Dwight Dumay
Klinisch Perfusionist, EKP
24 september 2024

Erasmus MC
Universitair Medisch Centrum Rotterdam

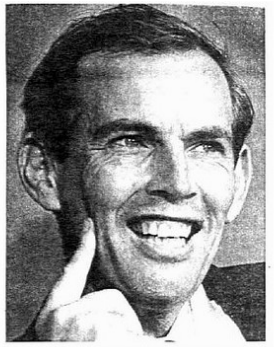
1967 1e succesvolle harttransplantatie, Zuid Afrika, Dr. Barnard

Moments in History

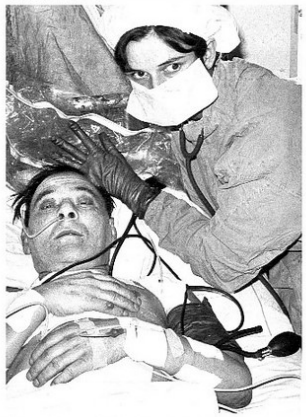
In December, 1967, a young woman, Denise Darvall, was walking across a street in Woodstock to buy a cake when a car struck her. She died in Groote Schuur Hospital and in doing so achieved immortality by becoming the world's first heart donor when Christiaan Neethling Barnard transferred her heart into the chest of Louis Washkansky.

Cape Town has been witness to many historic moments since the day Van Riebeeck anchored in Table Bay. Few, if any, brought more limelight to the city than the heart transplant. For the surgeon, Dr Barnard, soon to be a household name throughout the world, "the heart is merely a pump". But for those who equated the heart with love and death, the transplant seemed close to a miracle.

"Mr Louis Washkansky, the 55-year-old Cape Town man whose life is being sustained today by the heart of a dead 25-year-old woman after the world's first successful heart transplant yesterday, is conscious in Groote Schuur Hospital and in a satisfactory condition." Monday, 4th December 1967

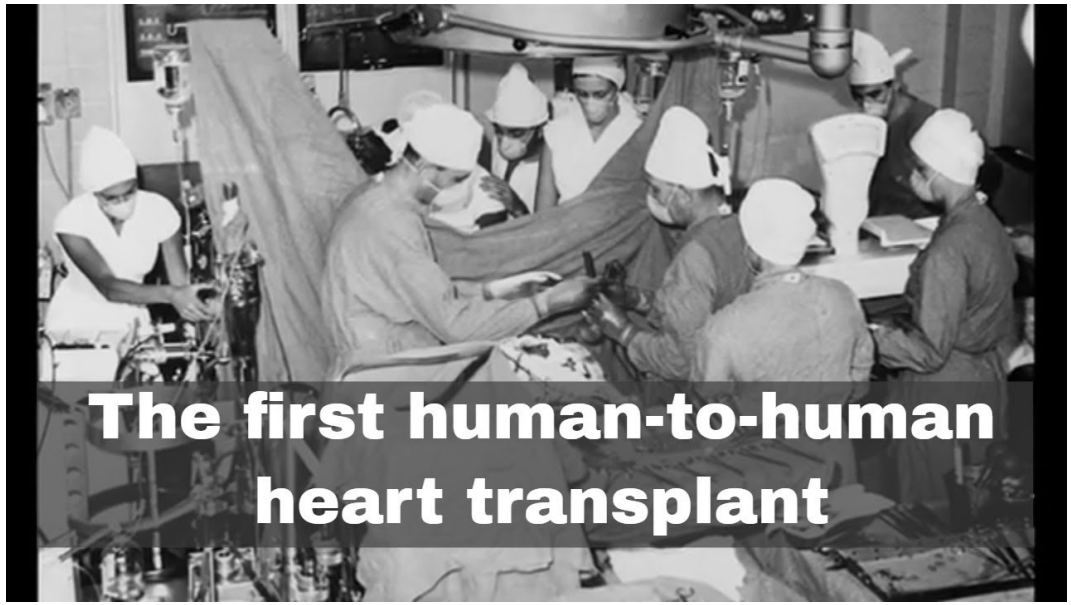


Professor Chris Barnard, leader of the heart-transplant team, in a characteristic pose during one of his many press conferences.



First close-up photograph to be taken of Mr Louis Washkansky, who underwent the world's first heart-transplant operation, was taken by a surgeon using an *Argus* photographer's camera at Groote Schuur Hospital. Mr Washkansky, whose condition was given as good, is being assisted to breathe by a respirator. 4.12.1967

1984 1e succesvolle Harttransplantatie in Nederland door chirurgen uit Rotterdam en Leiden



Erasmus MC

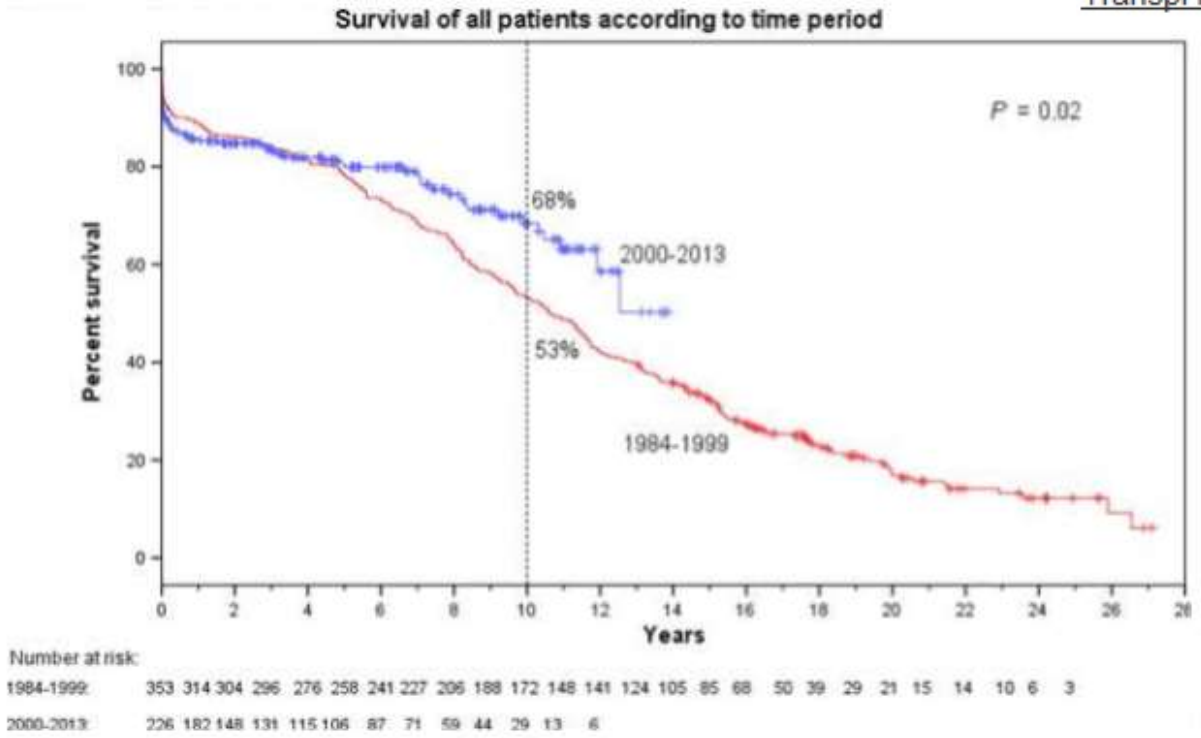
Eindstadium hartfalen; survival en kwaliteit van leven

Long-term outcome of Dutch heart transplant patients

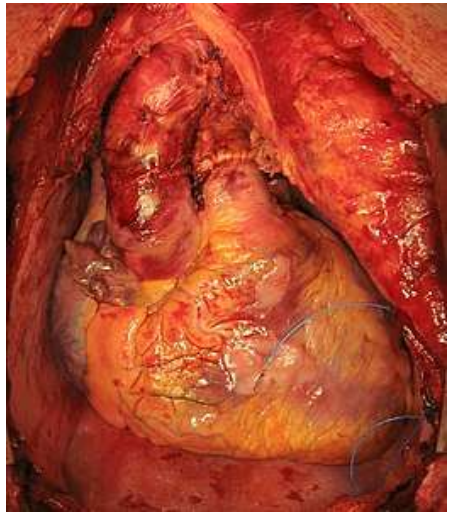
Improved long-term survival in Dutch heart transplant patients despite increasing donor age: the Rotterdam experience

Laurien E. Zijlstra,[1] Alina A. Constantinescu,[1] Olivier Manintveld,[1] Ozcan Birim,[2] Dennis A. Hesselink,[3] Robert van Thiel,[4] Ron van Domburg,[5] Aggie H. M. Balk[1] and Kadir Caliskan[1]

Transpl Int. 2015 Aug;28(8):962-71. doi: 10.1111/tri.12503.



TRANSPLANT INTERNATIONAL



Erasmus MC

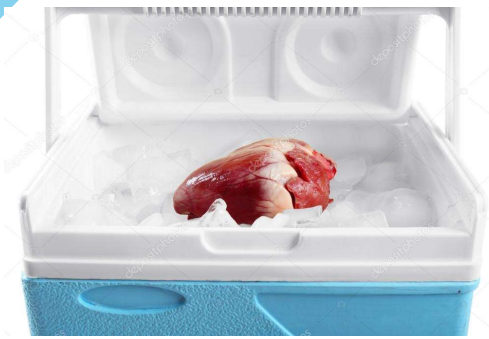
Wachtlijst harttransplantatie

* Wegens te kleine aantallen, is de filter op wachtlijst van de dunne darm op maandniveau weggelaten.

