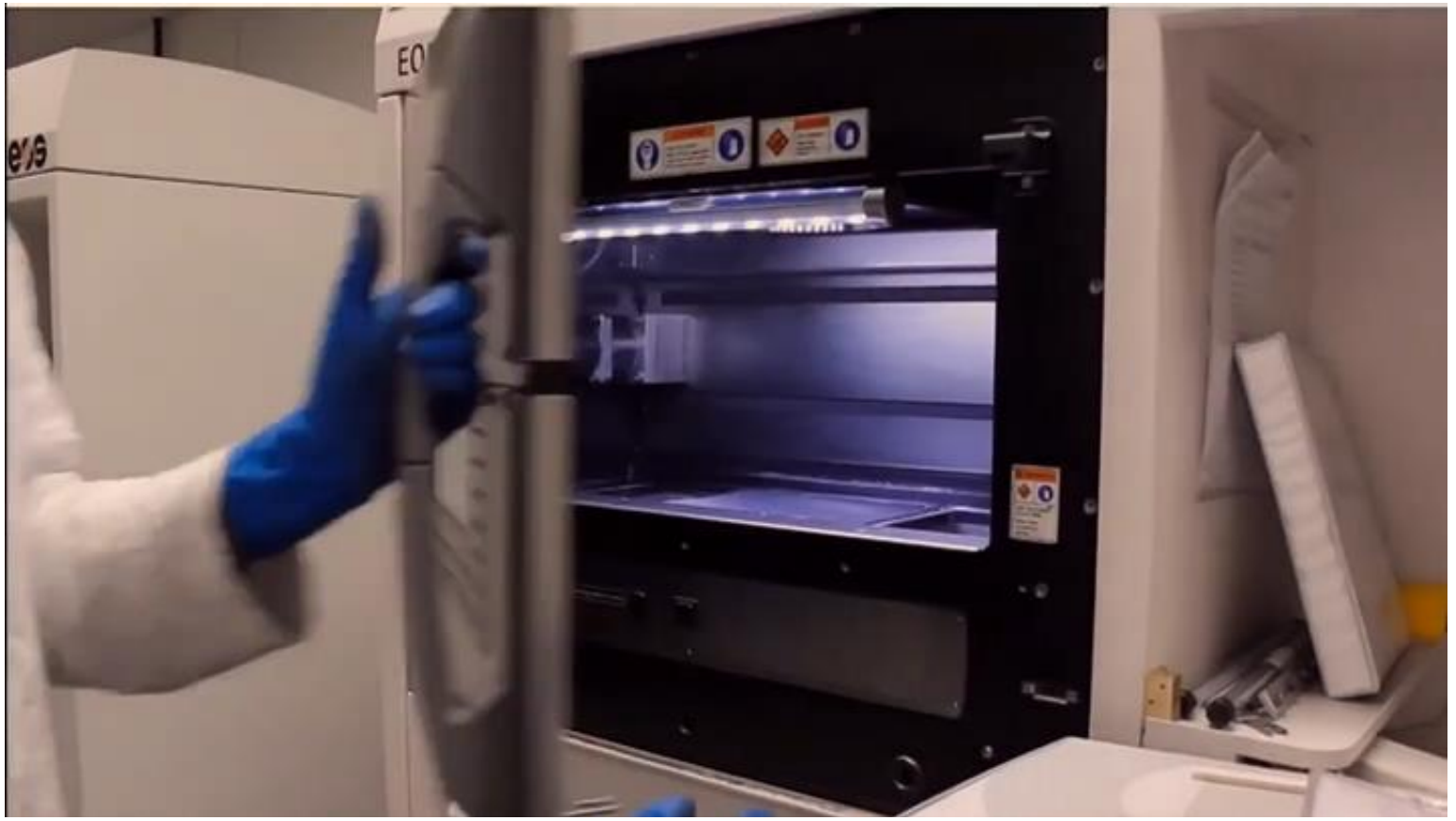

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The BiVACOR Total Artificial Heart

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First Chronic BiVACOR TAH Implant, THI Cardiovascular Research Lab

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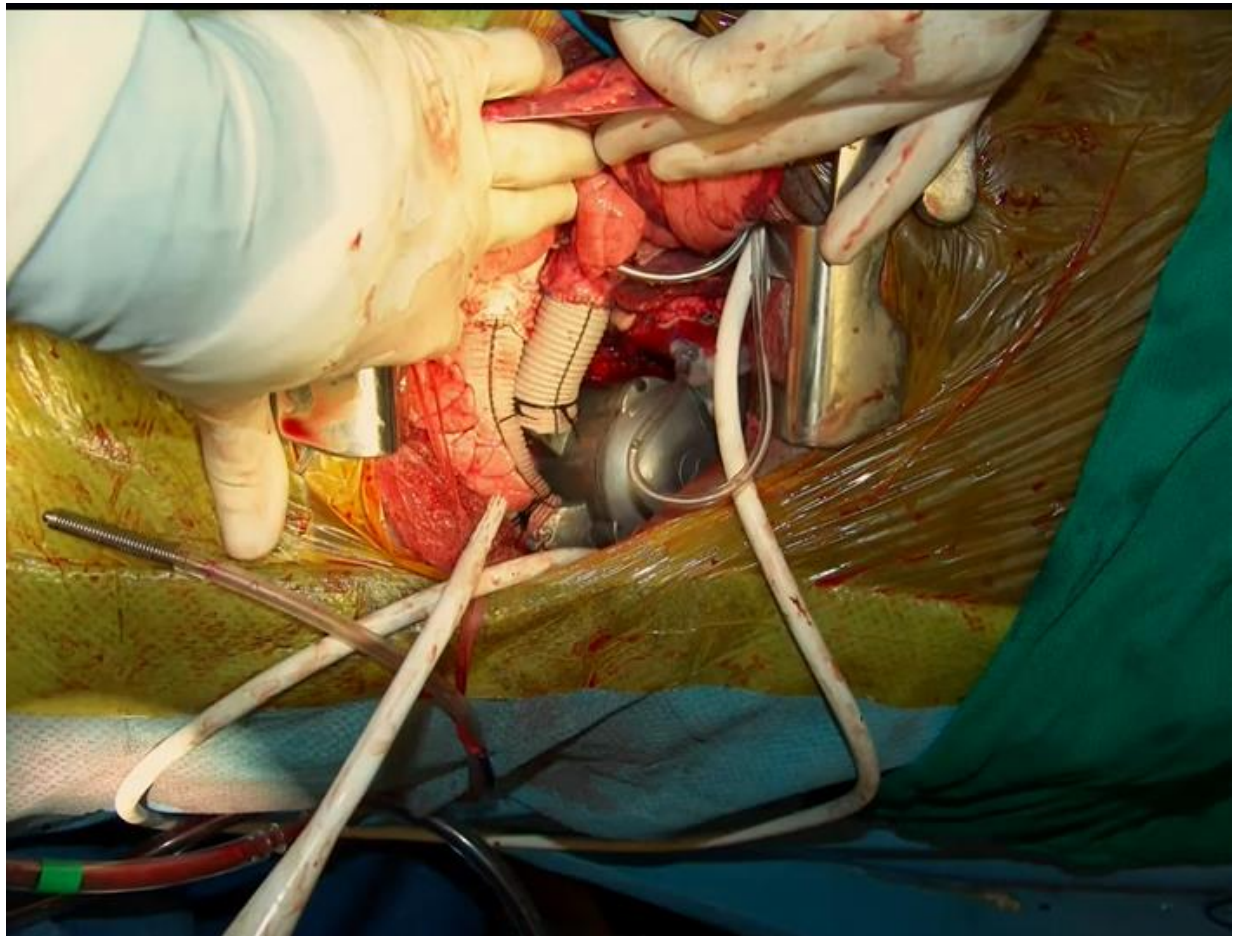

