Innovation in Heart Failure: Imagining the Next Decade of Care

March 20th, 2026

- Deane Smith, MD and Snehal R Patel, MD
- Co-Directors of the Center for Heart Failure, Transplant and Mechanical Circulatory Support

Sandra Atlas Bass Heart Hospital
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No disclosures

How can we possibly know what the next ten years will bring?

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Review

Heart failure 2016: still more questions than answers

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ABSTRACT

Heart failure has reached epidemic proportions given the ageing of populations and is associated with high mortality and re-hospitalization rates. This article reviews and summarizes recent advances in the diagnosis, assessment and treatment of the patients with heart failure. Data are discussed based also on the most recent guidelines indications. Open issues and unmet needs are highlighted.

NORTHWELL HEALTH•ZUCKER SCHOOL OF MEDICINE

North Shore-LIJ to Change Name to Northwell Health

September 15, 2015 6 Min Read

DONALD AND BARBARA
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AT HOFSTRA/NORTHWELL

AI Overview +7

In 2016, North Shore University Hospital (NSUH) in Manhasset was a key component of the newly rebranded **Northwell Health** system (formerly North Shore-LIJ). The 812-bed quaternary care teaching hospital operated as the clinical campus for the Hofstra Northwell Health School of Medicine. www.northwell.edu +4

Key 2016 Developments & Highlights

- **System Rebranding:** The hospital completed its transition to Northwell Health in 2016, following the name change from North Shore-LIJ.
- **Auxiliary Pledge:** The all-volunteer Auxiliary made a 10-year, $2 million pledge in 2016 to support the renovation of the Neonatal Intensive Care Unit (NICU), which was completed well ahead of schedule.
- **Facility Focus:** During this period, the hospital continued to operate the modernized Sandra Atlas Bass Cardiology Centers and the Harvey Cushing Institutes of Neuroscience.
- **Clinical Care:** The hospital was recognized as a major teaching center and clinical campus for the Hofstra Northwell Health School of Medicine. www.northwell.edu +4

The facility continued to serve as a flagship institution for the health system in 2016, focusing on complex, specialized care. www.northwell.edu +2

ARTIFICIAL INTELLIGENCE

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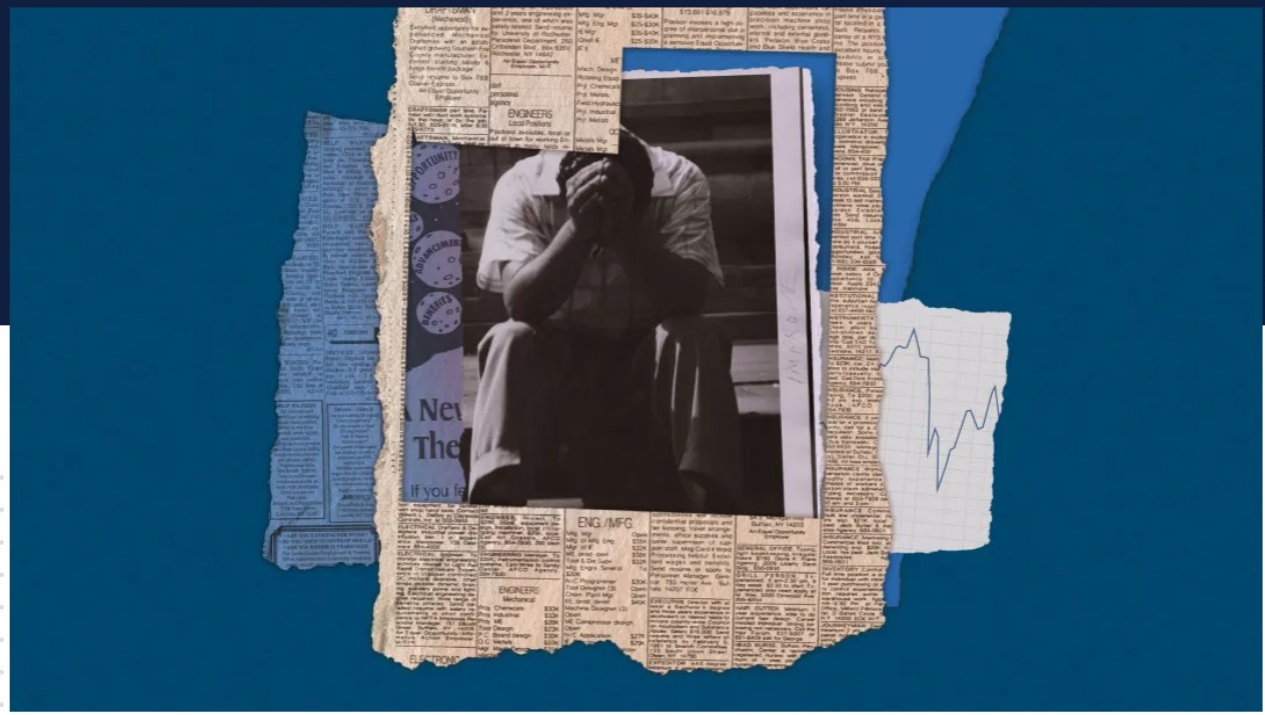
"We need a Manhattan Project for this," one economist says.

By James O'Donnell April 6, 2026



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Cardiologists

29-1212.00

Updated 2026

A subset of this occupation's profile is available. Data collection is currently underway to populate other parts of the profile.

Diagnose, treat, manage, and prevent diseases or conditions of the cardiovascular system. May further subspecialize in interventional procedures (e.g., balloon angioplasty and stent placement), echocardiography, or electrophysiology.