Laatst bijgewerkt: 19-09-2024

Erasmus MC

Preserveren van het hart



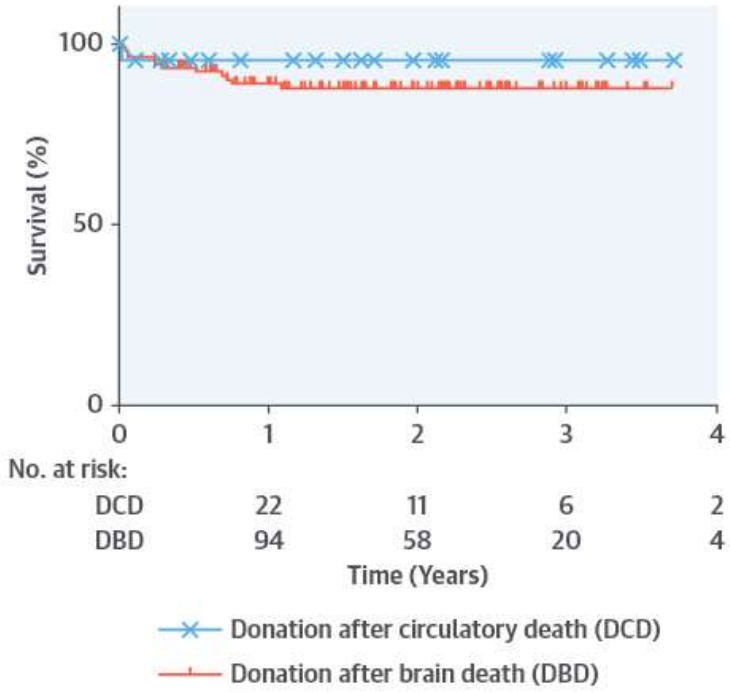
- Ernstig tekort aan donorharten (40 per jaar)
- Alleen DBD donoren
    - Preservatie door koude ischemie met behulp van cardioplegie. *maximale veilige tijd 5u ischemie*

- Ontwikkeling nieuwe cold storage technieken
    - *Nadeel koud cardiopleeg hart*

- **Sinds 2010 ontwikkeling Ex-vivo hart perfusie**
    - *Mogelijkheid om harten bij DCD procedures te gebruiken om zodoende de donorpopulatie te vergroten (10-20% meer transplantaties)*

Erasmus MC

CENTRAL ILLUSTRATION **Recipient Survival After Cardiac Transplantation Using Donation After Circulatory Death Versus Donation After Brain Death**



Chew, H.C. et al. J Am Coll Cardiol. 2019;73(12):1447-59.

This survival curve illustrates the excellent survival of donation after circulatory death (DCD) hearts at up to 4 years post transplantation when compared to the institutional donation after brain death (DBD) cohort over the same time period.

CONCLUSIONS

DCD heart transplantation is still in its infancy; however, early outcomes support DCD donor hearts as a safe source to address current organ shortages. In

The utilization of DCD hearts in our unit has led to a 15% increase in heart transplant activity per annum since its implementation in 2014.

Erasmus MC

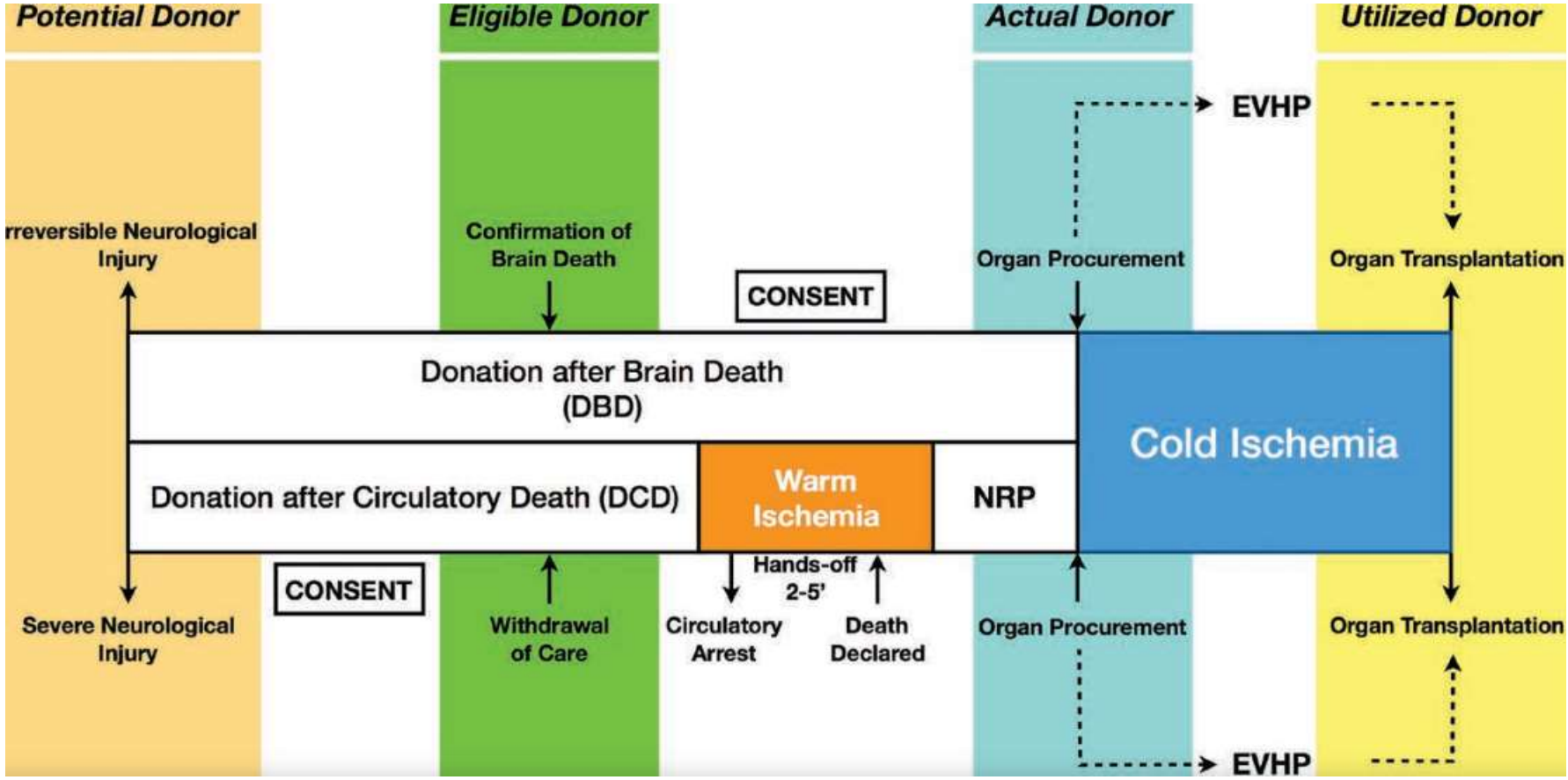
Ex-vivo hartperfusie tbv DCD hart donatie

2015	2018	2020	2021
Cambridge Symposium	Dutch national consensus meeting	Reimbursement government Covid	Training Start program (march 15th)