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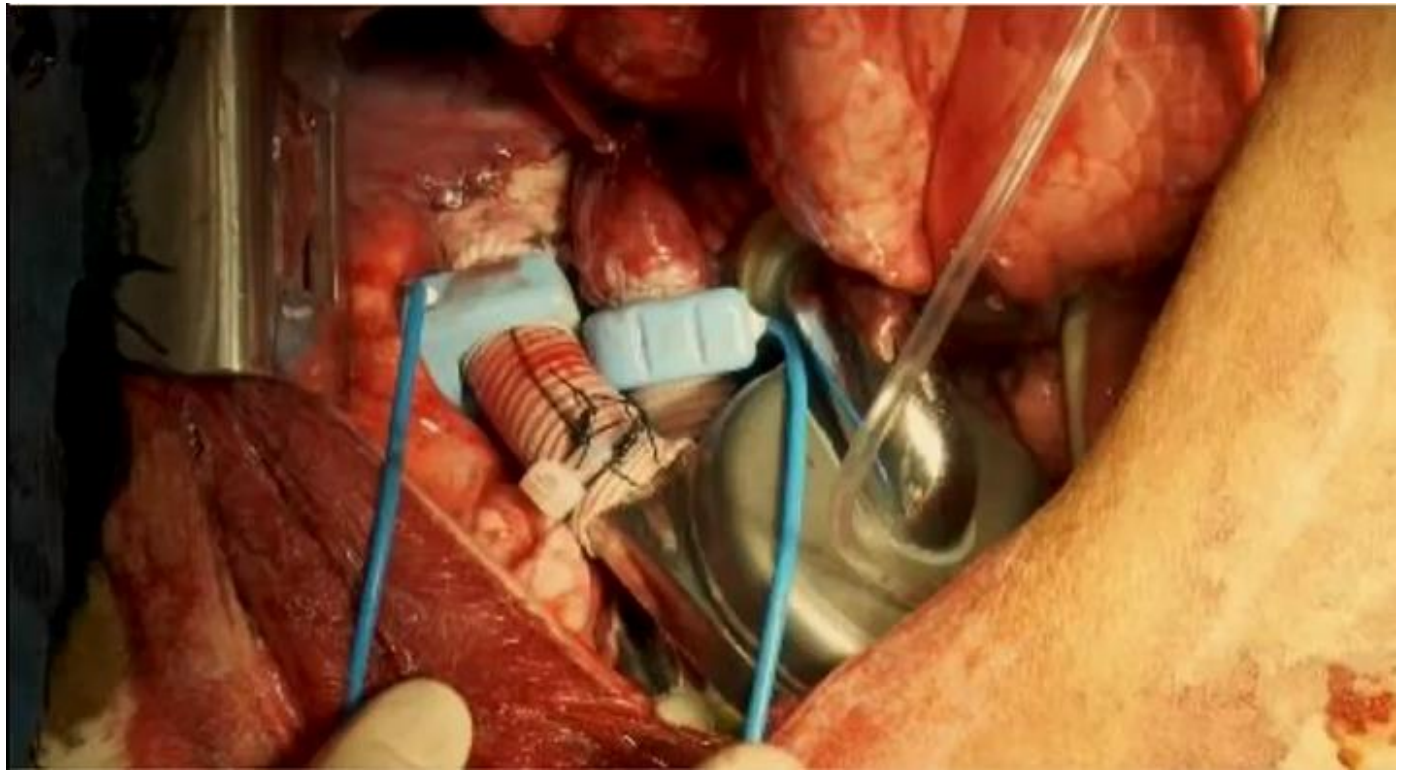

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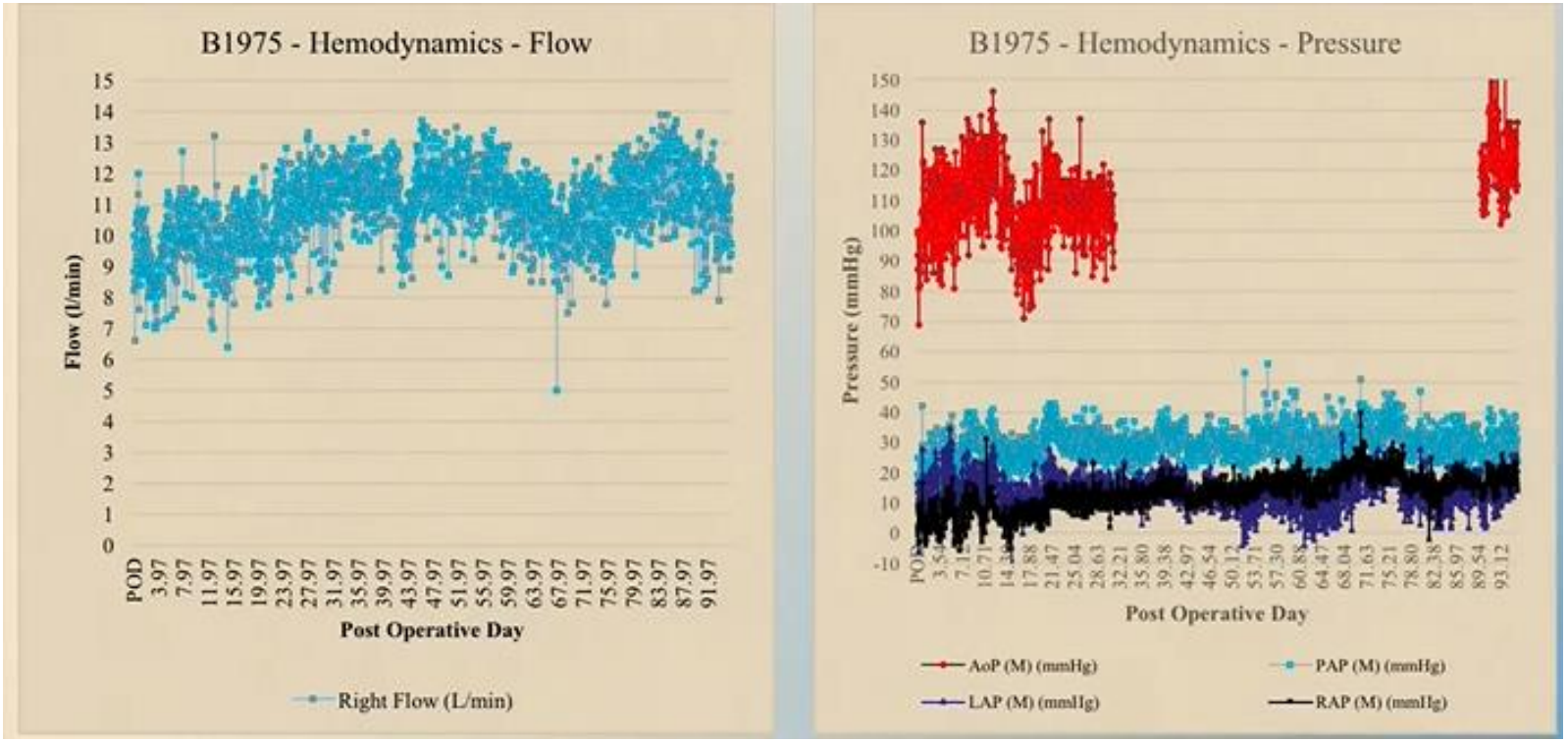
Hemodynamics over 96 days



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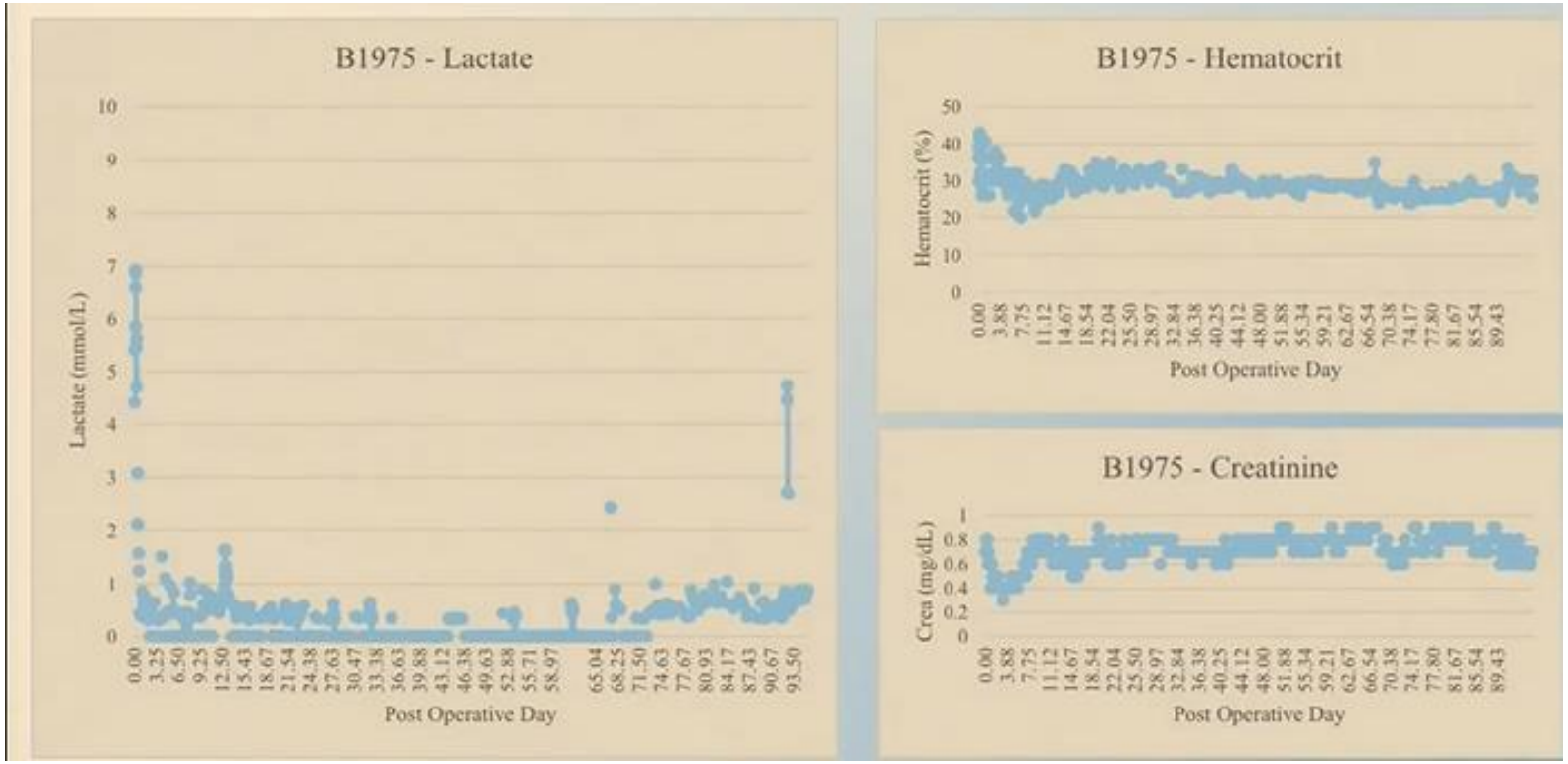