Occupation-Specific Information

Tasks

5 of 25 displayed

- Administer emergency cardiac care for life-threatening heart problems, such as cardiac arrest and heart attack.
- Advise patients and community members concerning diet, activity, hygiene, or disease prevention.
- Answer questions that patients have about their health and well-being.
- Calculate valve areas from blood flow velocity measurements.
- Compare measurements of heart wall thickness and chamber sizes to standards to identify abnormalities, using the results of an echocardiogram.

Technology Skills

All 2 displayed

- **Medical software** — Epic Systems ; MEDITECH software
- **Transaction security and virus protection software** — Watchman Monitoring

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See all 1 In Demand skills for this occupation.

Occupational Requirements

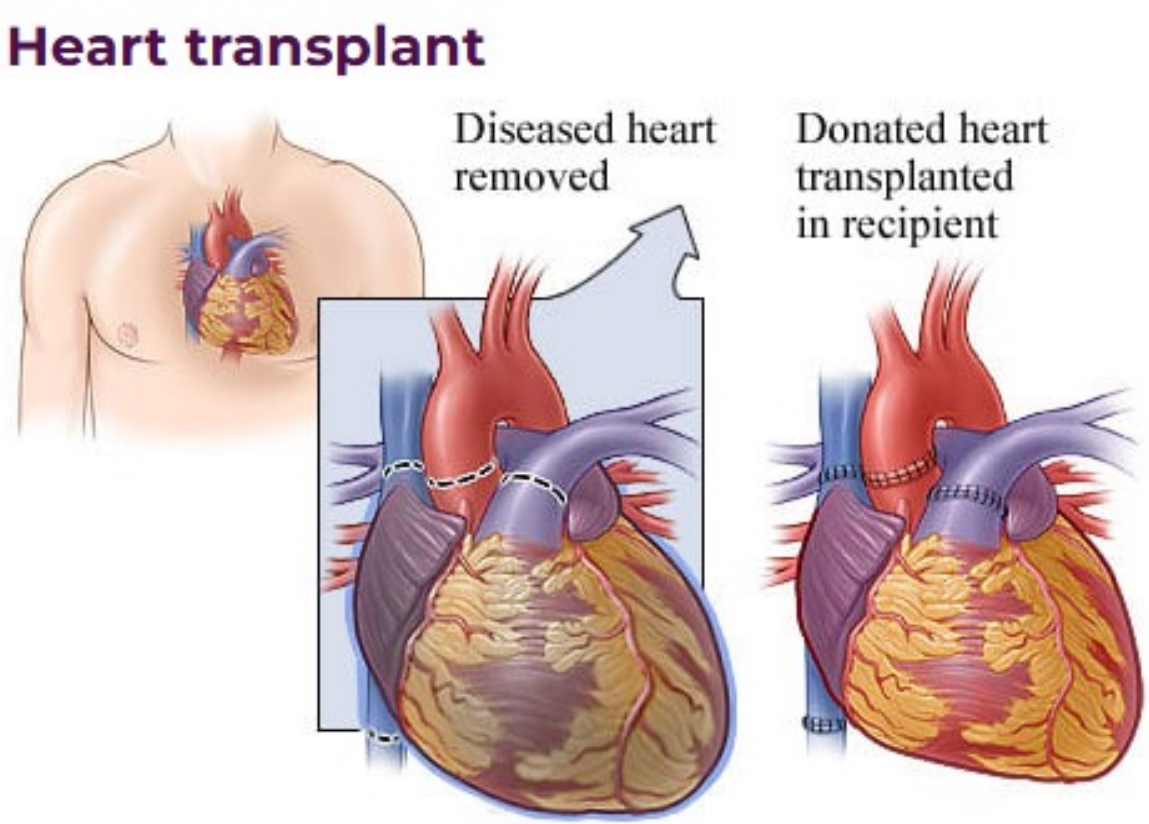
Detailed Work Activities

5 of 25 displayed

- Test patient heart or lung functioning.
- Analyze test data or images to inform diagnosis or treatment.
- Operate diagnostic or therapeutic medical instruments or equipment.
- Operate on patients to treat conditions.
- Provide health and wellness advice to patients, program participants, or caregivers.