Data Niels van der Kaaij en NTS

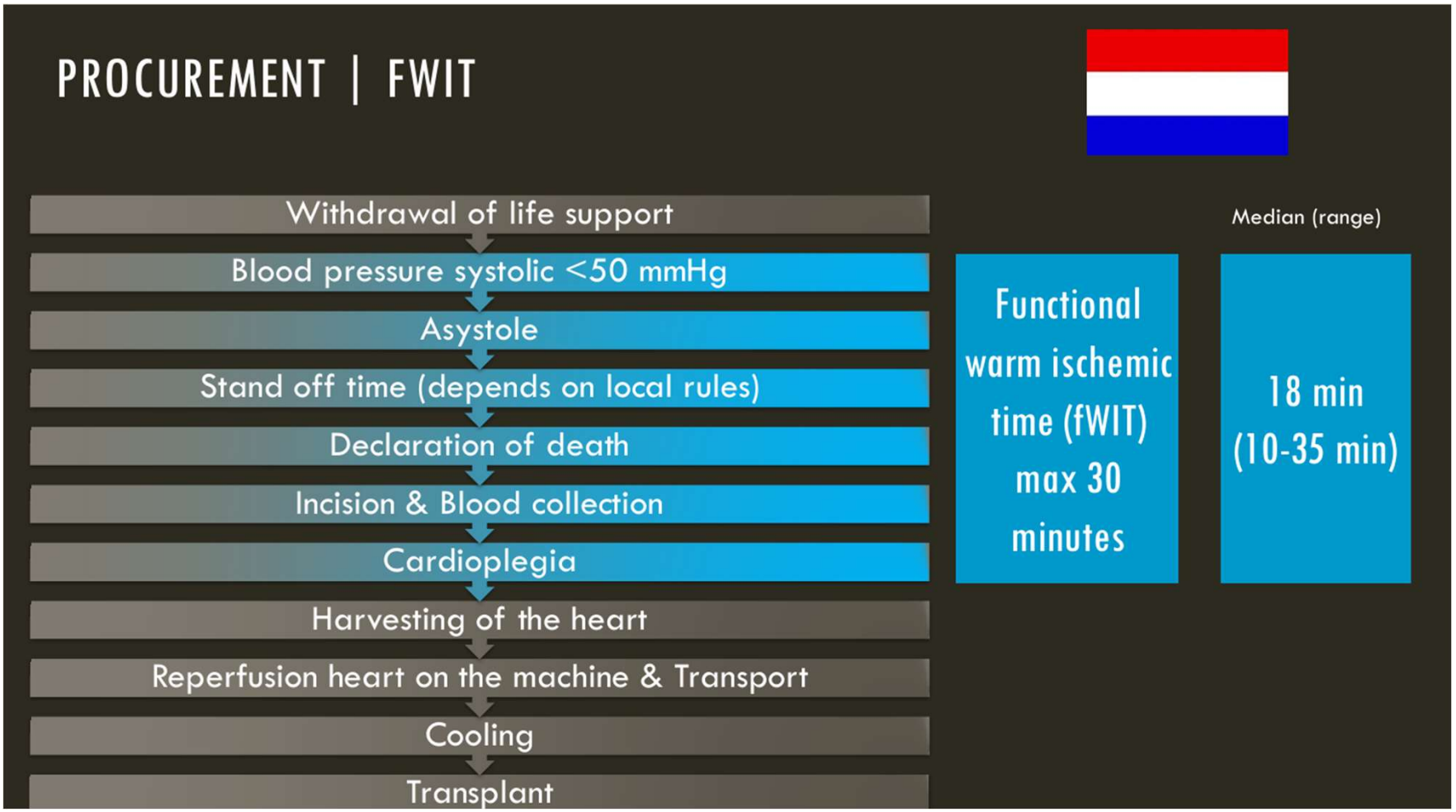
Erasmus MC

Verschil DBD vs DCD



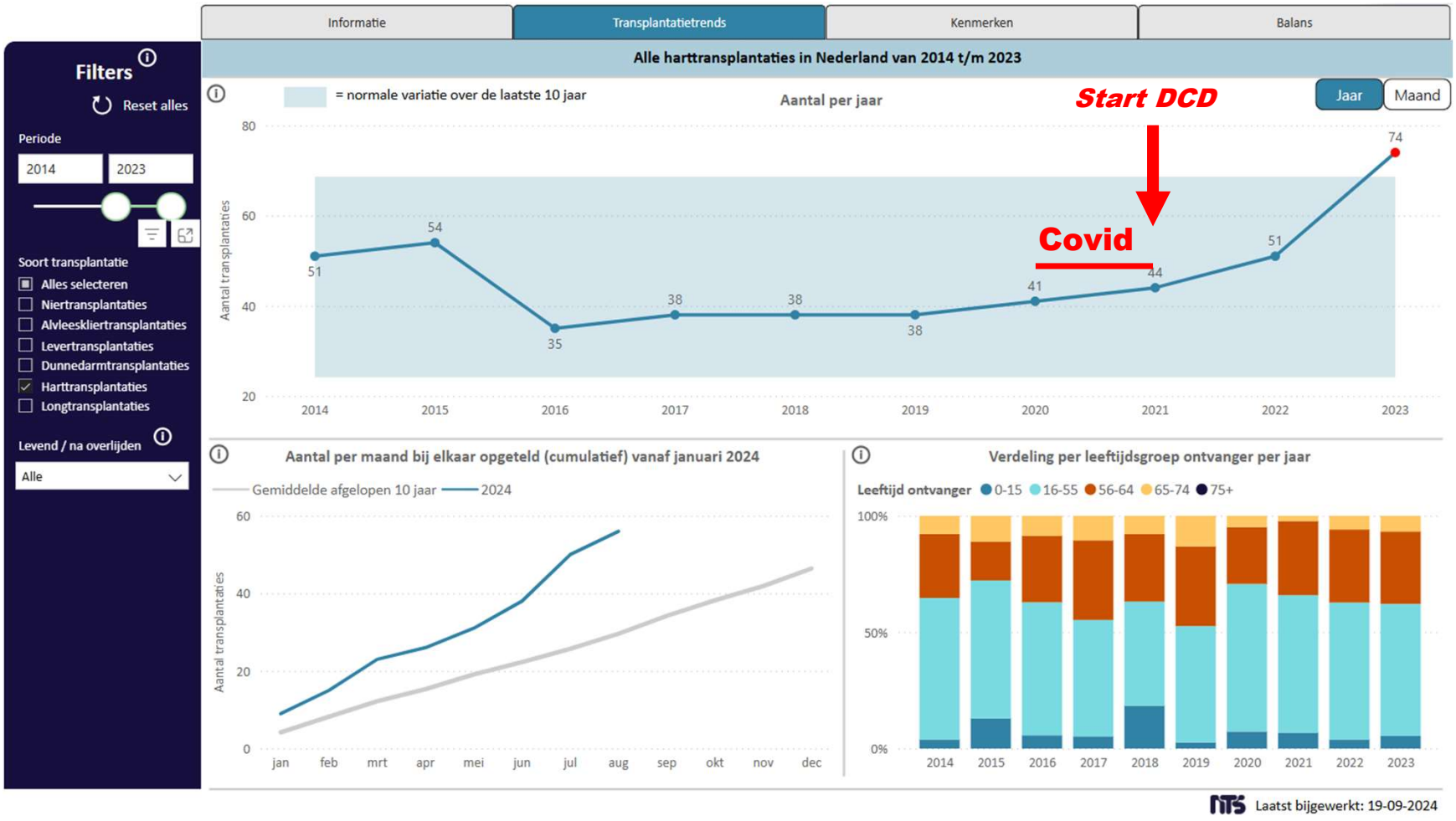
Erasmus MC

PROCUREMENT | FWIT



Erasmus MC

Aantal harttransplantatie per jaar



Erasmus MC

Uitstroom 2021 - 2023

Filters

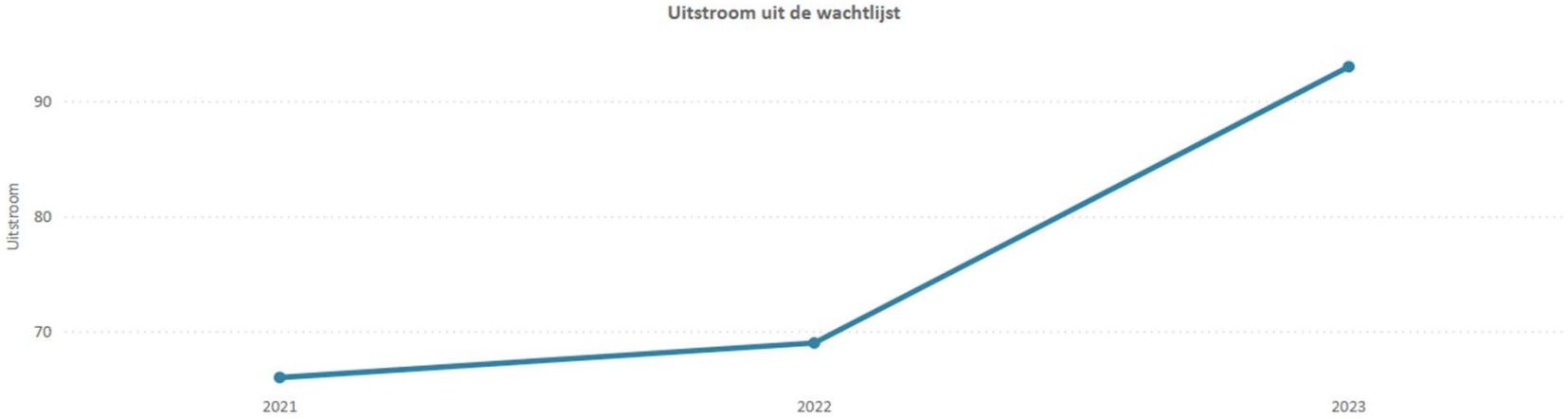
Periode

2021 — 2023

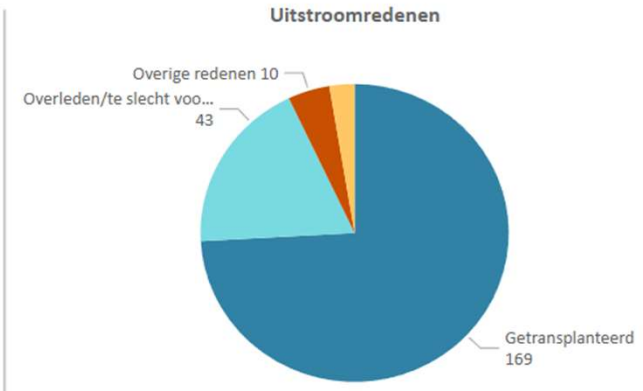
Orgaan

- [ ] Nier
- [ ] Alvleesklier
- [ ] Lever
- [ ] Dunne darm
- [x] Hart
- [ ] Long

Alle patiënten op de totale hartwachtlijst in Nederland in de jaren 2021 t/m 2023



Reden verwijdering van wachtlijst	Hart	Totaal
Getransplanteerd	**169**	**169**
Hersteld	**6**	**6**
Overleden/te slecht voor transplantatie	**43**	**43**
Overleden	25	**25**
Te slecht voor transplantatie	18	**18**
Overige redenen	**10**	**10**
Op verzoek van arts	6	**6**
Op verzoek van patiënt	2	**2**
Overig	2	**2**
Totaal	**228**	**228**



Laatst bijgewerkt: 19-09-2024

Erasmus MC

Voorwaarden voor DCD procedure

1. Donor overlijdt binnen 2 uur
2. Functioneel warme ischemie tijd *(Systole < 50mmHg)* max < 30 min
3. Afstand IC naar OK niet te groot
4. Chirurg en perfusionist zijn op elkaar ingespeeld
5. Uitname team en implanterend team stemmen goed af (met name bij complexe ontvangers)

Alles is bedoeld om hart zo snel mogelijk weer kloppend te hebben buiten het lichaam.

Beoordeling op pomp: contracties en lactaat verbruik

Logistiek rondom een DCD procedure

Samenwerking:
NTS
- **UMC Utrecht**
- **UMC Groningen**
- **Erasmus MC**

Elk ziekenhuis eigen system, disposables en bloedgas analyse apparatuur

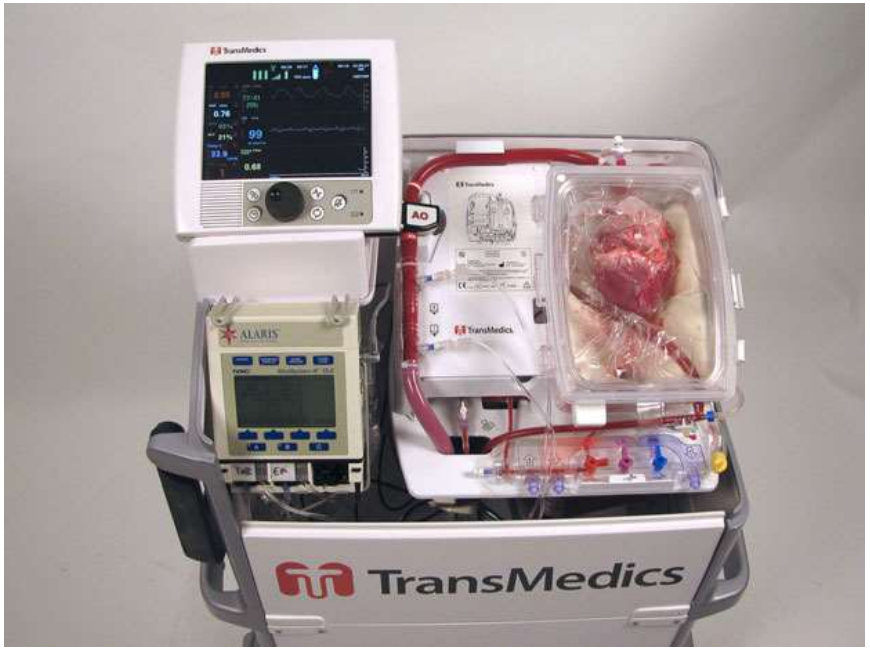
- **Oproep DCD 6-8u tevoren**
- **Transport materiaal + personeel naar donor-zkh**