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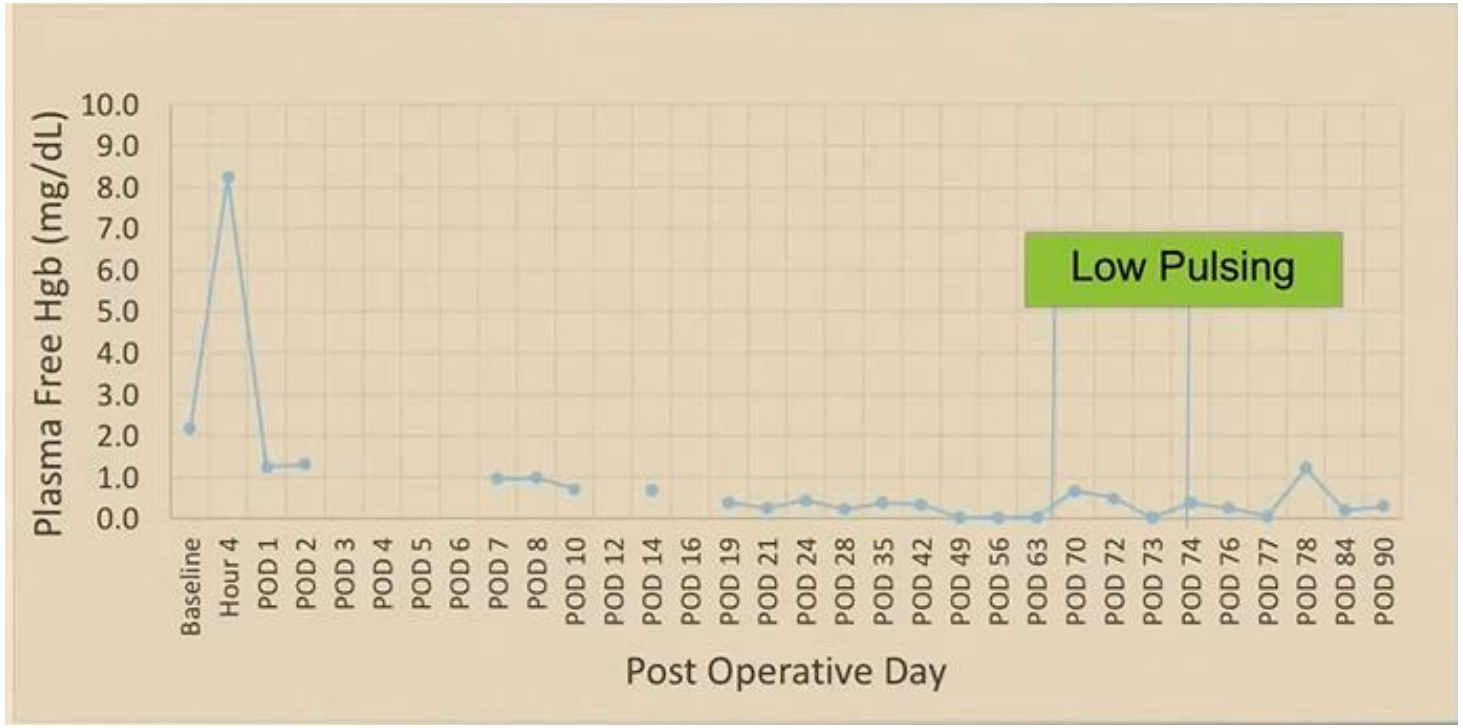

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BIVACOR V-3B TAH 96 day study ; 72 pound weight gain

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In Summary Old technique of TAH

- Continuous flow blood pumps are well suited for integration
  Into the next generation of total artificial heart
- If some degree of pulsatility is desirable, it can readily be achieved
  With a rotary pump
- The decreased size, marked reduction in mechanistic complexity, improved power
  Efficiency, and dramatic improvements in durability of rotary blood
  Pumps should be beneficial
- The First practical mechanical replacement for the failing human
  Heart will be continuous flow…

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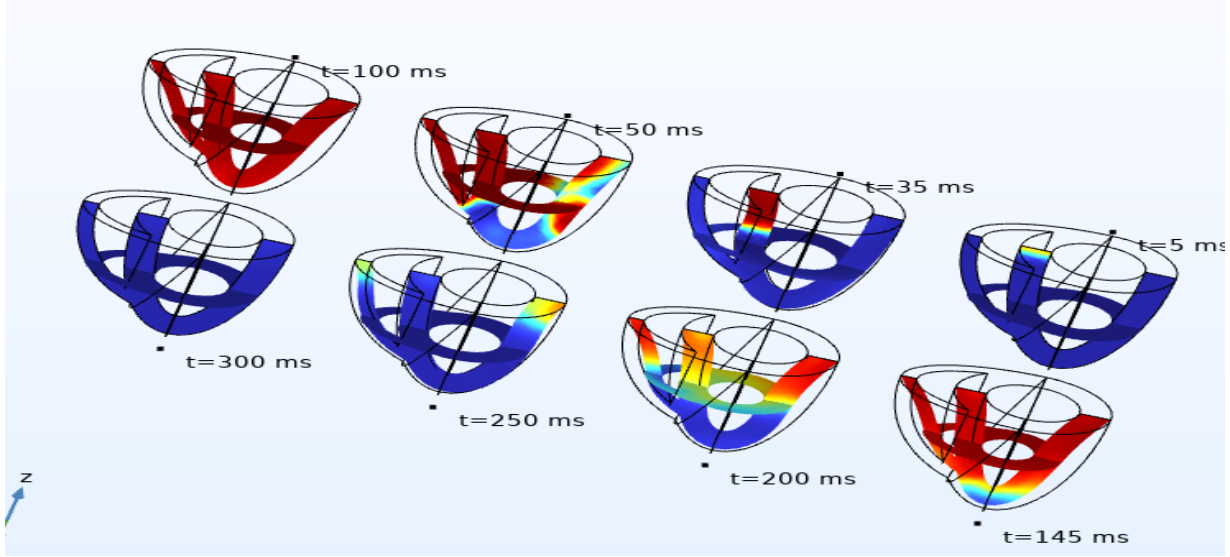
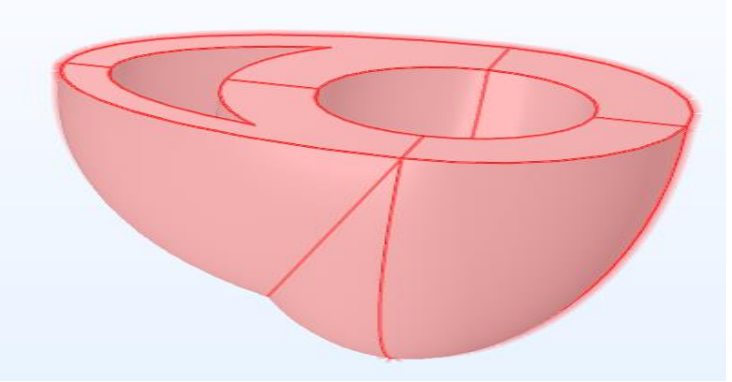
Total Artificial Heart





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Total Artificial heart (TAH) Core structure

1. MCU ⟹ RISC-V & AndresCore A27 Processor, Custom design ASIC, Analog/ASIC/RF IP, ROM/RAM, Motor Driver/ESC, Peripheral, SDK, Toolchain, BLE, Mems Bio sensors
2. TAH Body ⟹ Titanium ⟹ Polymer ⟹ Silicon
3. Valves ⟹ Titanium/Carbon ⟹ Or Valveless Technology
4. TAH ⟹ Artery to TAH Suture ⟹ PTFE (Polymer)
5. Battery ⟹ NDB / Lithium ⟹ Or Battery less ⟹ Self-charging magnetics field
6. Software ⟹ Mobile App /Tablet ⟹ Controller TAH
7. BLDC Motor ⟹ Hydraulic / Maglev (Pulsatile & Continuous mode)
8. Test Bench ⟹ Test quality, durability of Motor, Alarm, sensors Continues 6 Months
9. Animal Trial ⟹ Sheep, COW Minimum 30 days observation. Apply for FDA
10. Human Trial ⟹ Heart Transplant group lead by Prof. Dr Mehdi Khan

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Conference & Research Article

JMEMCS, Journal of medical, electronics, and mechanical circulatory support,
Artificial heart, Vol. 1, No. 1, November, 2023, pp. 1-4. Vol. 1, No. 1, Jul.-Aug., 2023, pp. 1-4.
Original article submitted June 30, 2023.