IAPW

Advanced Heart Failure

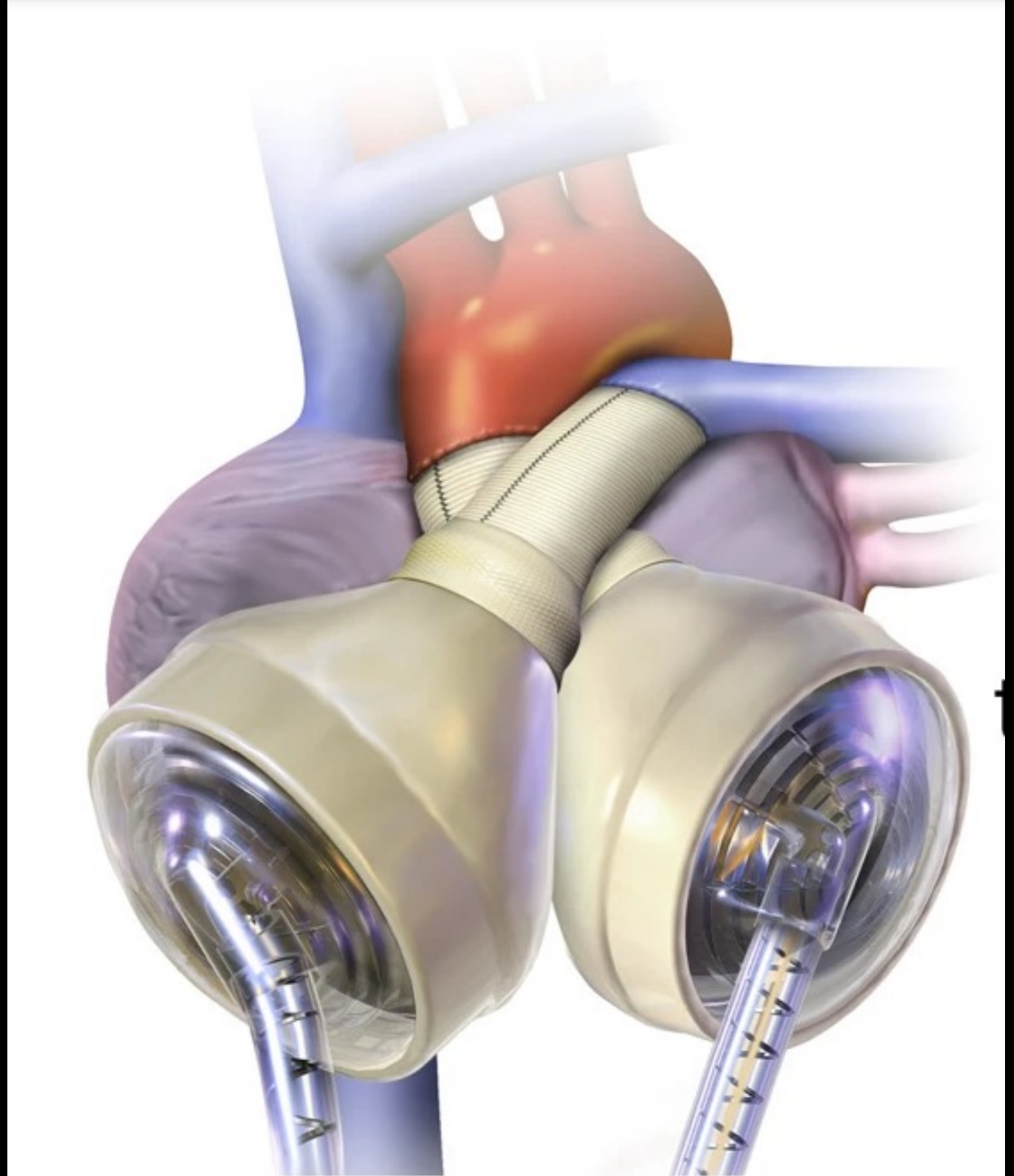


VAD limitations

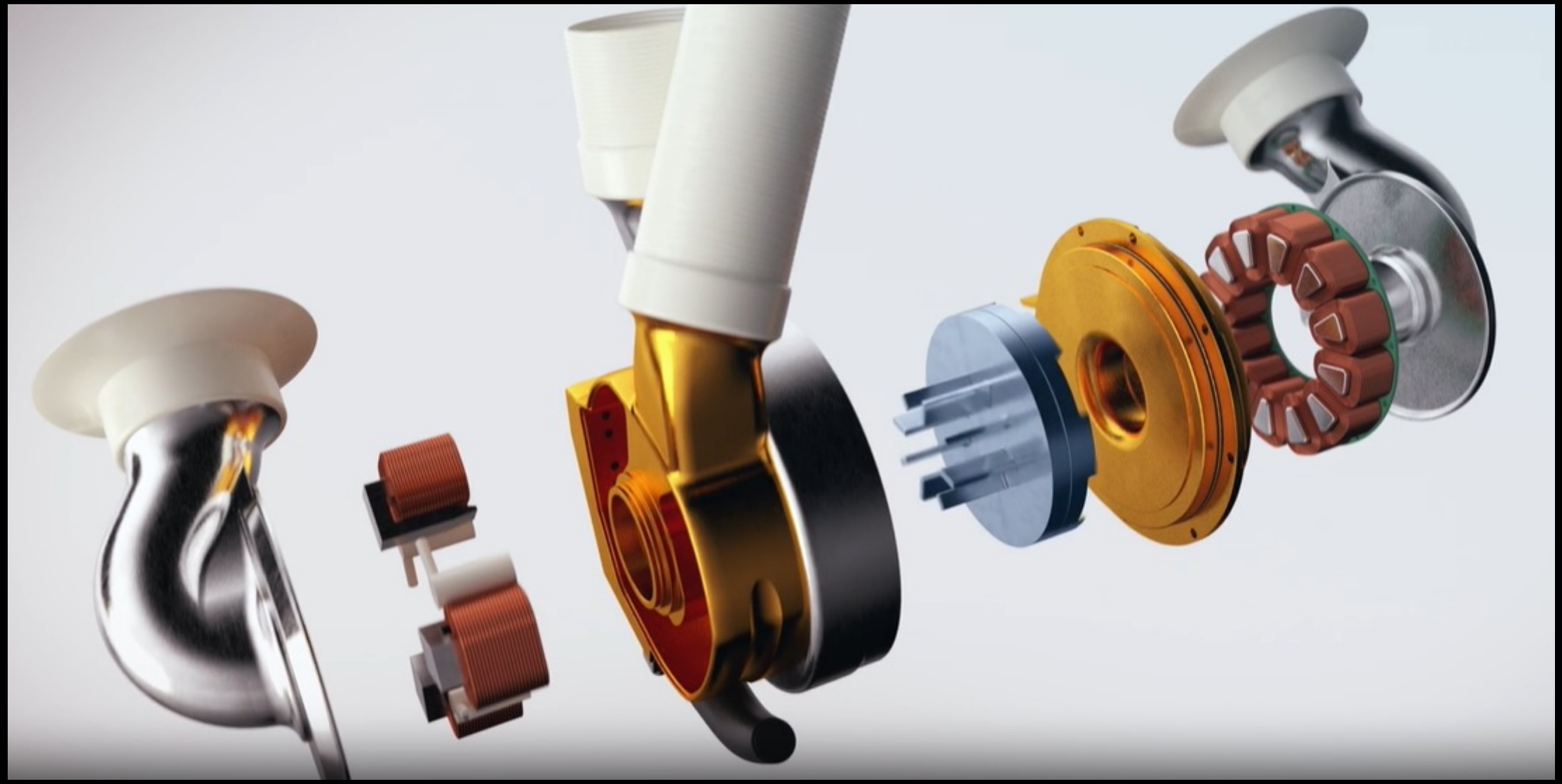
- Device related infections
- Strokes
- GI bleeds