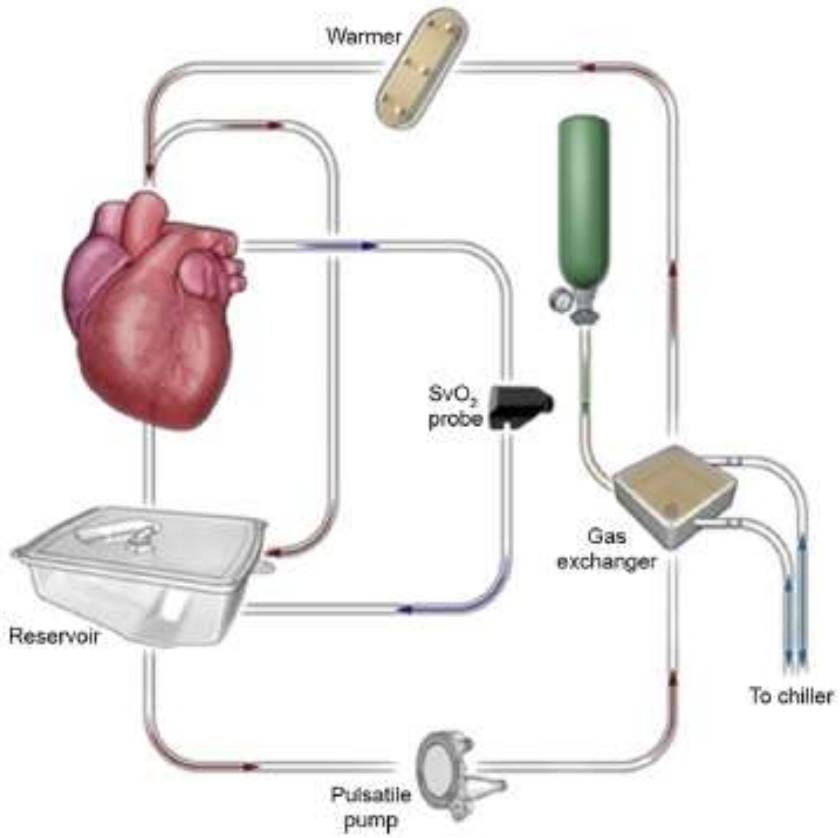
Erasmus MC

Voorbereiding voor Switch Off

Erasmus MC

OCS Heart





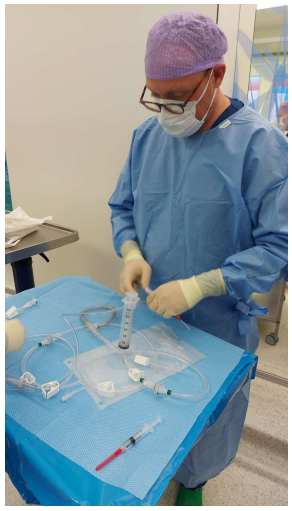
Kosten disposable 48.000,-

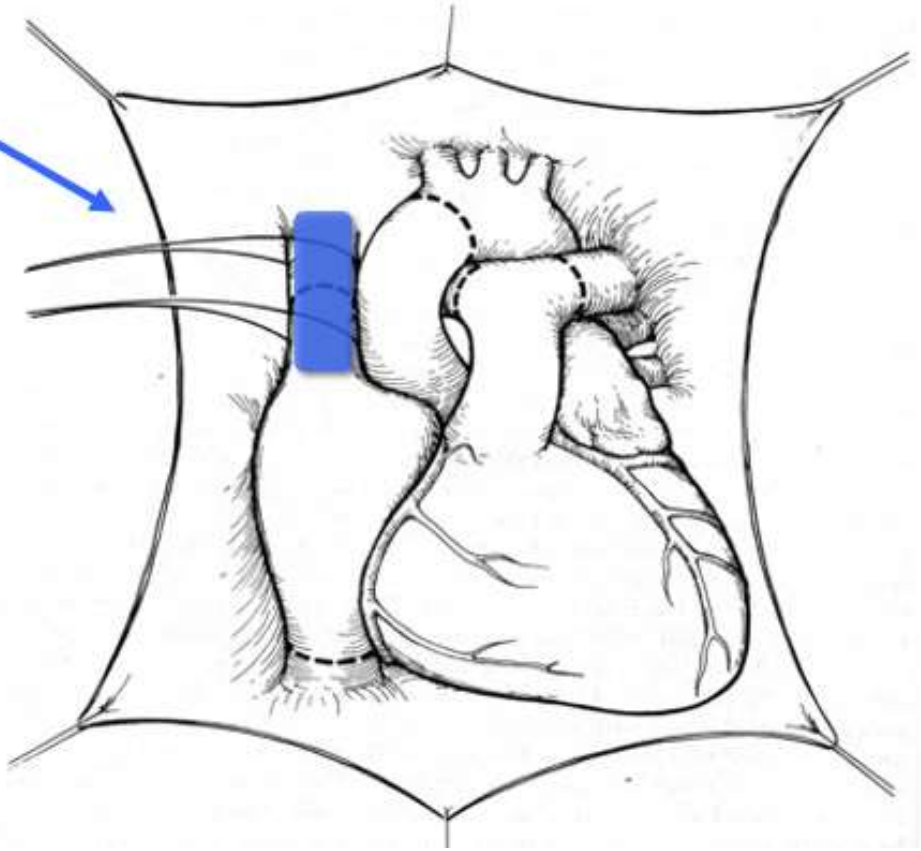
Erasmus MC

Blood Collection Sites

Blood Collection Cannulation Site

Use 34F single stage venous cannula

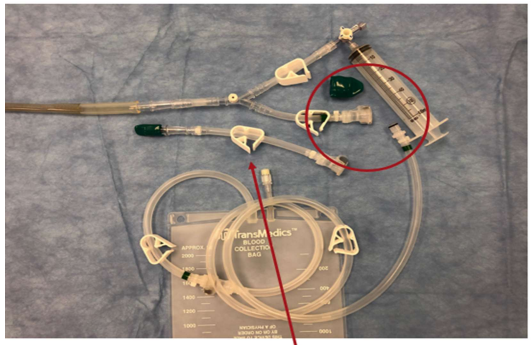


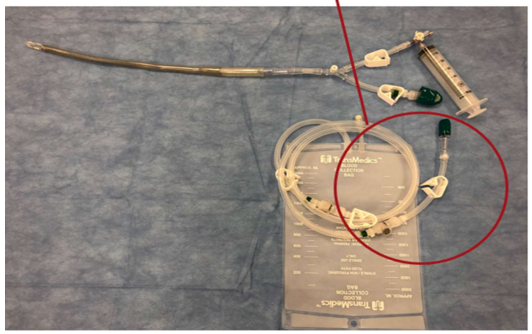


1200-1500mL of blood collected in 60-90 seconds immediately prior to donor cross clamp

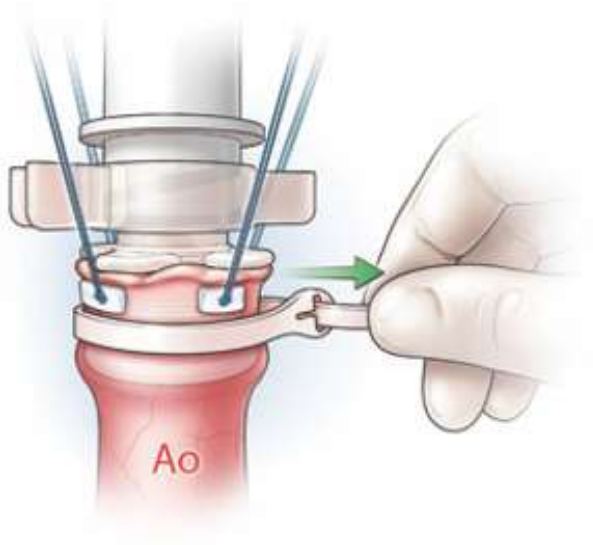
Erasmus MC

Bloedafname vanuit rechter atrium





Aortic Cannulation

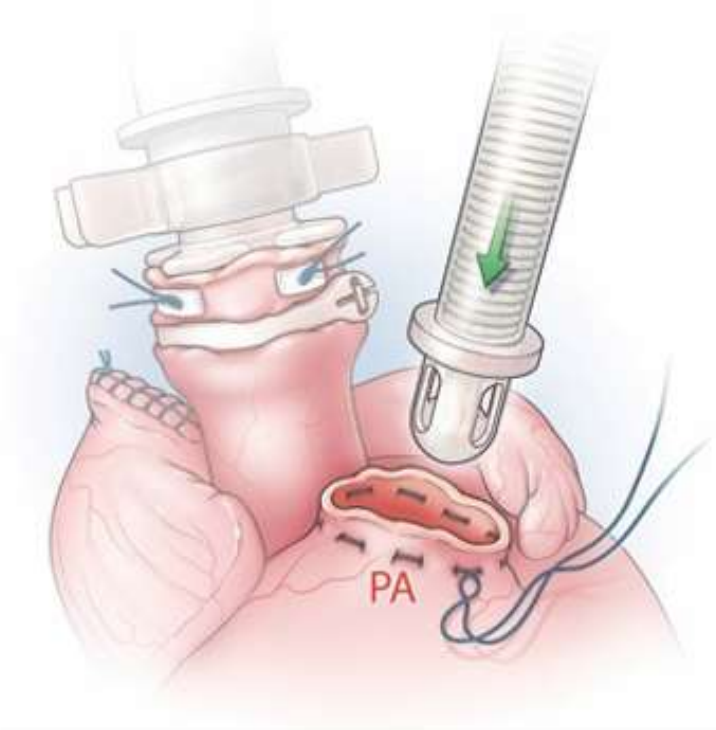


Place the appropriate sized aortic tip cannula after attaching it to the aortic tip holder

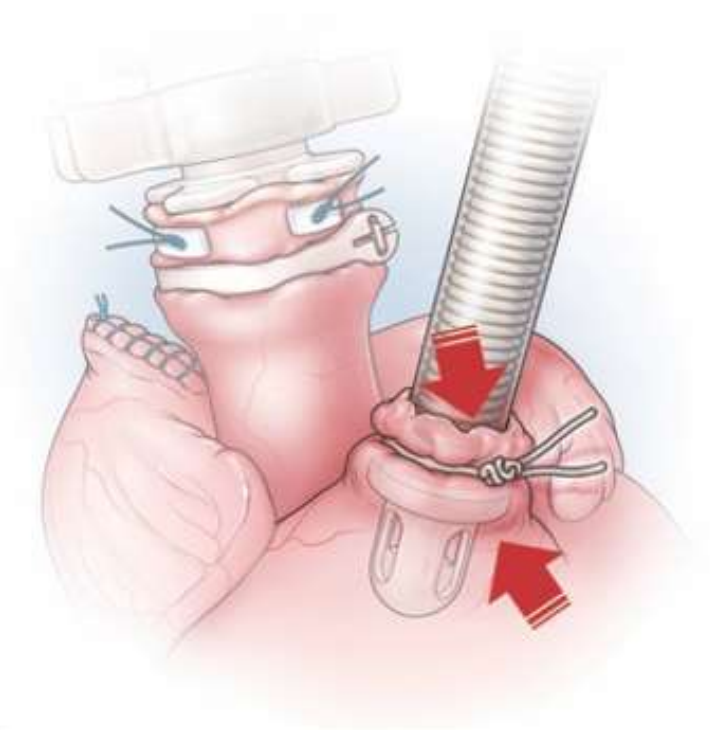
Use the pledgets to pull the aortic edges upwards to cover the entire collar of the cannula tip

Apply a single cable tie below the pledgets and secure it with the cable tensioning tool