Total Artificial Heart: State-of-the-art

Mehdi Khan[1], Pervaiz Chaudhry[2], Zhi-Cheng Jing[3], Lin Fujiang[4] and Muhammad Khalid Pervaiz[1]

A review is conducted of contemporary iterations of entire artificial pulsating hearts, including Syncardia, Abiocor, Upplysning Robotics (memma), and Carmat. There is a thorough examination of these devices' technical features, taking into account their common flaws for artificial pulsating hearts: lower dependability and limited usefulness because of the large size of the implantable module. The Carmat total artificial heart, which is presently undergoing clinical trials and partially resolves these issues, is thoroughly examined.

Introduction

The primary objective during the early stages of mechanical circulatory support (MCS) development was to replicate the physiological processes of the heart through the implementation of flexible diaphragms and unidirectional valves. Steel pulsating machines, including the entirely artificial heart Liotta-Heart and Jarvik 7, were the consequence of this development. Although the implantation process was fruitful, the utilisation of these devices was constrained by their substantial dimensions and inadequate dependability resulting from the multitude of mobile components [1–4].
Current frontrunners in the treatment of heart failure that have achieved the highest level of clinical success and are extensively implemented are third-generation circulatory support devices known as constant flow rotary pumps [1, 2, 5].
However, there are still potential applications for total artificial hearts (TAH), including the rescue of patients experiencing cardiogenic shock in the event that heart transplantation fails, specifically when there is an urgent need for hemodynamic recovery [6]. Additionally, TAH implantation offers a superior six-month survival rate in comparison to the circulatory support apparatus for both ventricles of the heart [7].

This analysis will provide a state-of-the-art description of pulsating MCS systems intended for total myocardial replacement. A summary of the characteristics and features of these devices is provided in Table 1.

Syncardia Total Artificial Heart

For the replacement of both ventricles of the heart, the Syncardia device (SynCardia Systems, USA), a pulsating total artificial heart, is the most prevalent MCS system variant. It measures 400 ml in volume and 160 g in weight [8]. For a bridge to transplant (2004) and voluntary implantation in patients who have been denied a heart transplant (2012), it has received approval from the FDA [6].

The artificial heart is comprised of the subsequent elements: autonomous left and right polyurethane ventricles, each with a volume of 70 ml (see Figure 1), and a transducer control cable that links the ventricles to an external pneumatic compressor [6, 9].

Directional blood flow is provided by two Medtronic-Hall single-leaf mechanical valves (27 mm inlet valves and 25 mm outflow valves) in each artificial ventricle [6, 11].

The main unit is composed of thermoplastic polyurethane IsoPlast. In order to construct the ventricular chambers, successive layers of polyurethane with varying hardnesses are poured. The ventricle is composed of two distinct sections.

[1] Upplysning Robotics:mehdi@upplysningavancez.com
[2] United Christian Hospital
[3] Peking union medical university
[4] University of science and technology of China

* To whom correspondence should be addressed.

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CERTIFICATE OF PARTICIPATION

The American College of Cardiology Foundation (ACCF) certifies that

Dr Mehdi Khan

participated in the Other (Live and Enduring Material) activity titled

New York Cardiovascular Symposium 2022

on December 9 - 11 2022.

This activity was designated for a maximum of 15.25 *AMA PRA Category 1 Credits™*.

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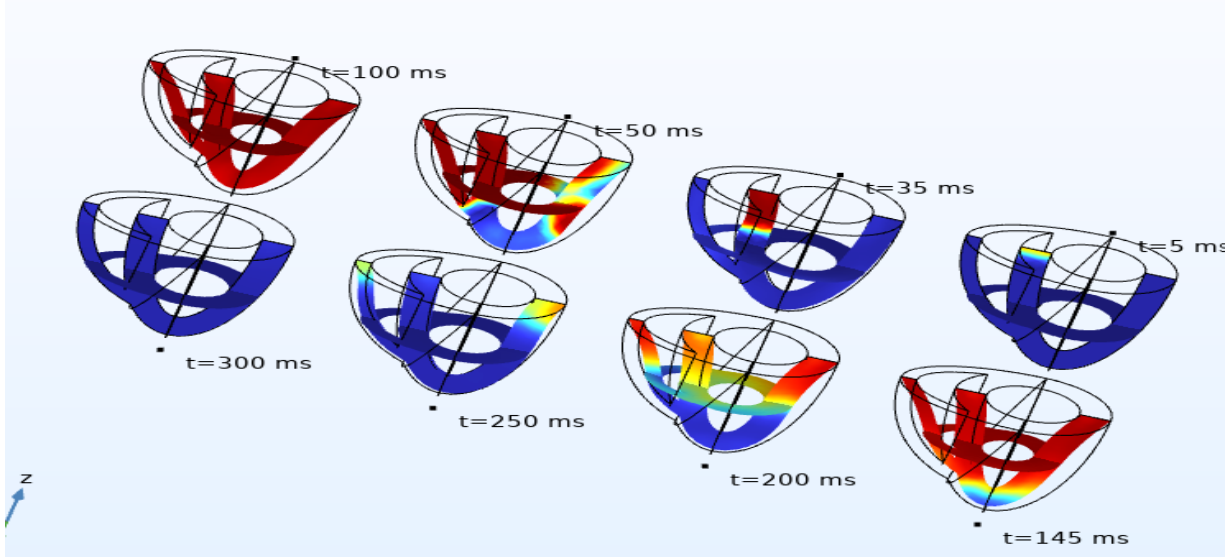
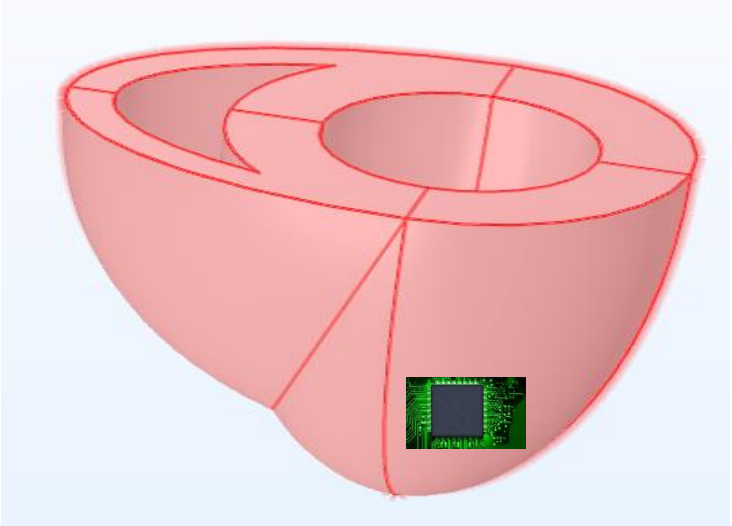
Upplysning Robotics TAH Structure
CAD Simulation





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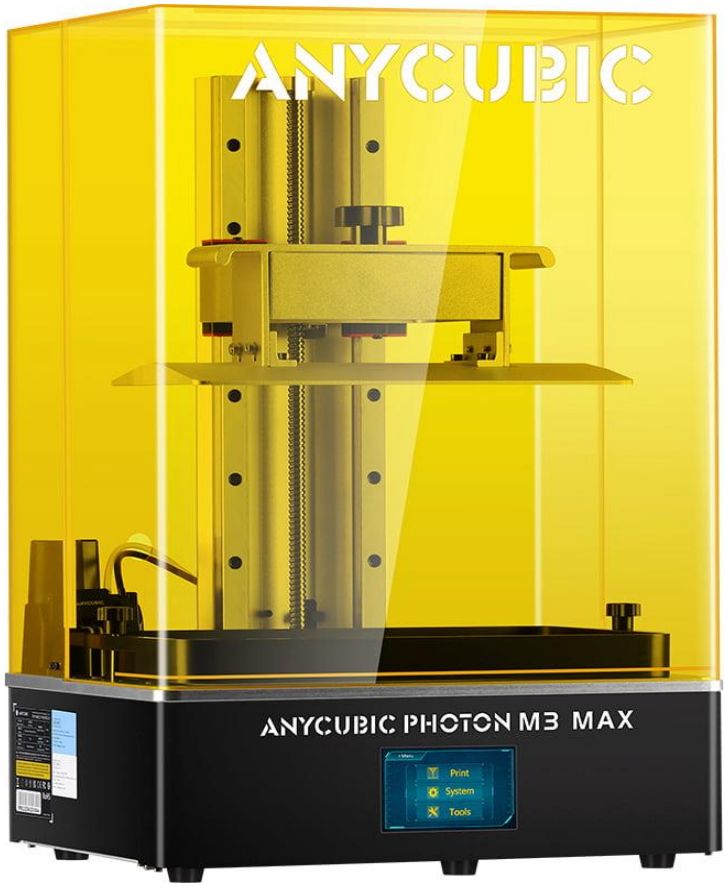
3-D printed the total artificial heart → Memma