VAD limitations

- Small ventricle
- RV failure
- Arrhythmia
- Valve disease



BiVACOR



World First: Man Leaves Hospital With Life-Saving Titanium Heart

HEALTH 13 March 2025 By CARLY CASSELLA

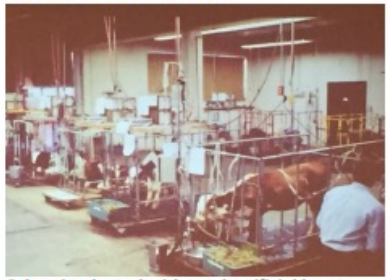
The First Total Artificial Heart

University of Utah Hospital

On the night of December 1-2, 1982, with a major winter storm howling outside, medical history was being made inside the University of Utah Hospital. This event was the implantation of the first destination total artificial heart (TAH) in a human being. That person, 61-year-old Barney Clark, was a retired Seattle dentist with family roots in Utah.

Dr. Clark's several year history of dyspnea and fatigability had been attributed to chronic obstructive pulmonary disease in a former smoker. However, 2 1/2 years before admission, a diagnosis of heart failure was made associated with atrial fibrillation with a rapid ventricular response. In-patient treatment for recurrent heart failure with paroxysmal ventricular tachycardia (VT) was required 1 ½ years before admission. Coronary angiography and left ventriculography established a diagnosis of advanced, non-ischemic dilated cardiomyopathy with an ejection fraction of 23%. Because of symptomatic progression of heart failure, Dr. Clark was referred to the author at LDS Hospital in Salt Lake City, near family members, for investigational inotrope therapy (amrinone), but this caused hypotension and exacerbated atrial and ventricular tachyarrhythmias. Endomyocardial biopsy showed low-grade cellular and humoral myocarditis, and a course of immunosuppressant therapy (prednisone and azathioprine) was begun with initial improvement. However, clinical deterioration resumed, with low-output failure and edema, 6 ½ months later, leading to hospitalization for IV diuretics and dobutamine. Clinical improvement was only marginal, leaving him in class IV heart failure.

Jeffrey L. Anderson, MD: Barney Clark's Cardiologist

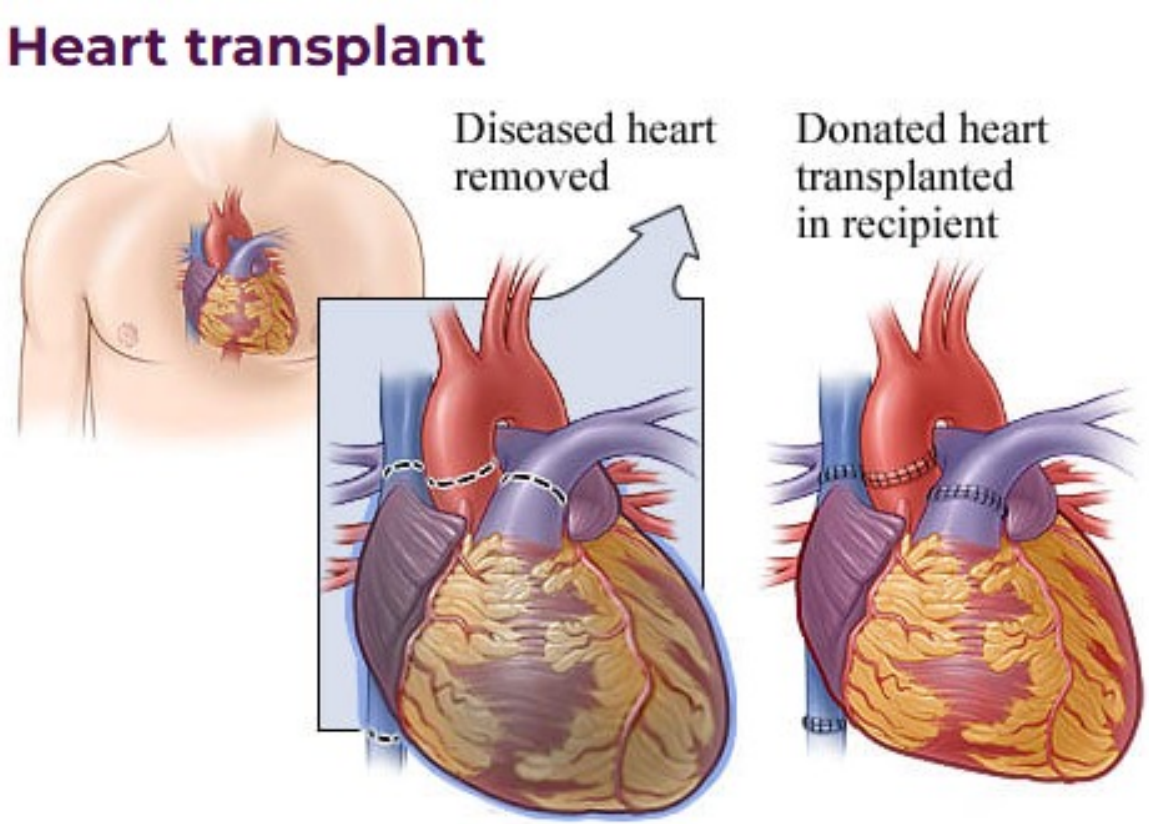


Calves implanted with total artificial hearts. Don B. Olsen, DVM lead the animal research effort