Pulmonary Artery Cannulation



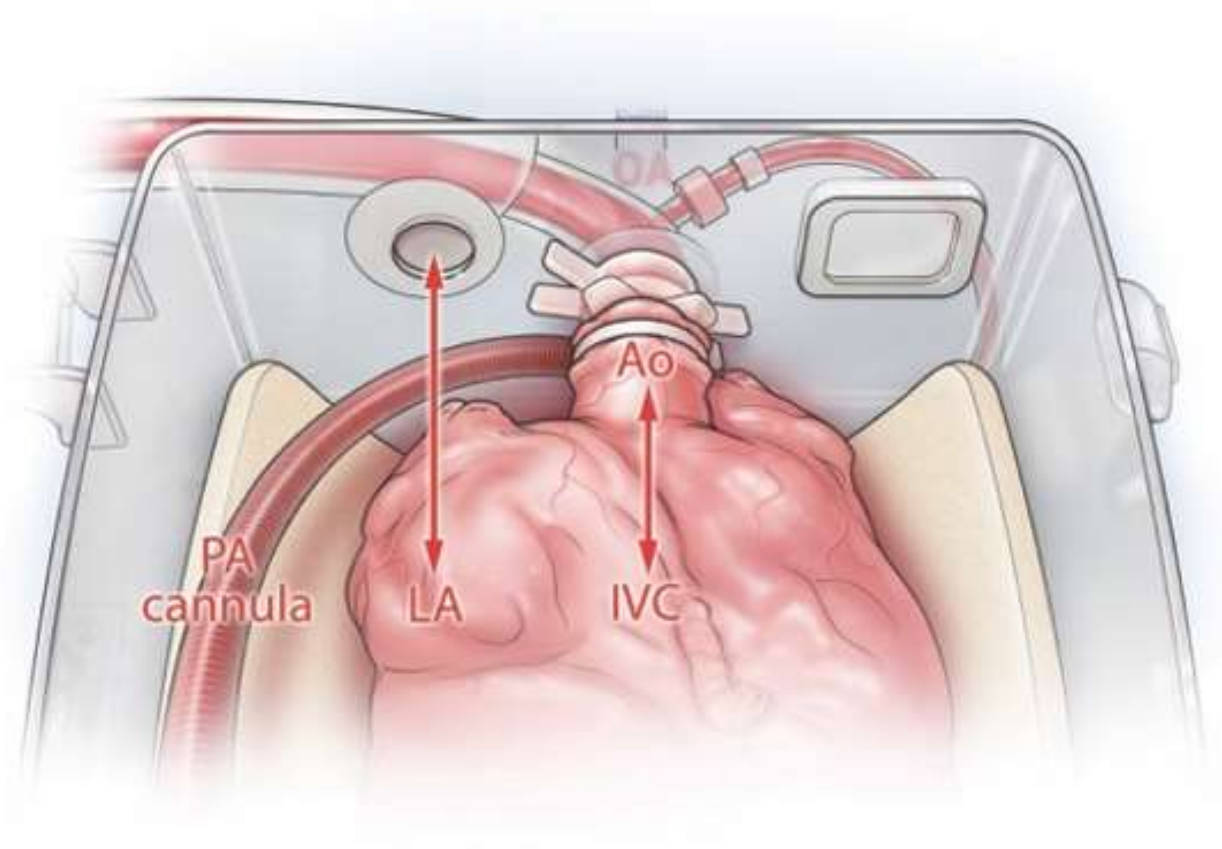
Use a prolene purse string suture to secure the PA cannula



Further secure with umbilical tape.
Ensure cannula does not interfere with PA valve motion.