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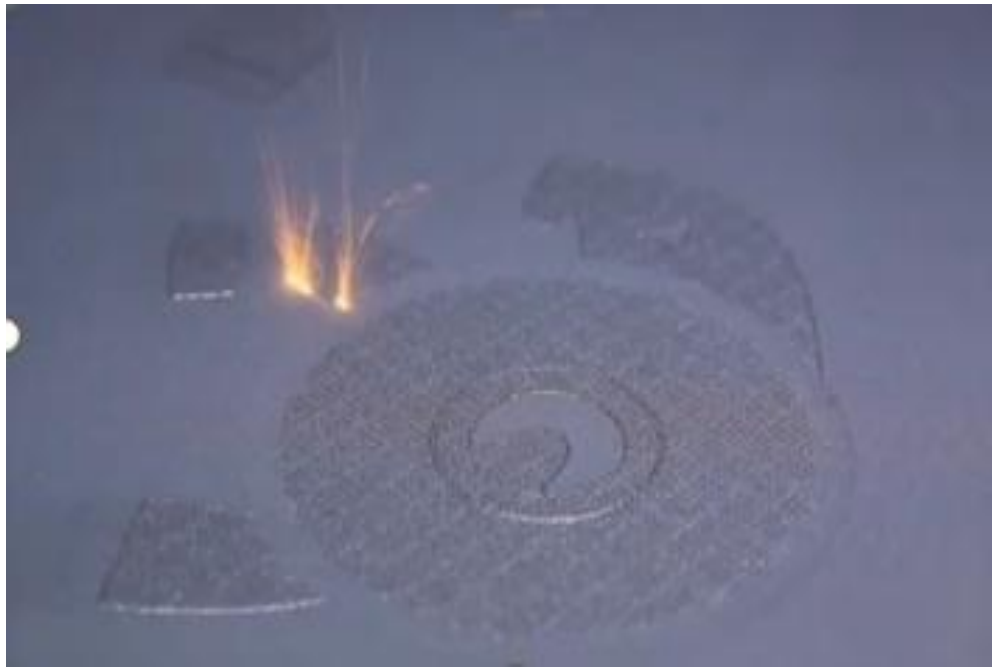
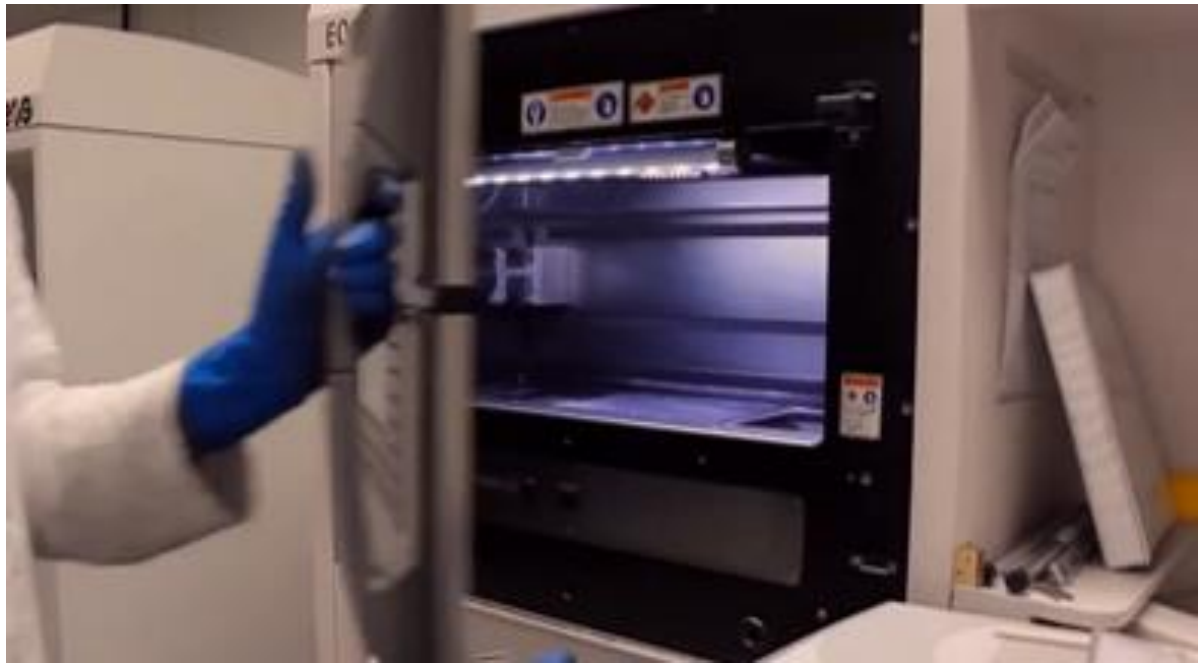
Linear Mold 3-D Titanium Printing on the EOS Machine
To make metal based total artificial heart





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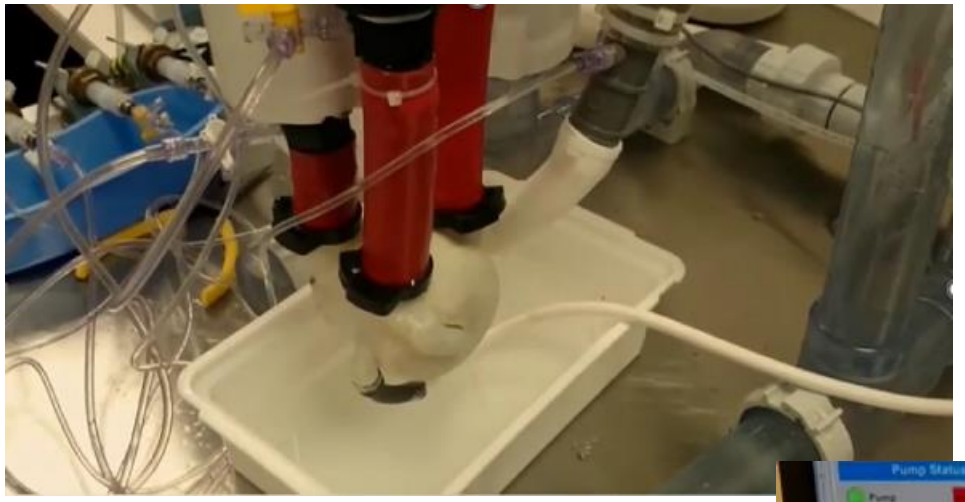
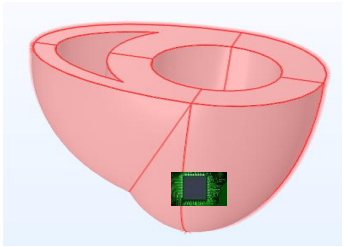
TAH Mock flow loop to characterized performance

Upplysning Robotics→ Memma





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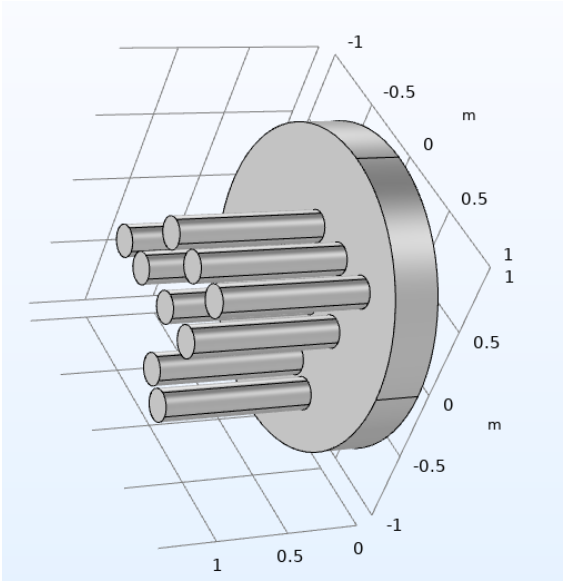
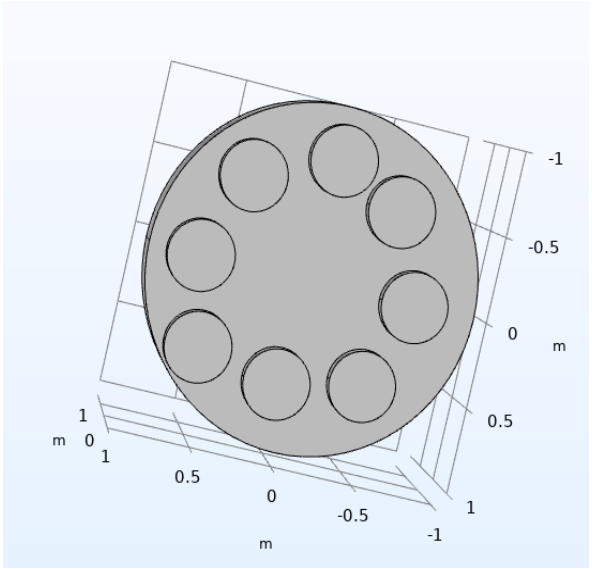
Upplysning Robotics SMC PVT LTD

One motor →Maglevation cum hydraulic motor for TAH
Continous mode Maglevation and Pulsatile Mode (Hydraulic)

Front



Back



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Continous mode Maglevation and Pulsatile Mode (Hydraulic)