An opportune meeting occurred 3-4 months prior to the final admission between the author and Dr. William DeVries in a hot tub after a workout at the old Einar Nielsen Fieldhouse on University campus. Dr. DeVries indicated readiness to select a patient for the first TAH implant, and Dr. Anderson provided the name of Dr. Clark as a potential candidate. A meeting between Dr. DeVries and Dr. Clark and spouse (Una Loy) was arranged in October 1982, where a thorough review of the TAH program occurred. The Clarks followed this a short time later with a visit to the nearby animal laboratory at the old St. Mark's Hospital complex to see calves with pneumatically powered artificial hearts. They also visited the manufacturing area where TAHs were in various stages of assembly. The Clarks were impressed with the TAH program and agreed to discuss with family members and personal physicians before enrolling. Ongoing deterioration in Dr. Clark's cardiac status in late November led to the final decision to proceed.

A long road had led to the development of the "Jarvik-7 model Utah Heart". Pioneering efforts began with Dr. Willem Kolff, a Dutch immigrant who was recruited to the University of Utah and became recognized worldwide as a leader in artificial organs, including artificial kidneys (efficient dialysis units)

Advanced Heart Failure



Transplant Limitations

- Waitlist mortality
- Primary graft dysfunction
- Rejection
- Complications of long-term immunosuppression

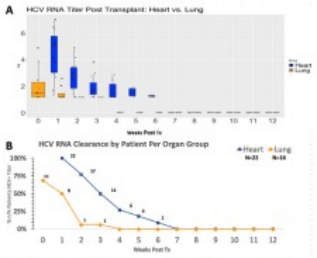
Impact of Early Initiation of Direct-Acting Antiviral Therapy in Thoracic Organ Transplantation From Hepatitis C Virus Positive Donors

Deane E. Smith, MD, Stacey Chen, MD,* Anthony Fargnoli, PhD,* Tyler Lewis, PharmD,† Aubrey C. Galloway, MD,* Zachary N. Kon, MD,* and Nader Moazami, MD**

Thoracic organs from hepatitis C virus (HCV) positive donors are not commonly used for transplantation. The development of direct-acting antivirals (DAA) for HCV treatment has led to renewed interest in using HCV-positive organs. We evaluated HCV transmission rates, viremia clearance, and short-term outcomes in HCV-negative patients who received HCV-positive thoracic organs at our institution. From January 1, 2018 to May 31, 2019, 38 patients underwent HCV-positive thoracic organ transplantation (16 lungs and 22 hearts). Heart recipients were started on glecaprevir/pibrentasvir, a pangenotypic DAA, when they developed HCV viremia. Lung recipients were empirically started on glecaprevir/pibrentasvir within the first 3 post-transplant days. The primary outcome was cure of HCV defined as sustained virologic response at 12 weeks (SVR12). All heart recipients developed HCV viremia with median initial viral load of 64,565 IU/mL (interquartile range: 1660−473,151). The median time from DAA initiation to viremia clearance was 19 days (confidence interval: 15−27 days). Eleven out of 16 (68.8%) lung recipients developed HCV viremia with median initial viral load of 26 IU/mL (interquartile range: 15−143). The median time from DAA initiation to viremia clearance was 10 days (confidence interval: 6−17 days). Five out of 16 (31.3%) lung recipients never became viremic. All patients demonstrated SVR12. Thoracic organ transplantation from HCV viremic donors is safe with excellent short-term survival. Early initiation of HCV treatment results in rapid viremia clearance and SVR12. Long-term outcomes and optimal timing of DAA initiation remains to be determined.

Semin Thoracic Surg 33:407–415

Keywords: hepatitis C virus infection, thoracic organ transplantation, direct-acting antiviral therapy



Weekly mean and median log HCV viral titers in thoracic transplant recipients.

Central Message

Early initiation of direct-acting antiviral therapy for hepatitis C virus (HCV) in HCV-negative recipients of HCV viremic thoracic organs correlates with rapid HCV viremic clearance.

Perspective Statement

Despite successful short-term outcomes of hepatitis C virus viremic thoracic organs into uninfected recipients, the optimal timing of initiating direct-acting antiviral (DAA) therapy is unknown. This study seeks to provide insight into this by implementing 2 different DAA initiation protocols. The results have implications for healthcare cost and patient outcomes as long-term studies emerge.

Abbreviations: HCV, Hepatitis C virus; DAA, Direct-acting antiviral; SVR12, Sustained virologic response 12 weeks post-treatment; PHS, Public health service; UNOS, United network for organ sharing; NAT, Nucleic acid test; Ab, Antibody; HIV, Human immunodeficiency virus; HBV, Hepatitis B virus; LAS, Lung allocation score; ISHLT, International society for heart and lung transplantation; PGD, Primary graft dysfunction

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Conflicts of Interest: Dr. Kon has received personal fees from Medtronic and Breethe, Inc. Dr. Galloway receives royalties from Medtronic and Edwards Lifesciences. No external funding was obtained.New York University Langone Health IRB Approval Date and Number: Heart IRB Protocol: approved January 5, 2018 (study number: i17-01775).Lung IRB Protocol: approved March 20, 2018 (study number: i18-00091).Read at the American Association for Thoracic Surgery 99th Annual Meeting, Toronto, Ontario, Canada.