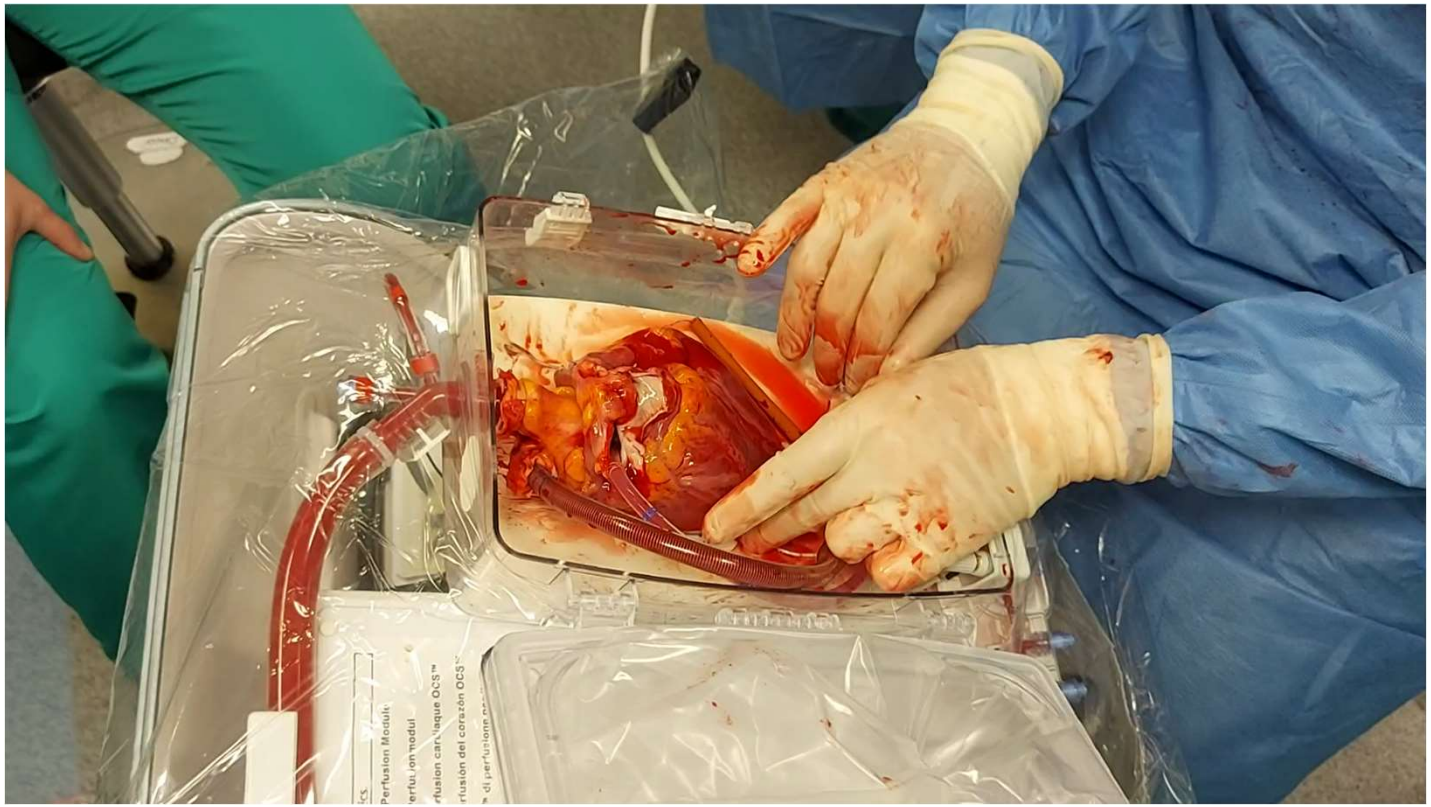
Erasmus MC

Heart Alignment

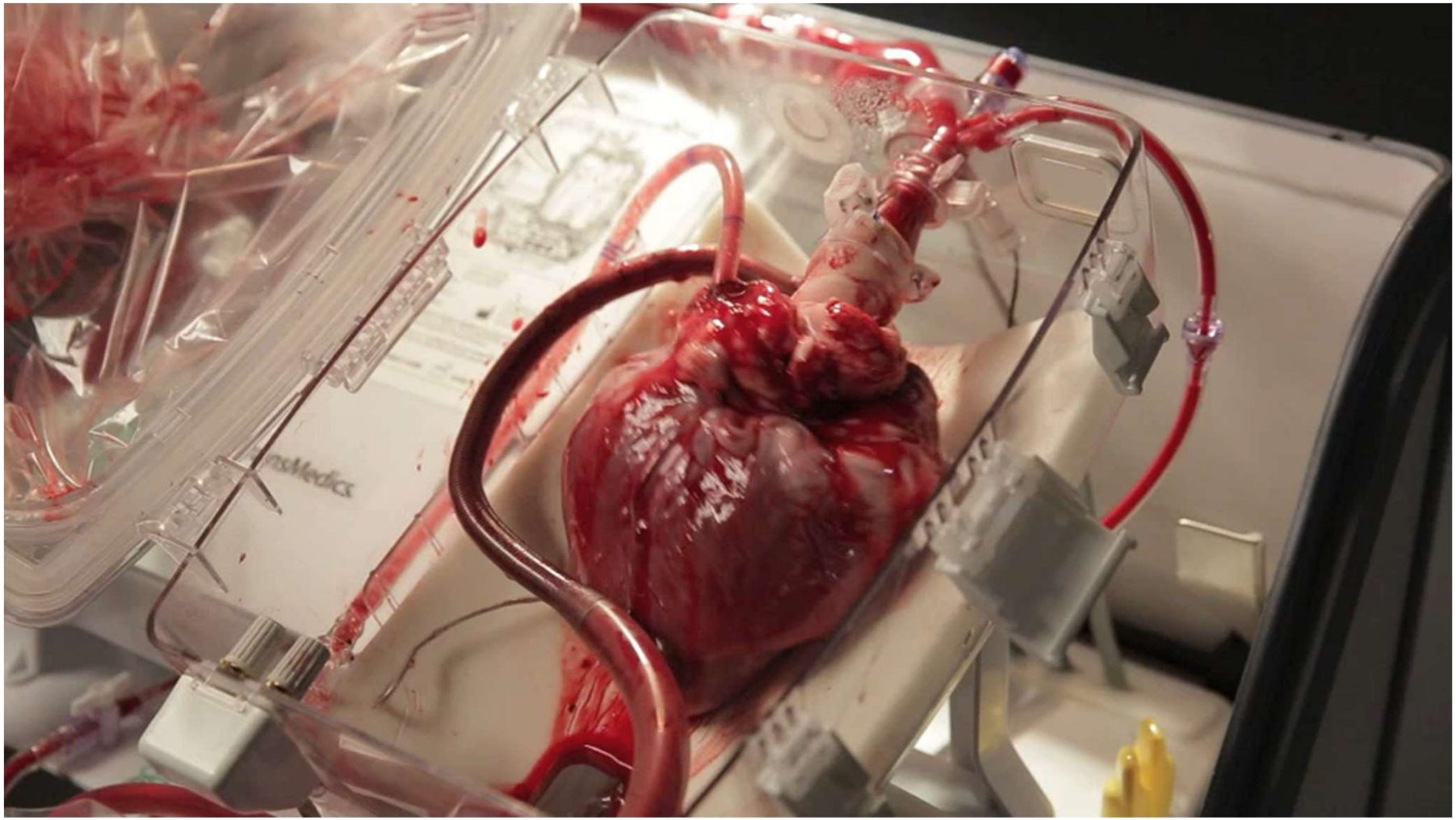


Erasmus MC

Erasmus MC



Erasmus MC



Erasmus MC

Monitored Parameters on OCS

Hemodynamic Parameters

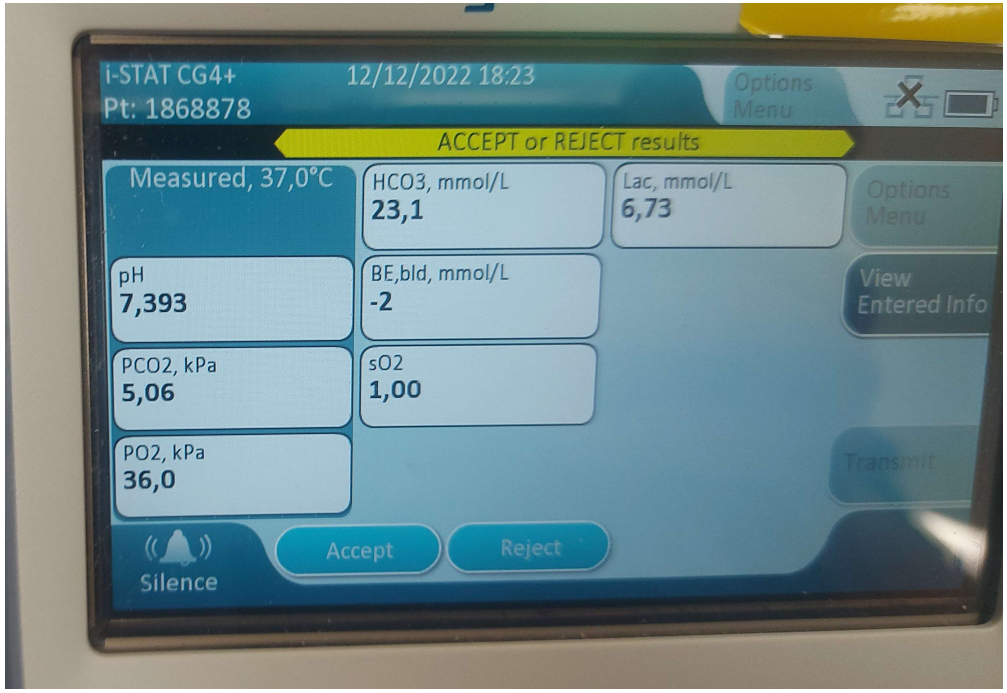
- *Coronary Blood Flow (CF)*
- *Aortic Pressure (AOP)*
- *Heart Rate (HR)*
- *Aortic Blood Flow (AOF)*

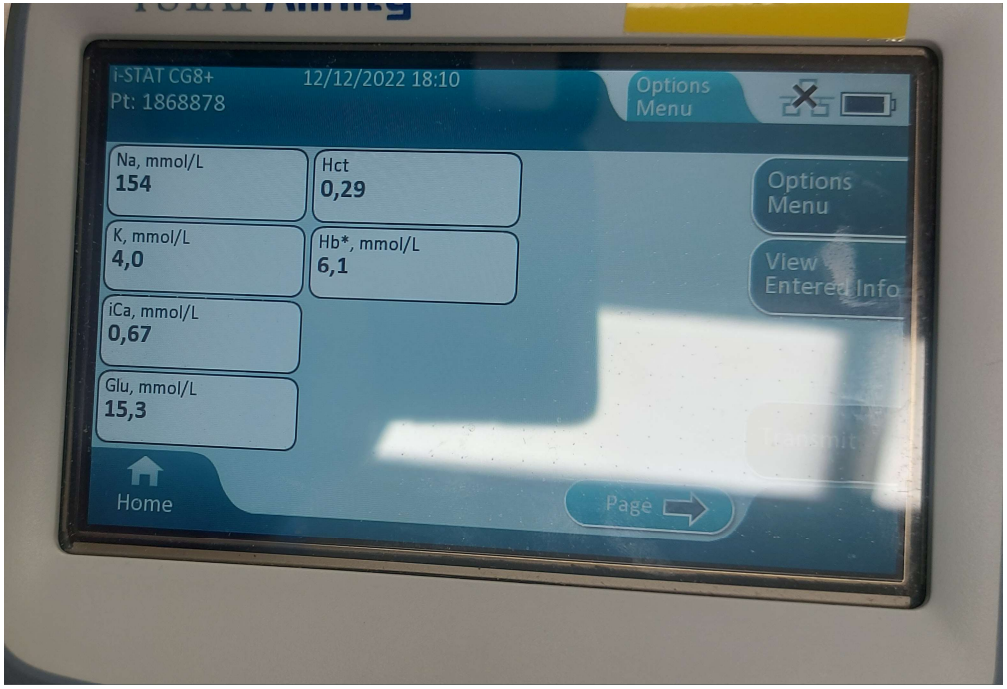
Metabolic Parameters

- *Serial lactate levels*
- *Serial Arterial – Venous lactate differential*
- *Coronary sinus saturation*
- *Temperature*

Erasmus MC

I-stat bloedgas en elektrolyten analyse





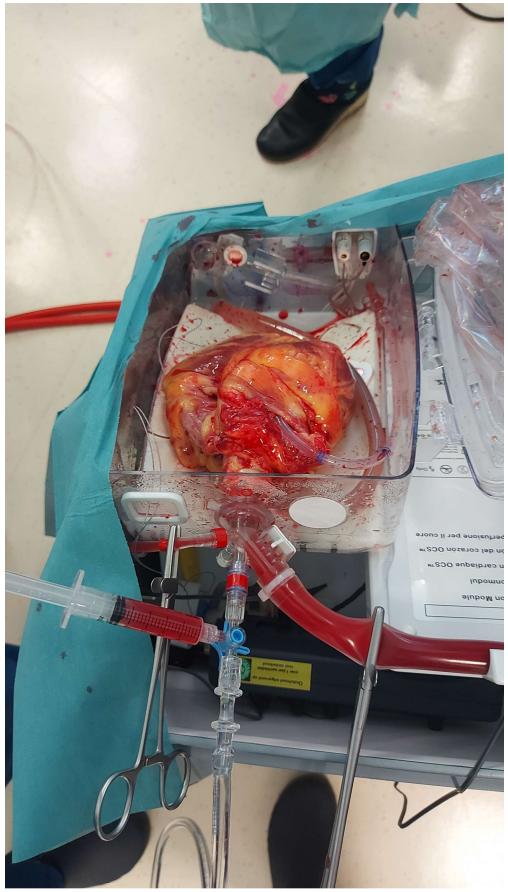
Erasmus MC

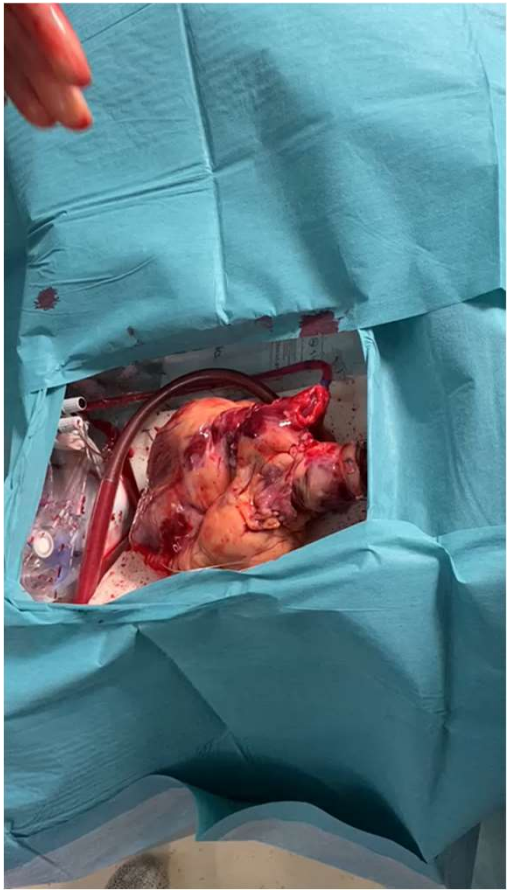
Sync modus voor verbeterde coronair perfusie

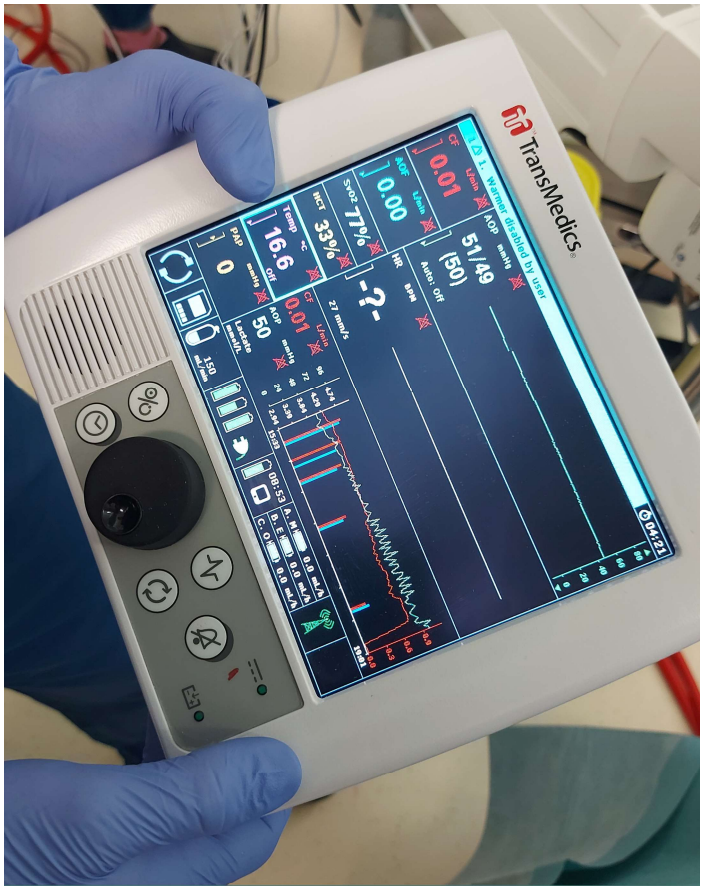
Transport naar transplantatie ziekenhuis