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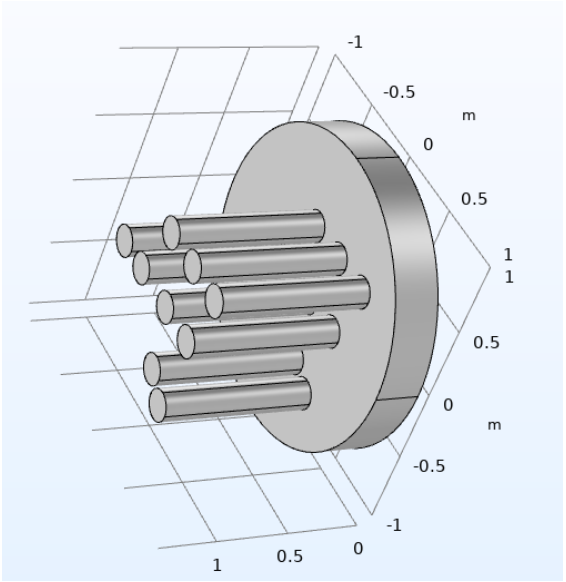

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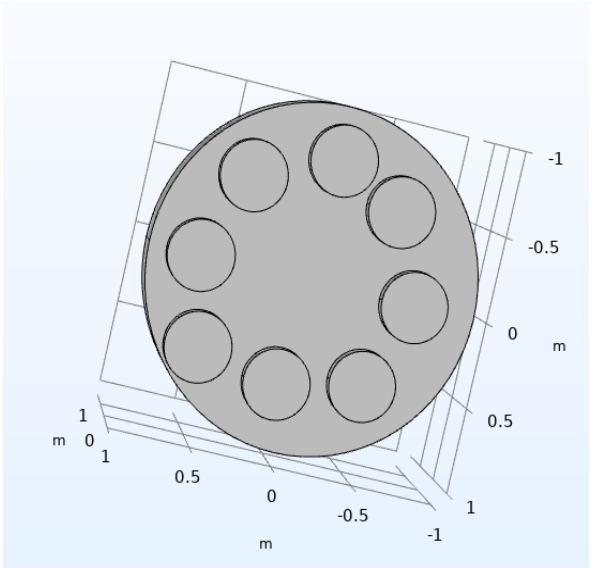

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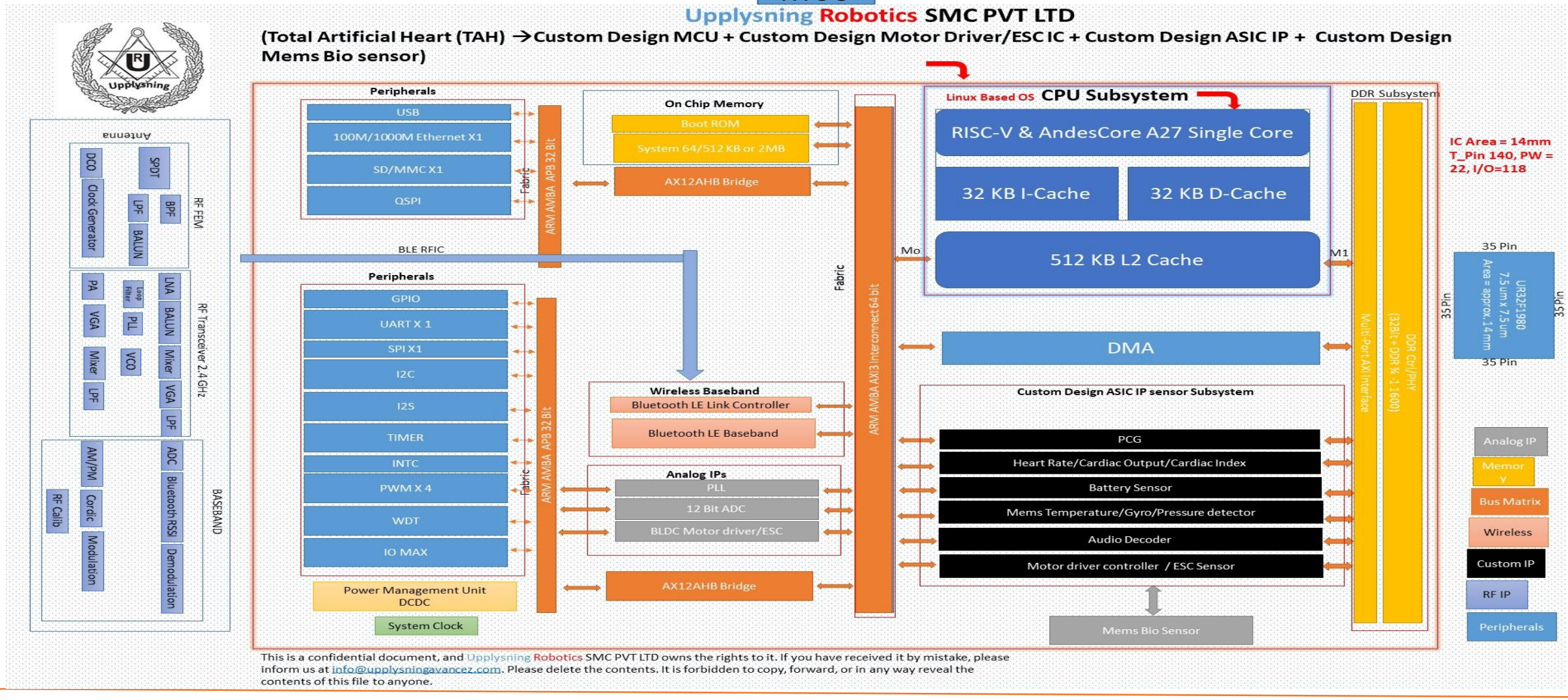
Upplysning Robotics SMC PVT LTD

MCU



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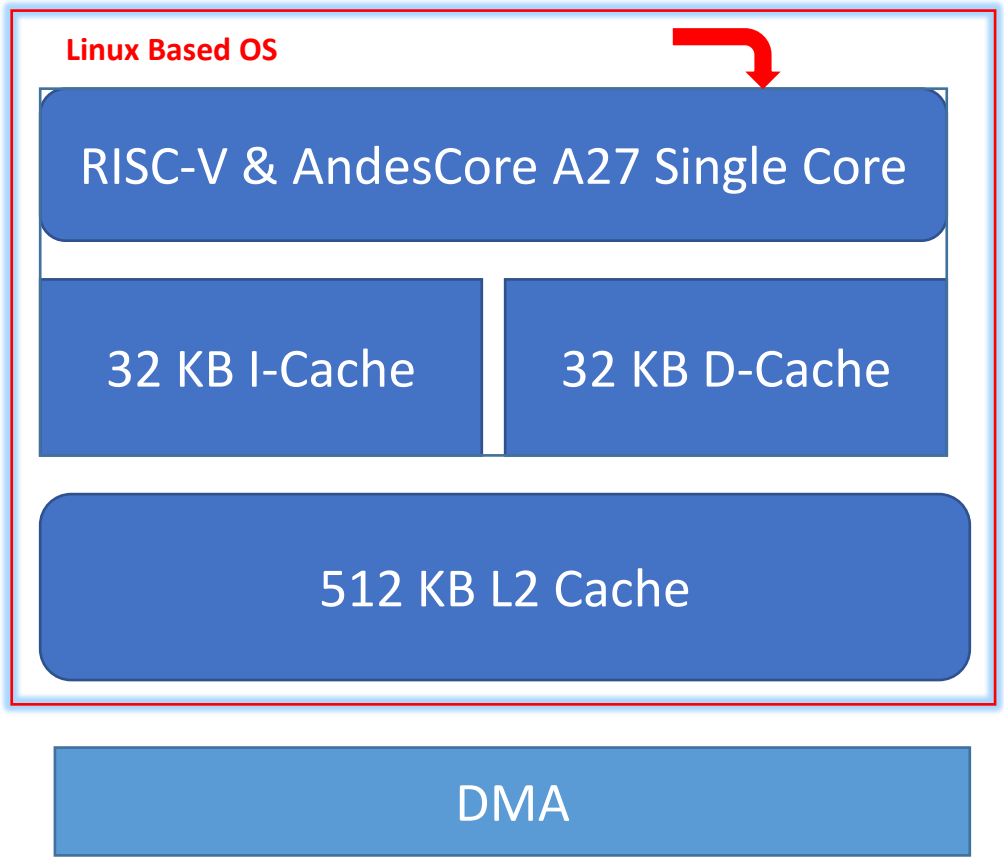
Processor / RAM / SDK/ Linux



On Chip Memory

Boot ROM

System 64/512 KB or 2MB

DDR Subsystem

Multi-Port AXI Interface

DDR Ctrl/PHY
(32Bit + DDR ¾ -1 1600)