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Early experience with donation after circulatory death heart transplantation using normothermic regional perfusion in the United States

Deane E. Smith, MD,[a] Zachary N. Kon, MD,[b] Julius A. Carillo, MD,[a] Stacey Chen, MD,[a] Claudia G. Gidea, MD,[c] Greta L. Piper, MD,[d] Alex Reyentovich, MD,[c] Robert A. Montgomery, MD,[d,e] Aubrey C. Galloway, MD,[a] and Nader Moazami, MD[a]

ABSTRACT

Objective: This pilot study sought to evaluate the feasibility of our donation after circulatory death (DCD) heart transplantation protocol using cardiopulmonary bypass (CPB) for normothermic regional reperfusion (NRP).

Methods: Suitable local DCD candidates were transferred to our institution. Life support was withdrawn in the operating room (OR). On declaration of circulatory death, sternotomy was performed, and the aortic arch vessels were ligated. CPB was initiated with left ventricular venting. The heart was reperfused, with correction of any metabolic abnormalities. CPB was weaned, and cardiac function was assessed at 30-minute intervals. If accepted, the heart was procured with cold preservation and transplanted into recipients in a nearby OR.

Results: Between January 2020 and January 2021, a total of 8 DCD heart transplants were performed: 6 isolated hearts, 1 heart-lung, and 1 combined heart and kidney. All donor hearts were successfully resuscitated and weaned from CPB without inotropic support. Average lactate and potassium levels decreased from 9.39 ± 1.47 mmol/L to 7.20 ± 0.13 mmol/L and 7.49 ± 1.32 mmol/L to 4.36 ± 0.67 mmol/L, respectively. Post-transplantation, the heart-lung transplant recipient required venoarterial extracorporeal membrane oxygenation for primary lung graft dysfunction but was decannulated on postoperative day 3 and recovered uneventfully. All other recipients required minimal inotropic support without mechanical circulatory support. Survival was 100% with a median follow-up of 304 days (interquartile range, 105-371 days).

Conclusions: DCD heart transplantation outcomes have been excellent. Our DCD protocol is adoptable for more widespread use and will increase donor heart availability in the United States. (J Thorac Cardiovasc Surg 2022;164:557-68)

Normothermic regional perfusion using cardiopulmonary bypass for DCD heart transplant.

CENTRAL MESSAGE

A donation after circulatory death protocol using cardiopulmonary bypass for normothermic regional perfusion allows for direct allograft evaluation, resulting in high organ acceptance rates and excellent post-transplantation outcomes.

PERSPECTIVE

Experience with donation after circulatory death (DCD) heart transplantation remains limited, with no consensus on the best method for DCD heart retrieval. Implementation of a DCD protocol using cardiopulmonary bypass for normothermic perfusion allows for optimal myocardial recovery, correction of metabolic abnormalities following circulatory arrest, and in situ cardiac assessment under physiologic conditions before transplantation.

See Commentaries on pages 569 and 571.

Heart transplantation remains the gold standard treatment for patients with end-stage heart failure refractory to medical therapy. However, the shortage of suitable donor hearts

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Scanning this QR code will take you to the table of contents to access supplementary information. To view the AATS Annual Meeting Webcast, see the URL next to the webcast thumbnail.

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ESTABLISHED IN 1812 JUNE 8, 2023 VOL. 388 NO. 23

Transplantation Outcomes with Donor Hearts after Circulatory Death

J.N. Schroder, C.B. Patel, A.D. DeVore, B.S. Bryner, S. Casalinova, A. Shah, J.W. Smith, A.G. Fiedler, M. Daneshmand, S. Silvestry, A. Geirsson, V. Pretorius, D.L. Joyce, J.Y. Um, F. Esmailian, K. Takeda, K. Mudy, Y. Shudo, C.T. Salerno, S.M. Pham, D.J. Goldstein, J. Philpott, J. Dunning, L. Lozonschi, G.S. Couper, H.R. Mallidi, M.M. Givertz, D.T. Pham, A.W. Shaffer, M. Kai, M.A. Quader, T. Absi, T.S. Attia, B. Shukrallah, B.C. Sun, M. Farr, M.R. Mehra, J.C. Madsen, C.A. Milano, and D.A. D'Alessandro

ABSTRACT

BACKGROUND

Data showing the efficacy and safety of the transplantation of hearts obtained from donors after circulatory death as compared with hearts obtained from donors after brain death are limited.

METHODS

We conducted a randomized, noninferiority trial in which adult candidates for heart transplantation were assigned in a 3:1 ratio to receive a heart after the circulatory death of the donor or a heart from a donor after brain death if that heart was available first (circulatory-death group) or to receive only a heart that had been preserved with the use of traditional cold storage after the brain death of the donor (brain-death group). The primary end point was the risk-adjusted survival at 6 months in the as-treated circulatory-death group as compared with the brain-death group. The primary safety end point was serious adverse events associated with the heart graft at 30 days after transplantation.