Erasmus MC

Hart opnieuw stoppen

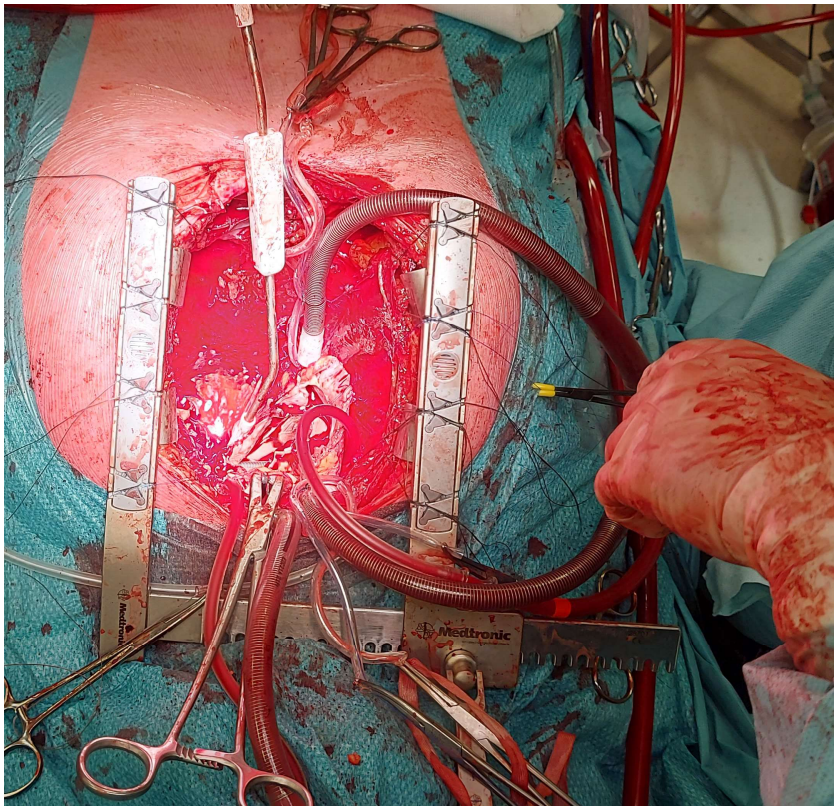


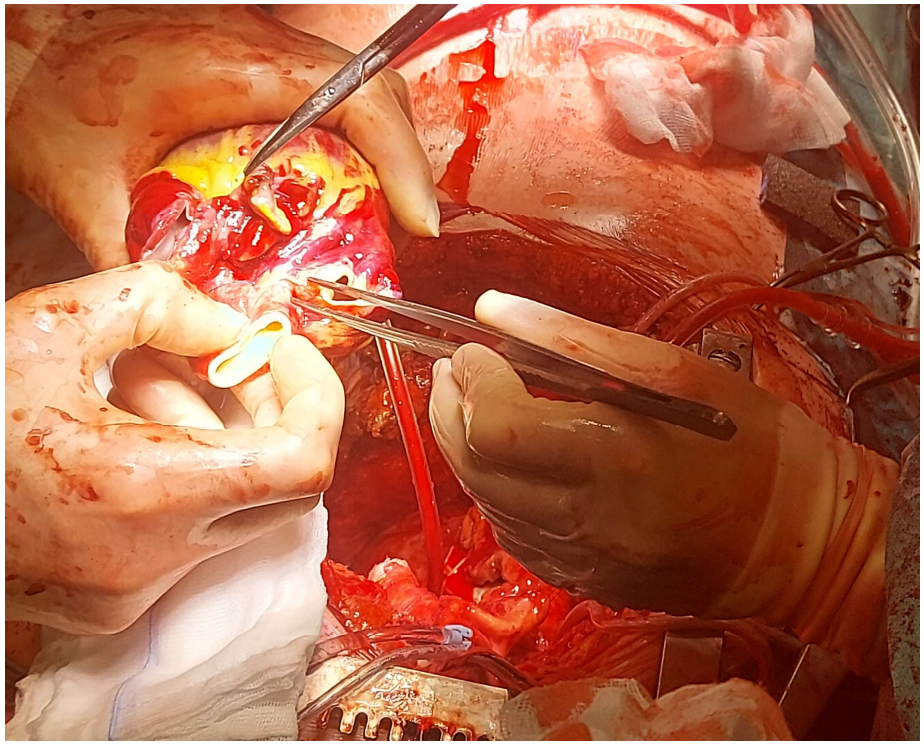




Erasmus MC

Oude hart eruit en nieuwe erin





Erasmus MC

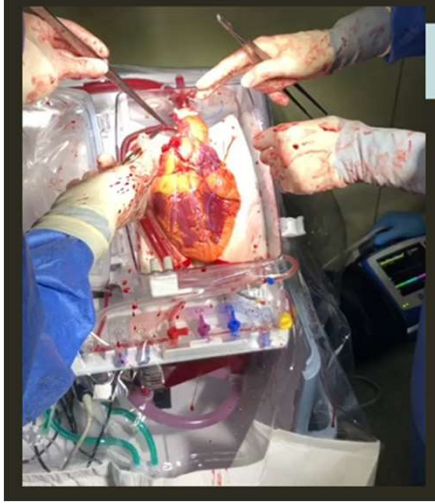
Nederlandse resultaten tot nu

DCD HEART DONATION AND TRANSPLANTATION 21/3/2021- 01/07/2024

136 Donors attended

15 did not progress within 120 minutes

1 Functional warm ischemic time >30 minutes



120 Direct Procurement and Perfusion

16 Hearts rejected

104 Transplanted (Retrieval rate 76%)

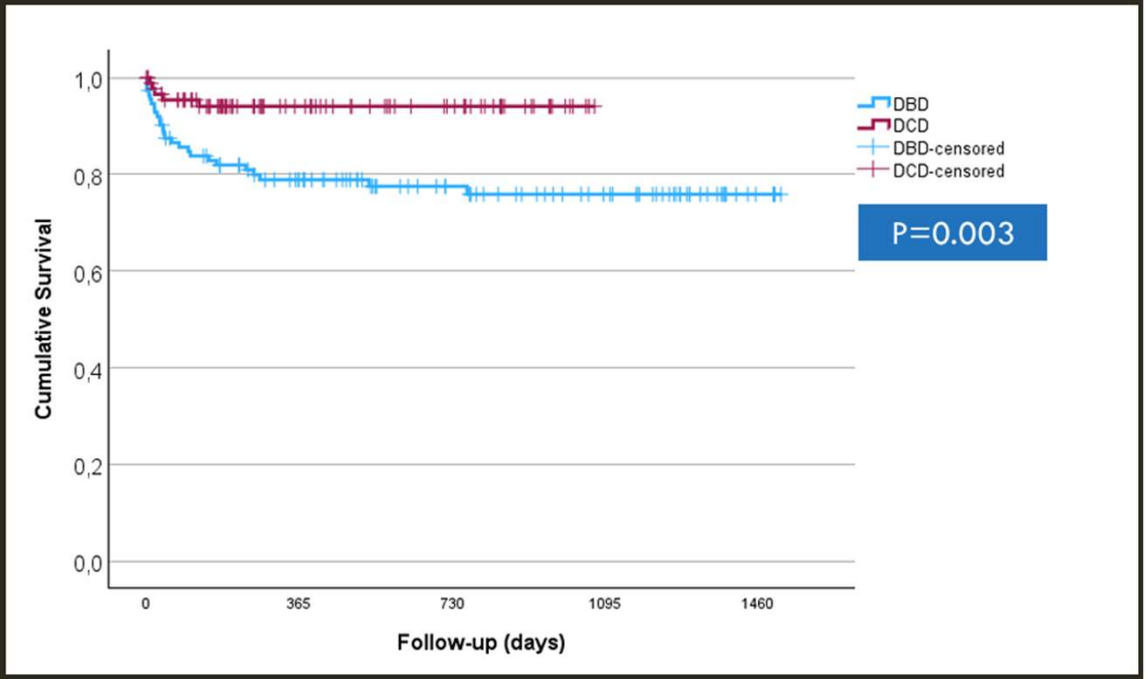
REJECTED DCD HEARTS MARCH 2021-NOVEMBER 2023

Rejected	N (14)	
Poor function	3	Increasing lactate (3)
Technical issues	9	Leakage pump housing Disconnection heart during transport Insufficient blood collection 2x High potassium in collected blood Size mismatch Coronary injury Complication before procurement Other
Malignancy at procurement	2	(Suspicion) of abdominal malignancy

Erasmus MC

SURVIVAL DCD VERSUS DBD THE NETHERLANDS

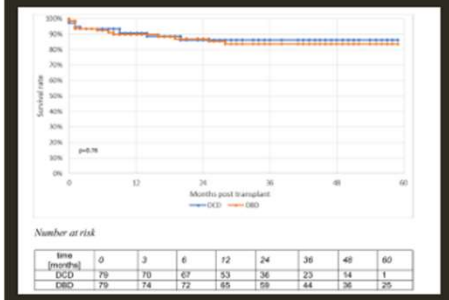
DCD		DBD	
N=92		N=113	
N	%	N	%
87	94.6	88	77.9

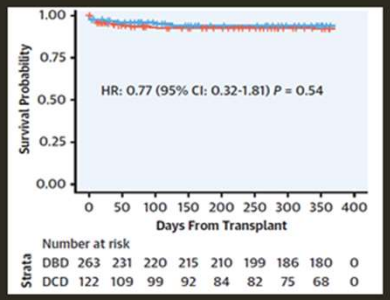


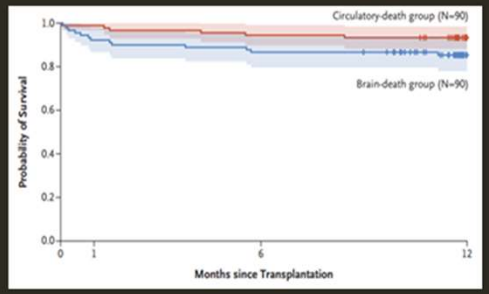
DPP 100%

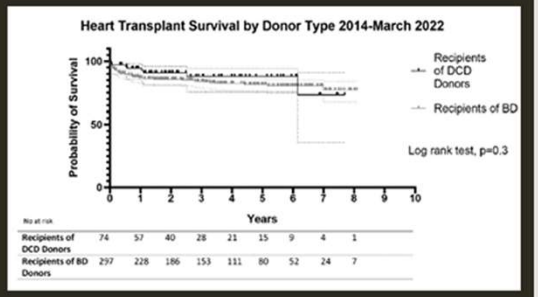
Erasmus MC

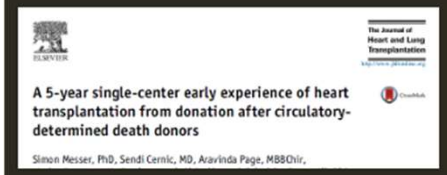
SURVIVAL DCD VERSUS DBD











Erasmus MC

PROCUREMENT | RUN TIMES

	Mean (SD)	Mean (SD)
Withdrawal of life support	10 min (4)	18 min (20)
Start functional warm ischemic time		
Asystole	14 min (4)	15 min (3)
Declaration of death		
Incision & Blood collection		
Cardioplegia		
Harvesting of the heart	36 min (10)	34 min (8)
Reperfusion heart on the machine		
OCS run	282 min (57)	285 min (68)

Erasmus MC

ASYSTOLIC WARM ISCHEMIC TIME

Heart Transplantation From DCD Donors in Australia: Lessons Learned From the First 74 Cases