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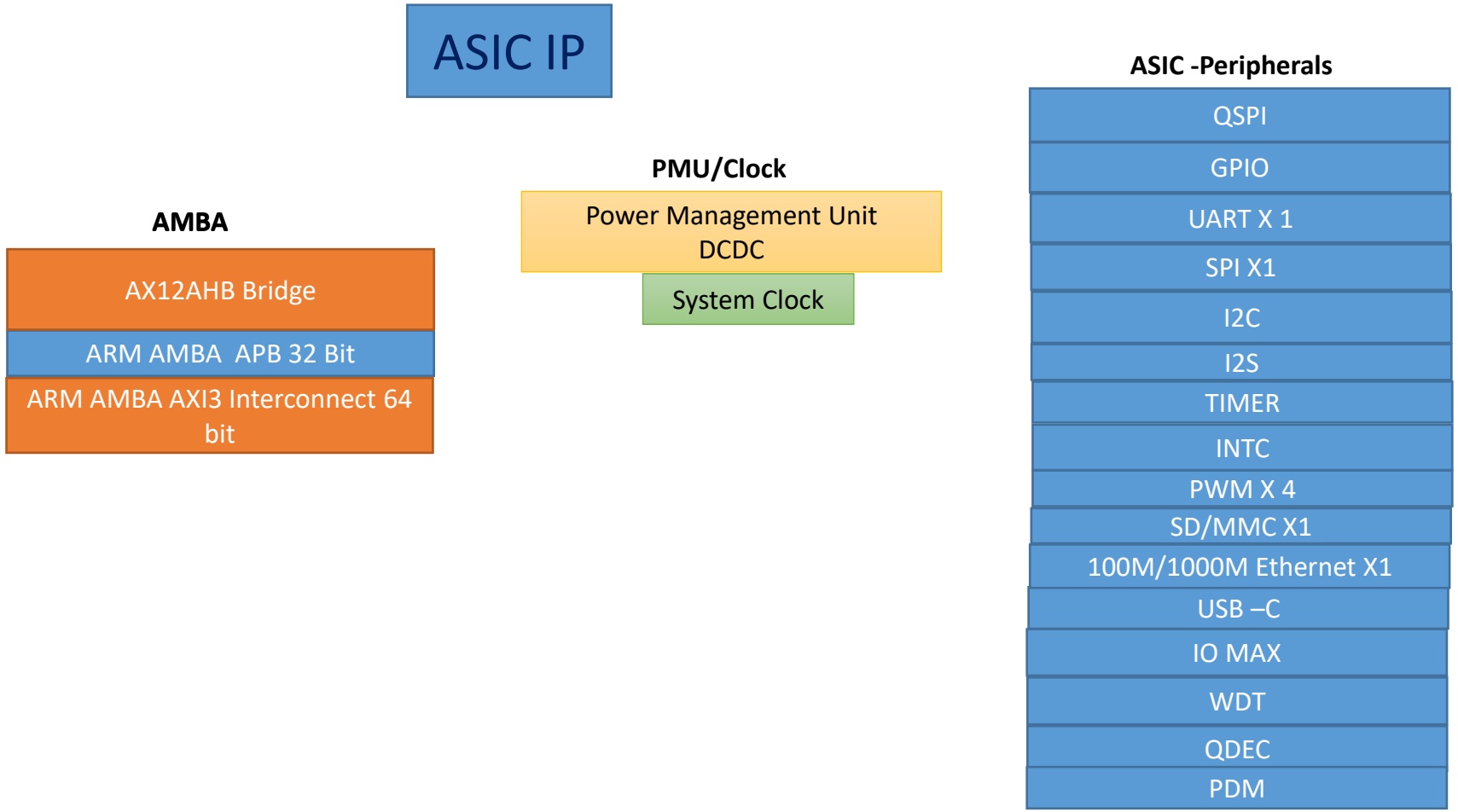
Upplysning Robotics SMC PVT LTD

DCDC
System Clock
AMBA Bus
UART
I2C
ISP
GPIO
Timer
INT
WDC
PWM
Timer
PDM
QDEC



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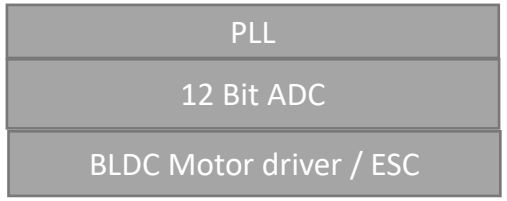
Upplysning Robotics SMC PVT LTD

Analog IP

Analog IPs



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BLE BaseBand

Wireless Baseband

Bluetooth LE Link Controller

Bluetooth LE Baseband

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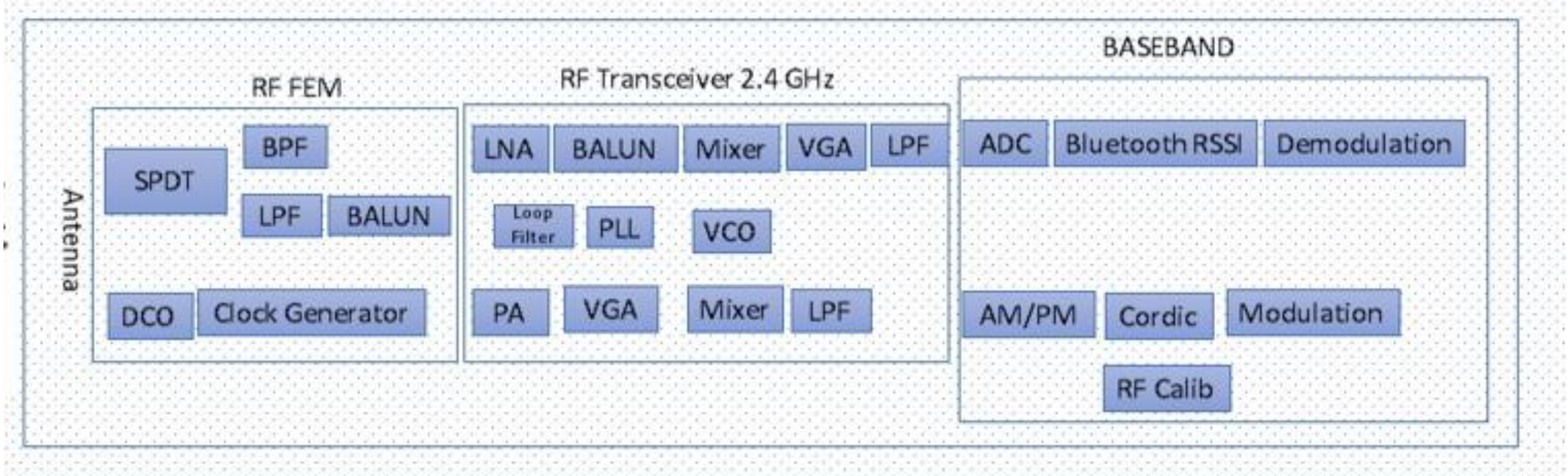
BLE -RFIC



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Upplysning Robotics SMC PVT LTD

Custom Design ASIC IP sensor Subsystem

PCG
Heart Rate/Cardiac Output/Cardiac Index
Battery Sensor
Mems Temperature/Gyro/Pressure
Audio Decoder
Motor driver controller / ESC

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Upplysning Robotics SMC PVT LTD

Mems Bio Sensor

- Heat / Temperature Sensor
- Movement / Gyro Sensor
- Pressure Sensor

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Upplysning Robotics SMC PVT LTD
MCU Specification

A one-of-a-kind platform for accelerating MCU integration inside the artificial heart.

Ready to use controller platform, configurable to your technology development

- Safety Critical Architecture suitable for a will be future Class III medical device by FDA
- Customizable Field Oriented Control
- Ease of integration of physiological and motor control algorithms
- 4 motor drives with status indicators (can customize for more)
- Programmable sensor inputs/outputs, LED status indicators & function switches
- Removable SD card for data logging
- Data streaming to the UR75 User Application
- Switching between UR75 and FPGA processor.
- Wireless Control of Motor RPM and Pulse Rate via Bluetooth Low Energy
- Integrated Motor Driver for Motor Control

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Upplysning Robotics SMC PVT LTD

MCU Specification

A one-of-a-kind platform for accelerating MCU integration inside the artificial heart.

Customizable user interface supports flexible testing with real-time feedback

- data visibility in real time
- Data logging from all available streams
- Configurable physiological & motor control parameter including pump speed, motor control gains, motor on/off, pulse rate, and pulse amplitude
- Customizable to view extra data streams
- Customizable dashboards to monitor tests and trials
- Event & fault extracts from the controller

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MCU Specification

Motor Control	
Motor Drive	2 Independent BLDC
Drive Power	Nominal 24 V Upton to 33.6V (to allow for future use of 8 series) Connected LiPo batteries ¬ 5 A continuous
Timer	Control RPM to control blood pressure level through controller , BLE

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Upplysning Robotics SMC PVT LTD
MCU Specification

Physical	
Physical dimension	250 x 212 x 110 mm
Configurable Indications	6 LEDs
Configurable Switches	3 Illuminated momentary switches
Fixed Indications	Motor Status x4, Power, Error, Computer Connected and FPGA bypass
	For Computer Connection
SD-Card	1 Removable Micro SD
Integrated Touch Screen	Colour
Operating Conditions	Room Temperature 20 – 25 C and laboratory humidity

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MCU Specification

Connectors

DC Power-Logic	12-34 VDC
Dc Power – Motor Drive	12-52 VDC
Motor Drive Connector	2 x 3 Phase

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MCU Specification

External Interfaces

Engineering Console	USB (Virtual Serial COMs) with isolation, OTS connector
Driveline	Customer specific during initial customization

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MCU Specification

Available for connection to expansion boards or front panel I/O connector during initial customization