RESULTS

A total of 180 patients underwent transplantation; 90 (assigned to the circulatory-death group) received a heart donated after circulatory death and 90 (regardless of group assignment) received a heart donated after brain death. A total of 166 transplant recipients were included in the as-treated primary analysis (80 who received a heart from a circulatory-death donor and 86 who received a heart from a brain-death donor). The risk-adjusted 6-month survival in the as-treated population was 94% (95% confidence interval [CI], 88 to 99) among recipients of a heart from a circulatory-death donor, as compared with 90% (95% CI, 84 to 97) among recipients of a heart from a brain-death donor (least-squares mean difference, −3 percentage points; 90% CI, −10 to 3; P<0.001 for noninferiority [margin, 20 percentage points]). There were no substantial between-group differences in the mean per-patient number of serious adverse events associated with the heart graft at 30 days after transplantation.

CONCLUSIONS

In this trial, risk-adjusted survival at 6 months after transplantation with a donor heart that had been reanimated and assessed with the use of extracorporeal nonischemic perfusion after circulatory death was not inferior to that after standard-care transplantation with a donor heart that had been preserved with the use of cold storage after brain death. (Funded by TransMedics; ClinicalTrials.gov number, NCT03831048.)

The authors' full names, academic degrees, and affiliations are listed in the Appendix. Dr. Schroder can be contacted at jacob.schroder@duke.edu or at the Heart Transplantation Program, Division of Cardiovascular and Thoracic Surgery, Duke University Medical Center, 10 Duke Medicine Cir., Durham, NC 27710-1000.

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DOI: 10.1056/NEJMoa2212438

CME at NEJM.org

BRIEF REPORT

Rapid Recovery of Donor Hearts for Transplantation after Circulatory Death

Aaron M. Williams, M.D.,[1] John M. Trahanas, M.D.,[1] Swaroop Bommareddi, M.D.,[1] Brian Lima, M.D.,[1] Stephen A. DeVries, P.A.-C.,[1] Joshua Lowman, P.A.-C.,[1] Awab Ahmad, M.D.,[1] Eric Quintana, M.D.,[1] Shelley R. Scholl, R.N.,[1] Stacy Tsai, M.D.,[2] Dawn Pedrotty, M.D.,[2] Matthew Warhoover, C.C.P.,[1] Harry Moneypenny, C.C.P.,[1] Stephen Tapia-Ruano, M.D.,[3] Matthew Bacchetta, M.D.,[1] Kelly Schlendorf, M.D.,[2] and Ashish S. Shah, M.D.[1]

SUMMARY

We report a method for the recovery of hearts for transplantation from deceased donors after circulatory death that obviates the need for thoracoabdominal normothermic regional perfusion or ex situ perfusion systems. After death, the aorta is clamped and a flush circuit is established to perform a controlled, extended, ultraoxygenated flush of the donor heart at a mean aortic-root pressure of 80 mm Hg. In the first three reported cases in which this method was used, the hearts were transplanted successfully with normal biventricular function, no evidence of acute cellular or antibody-mediated rejection, and excellent early postoperative outcomes. No adverse events were reported during the perioperative period. By avoiding the limitations of ex situ perfusion platforms as well as the controversial aspects of thoracoabdominal normothermic regional perfusion, this method of heart recovery offers the possibility of broad application.

Author affiliations are listed at the end of the article.

Drs. Williams and Trahanas contributed equally to this article.

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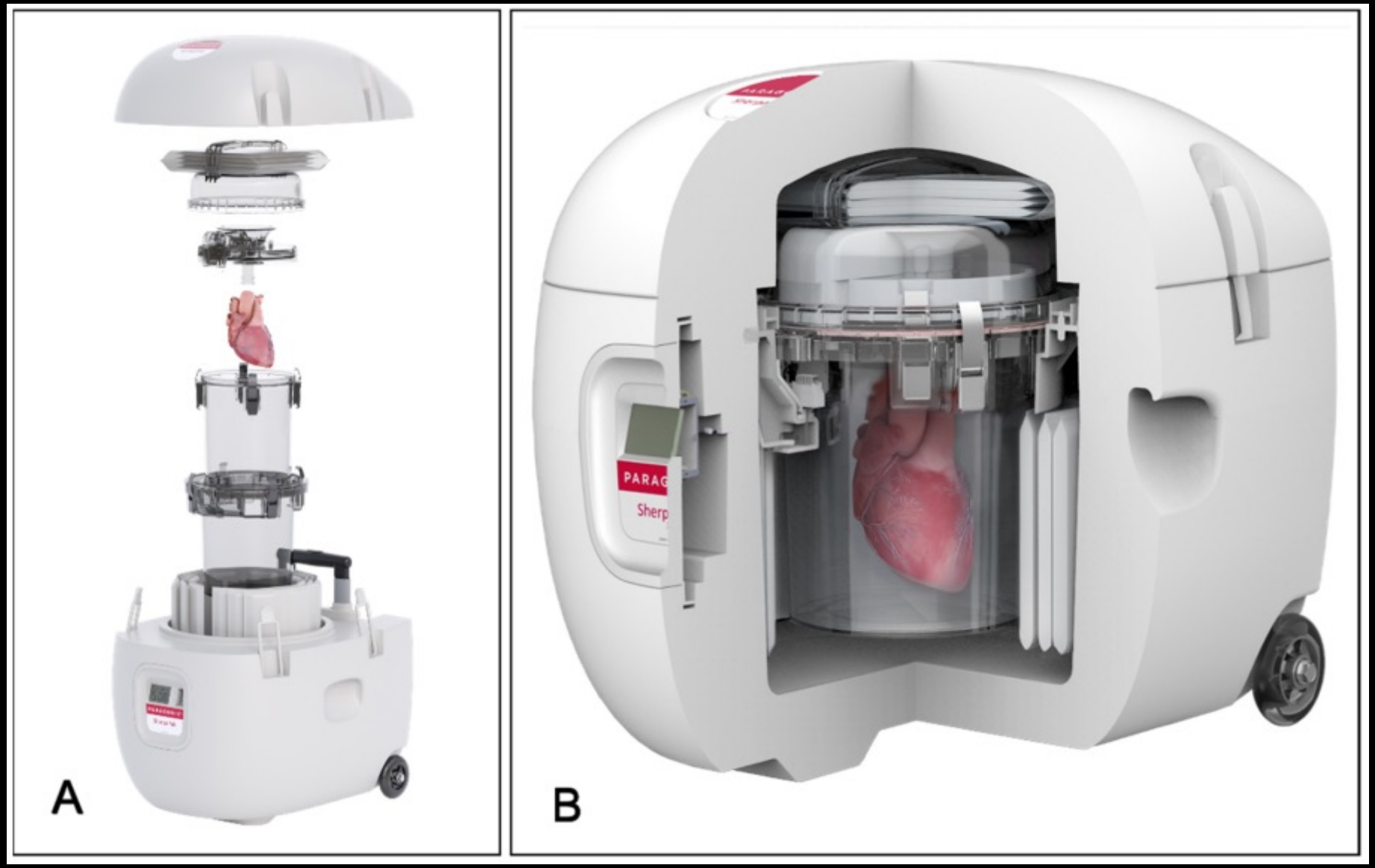
CARDIAC ALLOGRAFTS FROM DECEASED DONORS AFTER CIRCULATORY death (i.e., DCD [donation after circulatory death] cardiac allographs) are typically recovered with either direct procurement and perfusion or with normothermic regional perfusion. Both techniques have been shown to yield acceptable outcomes.[1-3]