Yashutosh Joshi, MBBS,[1,2,3] Sarah Scheuer, MD,[1,2,3] Hong Chew, PhD,[1,2,3] Min Ru Qiu, PhD,[3,4] Claudio Soto, MSc,[1,5] Jeanette Villanueva, PhD,[2] Ling Gao, PhD,[2] Aoife Doyle, MSc,[2] Shingo Takahara, PhD,[1] Charles Jenkinson, MBBS,[1] Nikunj Vaidhya, MS,[1] Yoshiko Matsumoto, MD,[1] Bridget Hwang,[1] Christine Zhao, MD,[2] Arjun Iyer, PhD,[1,2,3] Mark Connellan, MBBS,[1] Alasdair Watson, PhD,[1] Emily Granger, MBBS,[1] Kavitha Muthiah, PhD,[1] Andrew Jabbour, PhD,[1] Eugene Kotlyar, PhD,[1] Anne Keogh, MD,[1] Nicole K. Bart, PhD,[1,2,3] Chris Hayward, MD,[1] Kumud Dhital, PhD,[1,2,3] Paul Jansz, PhD,[1,2] and Peter S. Macdonald, PhD[1,2,3]

Comparison of perioperative and ischemic time characteristics of patients requiring versus not requiring ECMO for severe primary graft dysfunction

Characteristics:	ECMO requirement for PGD (n = 12)	No ECMO for PGD (n = 62)	*P*
aWIT (min) [median (IQR)]	15 (12–17)	13 (11–14)	**0.03**
aWIT [median (IQR)]	16 (15-18)	15 (13-17)	
aWIT >15 min [n (%)]	5/12 (42)	4/62(6)	**0.0043**
aWIT [>15 min [n (%)]	9/17 (53%)	28/71 (39%)	

Erasmus MC

BUT..... RISKS OF NORMOTHERMIC PERFUSION

Normothermic graft loss

136 Donors attended

15 did not progress within 120 minutes

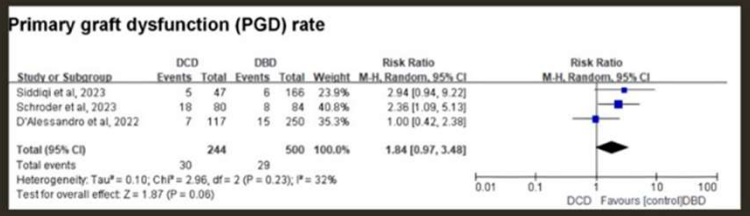
1 Functional warm ischemic time >30 minutes

119 Direct Procurement and Perfusion

16 Hearts rejected

104 Transplanted (Retrieval rate 76%)

Incidence of Primary graft dysfunction



DPP & NRP

Erasmus MC

Voor en Nadelen EVHP

Voordelen	Nadelen
Hart kan beoordeeld worden en eventueel in de toekomst gemodificeerd of verbeterd worden.	Hart kan (nog) niet belast beoordeeld worden
Ischemie tijd wordt beperkt alvorens te transplanteren, voordeel bij reoperaties en patiënten met LVAD	Logistieke uitdaging
Verlenging tot uiteindelijke transplantatie tot wel 18u na uitname	Kostbare procedure (perfusieset kost €48.000,-)
Zelfde outcome als bij DBD harttransplantaties	Nog niet geschikt voor kleine harten

Quality assessment: Electrical mapping

Practicalities

Conform mapping standaard OK

Elektrode in echo-hoes

2x bipolair pacing cables

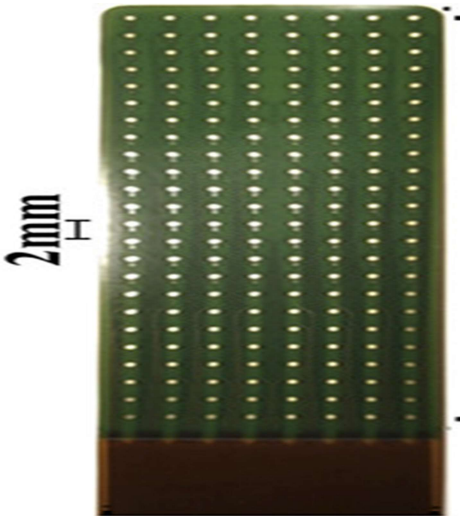
Aarde

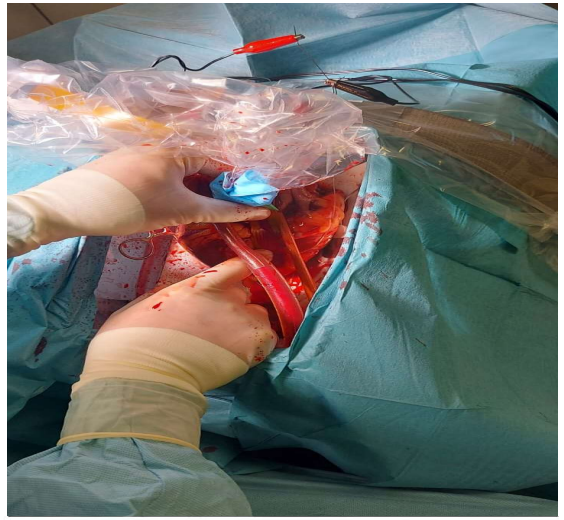
Referentie

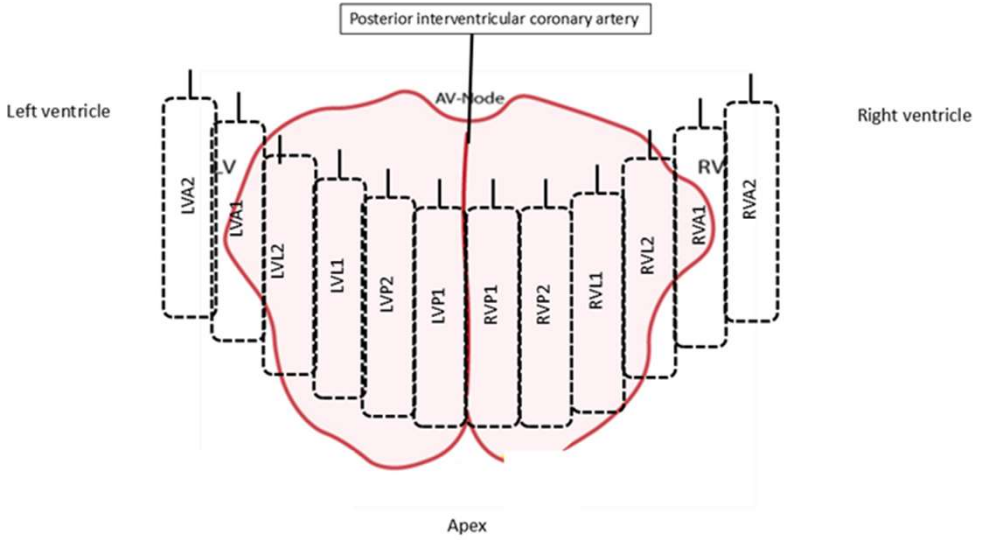
*Aarde = **staaldraad** om aorta*

Referentie = 1 op ventriculaire PM draad (onsteriel) & 1 op staal

Steriliteit!







Metabolic markers of vitality

Practicalities

Measurements using standard blood sampling

- *Arterial and venous pO2*
- *Arterial and venous saturation*
- *Hb concentration*

MdO2 (ml O2/min): coronary blood flow * arterial oxygen content

MvO2: coronary blood flow * arteriovenous oxygen content difference

MeO2 MvO2 / MdO2

$$CxO2 = \frac{(O2\ carried\ by\ Hb) + (O2\ in\ solution)}{100}$$

$$CxO2 = \frac{([Hb] * 1.34 * sO2) + (0.0031 * pO2)}{100}$$

Erasmus MC

DIRECT PROCUREMENT AND PERFUSION

- Withdrawal of life support
- Blood pressure systolic <50 mmHg
- Asystole
- Stand off time (depends on local rules)
- Declaration of death
- Incision & Blood collection
- Cardioplegia
- Harvesting of the heart
- **Reperfusion heart on the machine & Transport**
- Cooling
- Transplant

XVIVO Heart assist transport system

YOU GOTTA HAVE
HOPE
HYPOTHERMIC
OXYGENATED **PE**RFUSION

HOPE AT HEART

- HOPE=Hypothermic Oxygenated PErfusion (8 °C)
- XVIVO Heart assist transport system

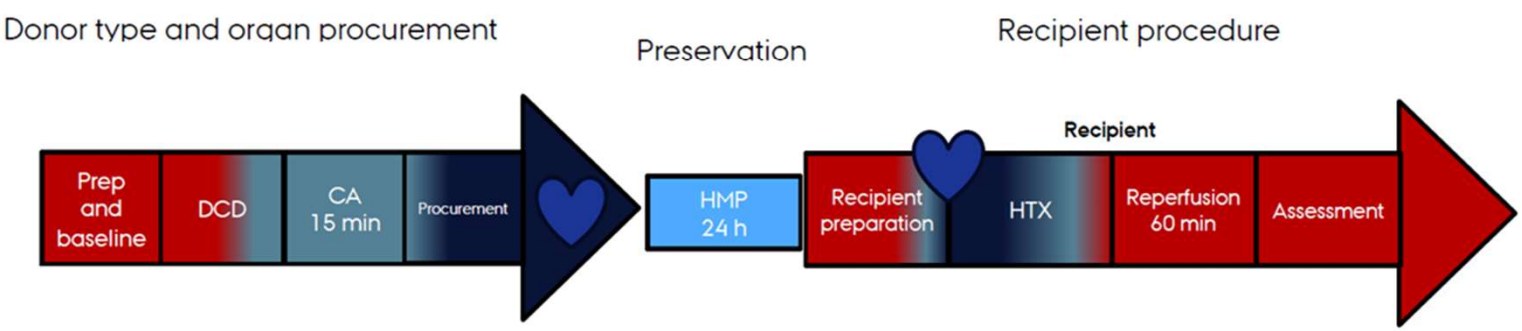
Erasmus MC

24-HOUR HYPOTHERMIC OXYGENATED PERFUSION DCD

Verdensrekord: Donorhjerte transplanteret succesfuldt efter 24 timer i kølemaskine

Det er lykkedes forskere fra AUH i samarbejde med firmaet XVIVO at holde et grisehjerte i live 24 timer i kølemaskine.

Prolonged (24-hours) Hypothermic Machine Perfusion



Erasmus MC

WHY HOPE TRIAL?

Pro

- Bank RBCs instead
- Easy and fast mounting on the device

→ Shorter WIT and first CIT intervals

- Potentially reduced incidence of PGD
- No hematoma/less edema at implant
- Potentially extended preservation
- In the case of technical issues, there is no risk of warm ischemia

Con

- No functional assessment
- CE mark end of 2024/early 2025

Erasmus MC