I2C	1
SPI	1
GPIO uC (incl PWM)	8
GPIO FPGA	8
ADC uC	3
UART	2

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MCU Specification

Data Streaming	
Data Streaming channels	20
Data Streaming rate	100 Hz
Data Streaming resolution	16 bits

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MCU Specification

Batteries	
Internal/external batteries	Not Supported

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MCU Specification

Algorithm Support

Physiological Drive	Customisable @ 1kHz
Physiological & pump control algorithms	C/C++17 via code generation to C
FOC Algorithm	Sstandard, customizable with customer Simulink model via code generation

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MCU Specification

Microcontroller

Model	URRIC40
CPU	450 MHz RISC-V
DMIPS	1.66 DMIPS/MHz
Fixed Indications	Motor Status x4, Power, Error, Computer Connected and FPGA bypass
Memory	Flash 4096KB RAM 512KB
RAM	512KB
Safety features	ECC on RAM & FLASH
Realtime Clock	Yes

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MCU Specification

FPGA (hardware included but not activated in default configuration

Max Logic Elements	56K
Math Blocks	72
Embedded memory	1826 Kbit

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MCU Specification

BLE Protocol / RF	
BLE	2 Mbps / 1 Mbps
ANT	1 Mbps / 2 Mbps
TX Power	Programmable from +4 to -20 dBm in 4 dB steps
RX sensitivity	Bluetooth LE: -96 dBm at 1 Mbps -89 dBm at 2 Mbps ANT -93 dBm at 1 Mbps

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Upplysning Robotics SMC PVT LTD

MCU Specification

Analog

Analog Interface	12-bit, 200 ksps ADC low-power comparator general-purpose comparator
PLL	Min Freq 2.2 Max Freq 2.8 2.7 to 5 V
ESC Electronic Speed Controller	30A

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Upplysning Robotics SMC PVT LTD

MCU Specification

Custom design IP

PCG	Artificial heart Sounds waves detection
Heart Rate/Cardiac Output/Cardiac Index	Calculation Cardiac output/ Heart Rate
Battery Sensor	Battery Health, Total battery usages, backup battery connected
Mems Heat/Temperature Sensor	Body temperature sensor
Audio Decoder	Sounds wave of heart Decode and Anode
BLDC Motor driver controller / ESC/ Sensor	Control Motor speed RPM, Blood Pressure Control
Mems Pressure Sensor	Valves pressure sensor
Gyro Sensor	Body velocity

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Partners

ChipMotion 芯荣

IC·CAFE

Journal of Electronics and Mechanical circulatory support

华虹集团 HUAHONG GROUP

Aitemad Advanced Cardiovascular Research and Development Hospital

University of Science and Technology of China 1958

AIM

International society of Electronics And Mechanical Circulatory support

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Upplysning Robotics SMC PVT LTD

Upplysning Robotics Functionality

- 10 l/min on left and right for <10 watts
- Max output of 23l/min
- Pulsatile output if felt desirable
- Autonomous moment-to-moment balancing between Systemic and pulmonary circulation
- Magnetic levitation- no mechanical wear
- One moving part-mechanistic simplicity
- Wide blood gaps (4mm radial) so no hemolysis
- Programed left-to-right shunt for venous emboli protection
- 6cm x 6cm – smallest contained TAH
- The MCU chip build-in on TAH, more compact

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Upplysning Robotics SMC PVT LTD

In Summary Upplysning Robotics TAH

- Continuous flow blood pumps with Pulsate option will be well suited for integration Into the next generation of total artificial heart
- If some degree of pulsatility is desirable, it can readily be achieved With a rotary pump
- The decreased size, marked reduction in mechanistic complexity, improved power Efficiency, and dramatic improvements in durability of rotary blood Pumps should be beneficial and also decrease in controller size.
- The First practical mechanical replacement for the failing human Heart will be continuous flow & Hydraulic for Pulsates…
- The MCU will be implant inside human body to monitor which lack BIVACOR

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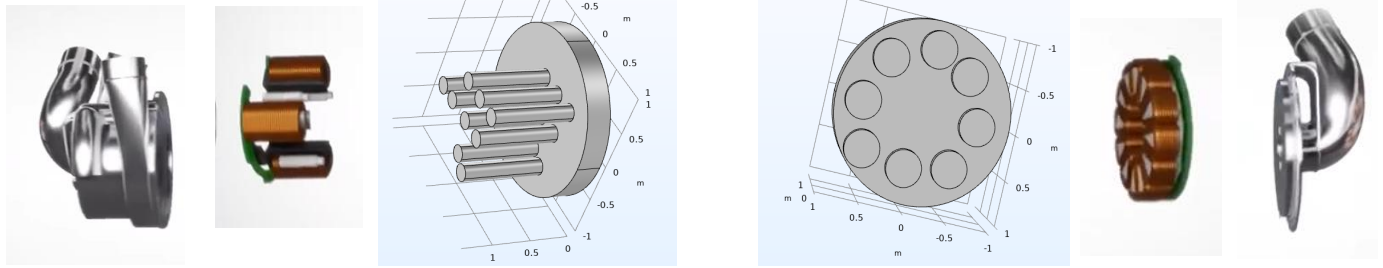
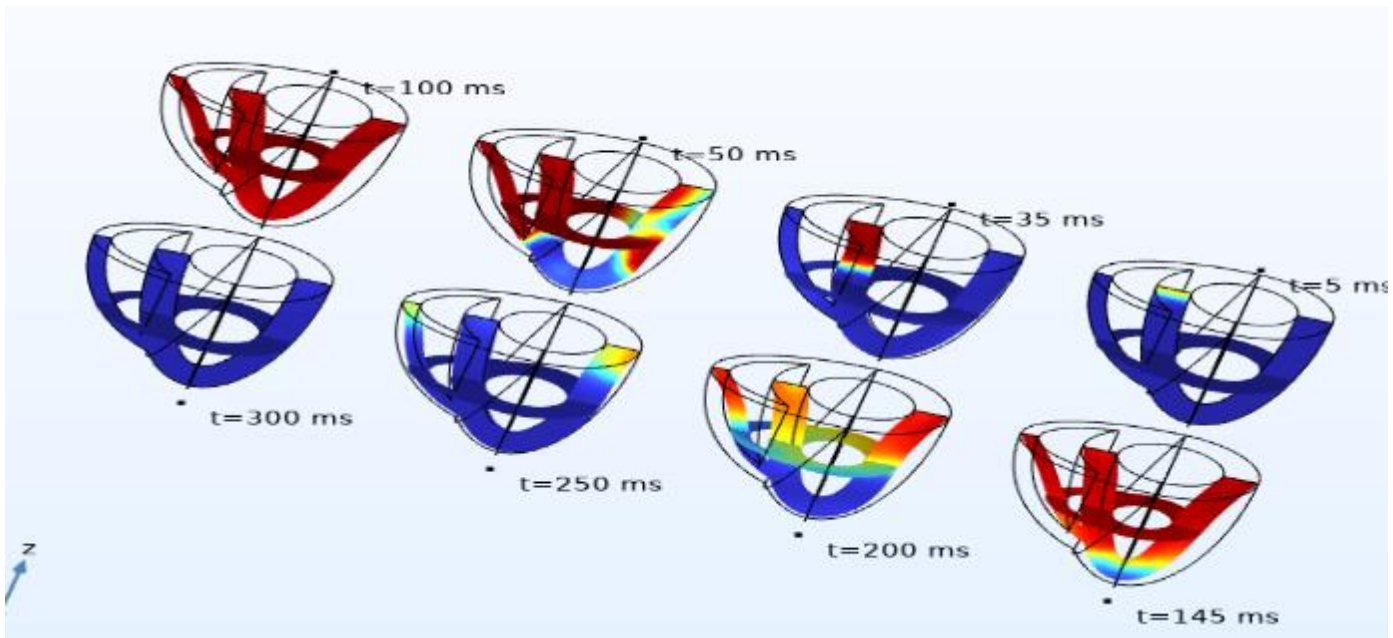
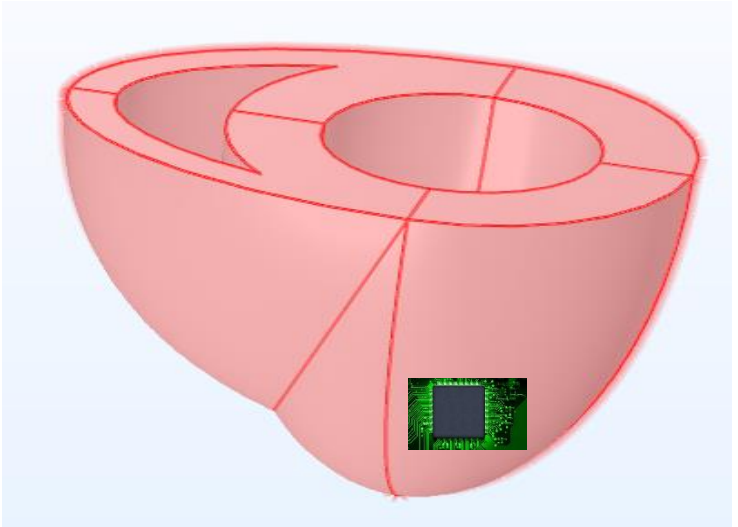
Q & A

Upplysning Robotics SMC PVT LTD







Thank You

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