The direct procurement and perfusion technique involves the use of commercially available ex situ devices that can be complicated, labor intensive, and associated with an increased risk of primary graft dysfunction. In addition, direct procurement and perfusion does not provide resuscitation for the abdominal organs. As such, many programs prefer the use of normothermic regional perfusion for DCD organ recoveries. Normothermic regional perfusion is more easily adopted, increases organ yield, and has also been shown to have superior outcomes in heart and abdominal organ transplantation as compared with direct procurement and perfusion.[4-8] However, normothermic regional perfusion has been the subject of ethical controversy, and many hospitals, organ-procurement organizations, and countries prohibit its use.[9-11] Thoracoabdominal normothermic regional perfusion is controversial for two reasons: it results in reanimation of the heart in the donor, which critics argue negates the definition of circulatory death, and it involves clamping the aortic-arch vessels to prevent brain perfusion, which some critics

Transportation strategies

- Traditional cold static storage
- Controlled hypothermic preservation
- Hypothermic oxygenated perfusion
- Normothermic machine perfusion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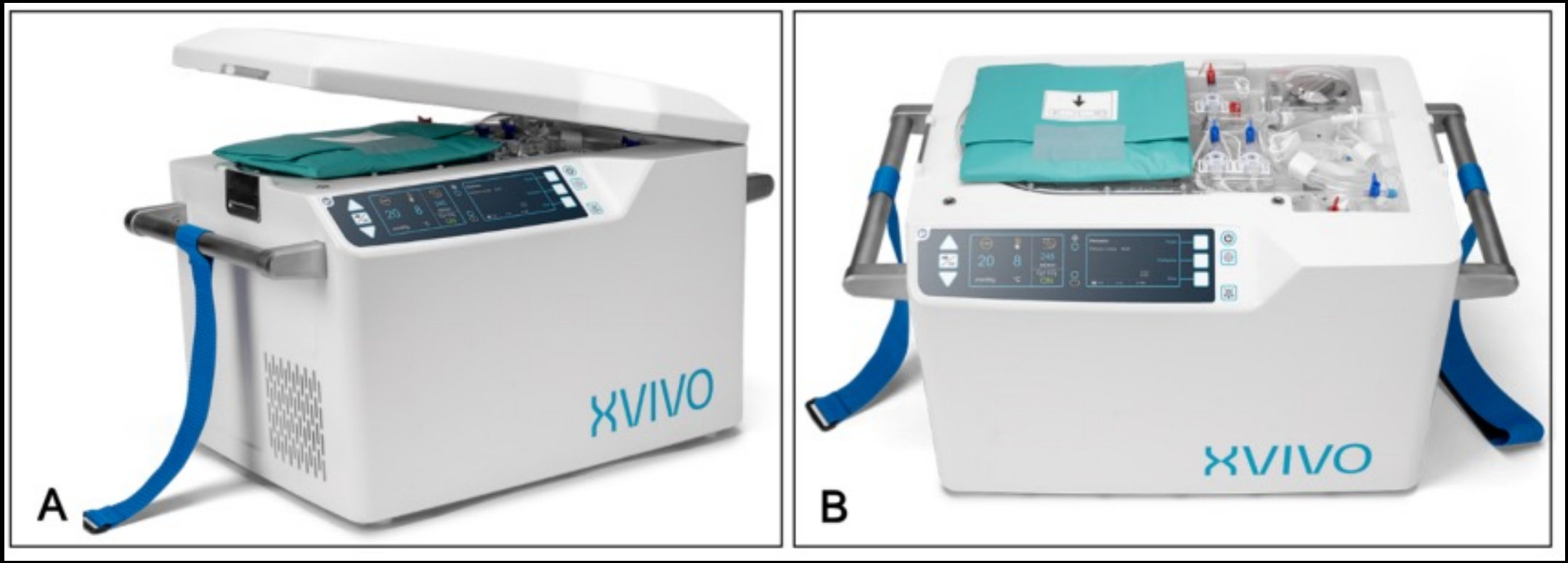

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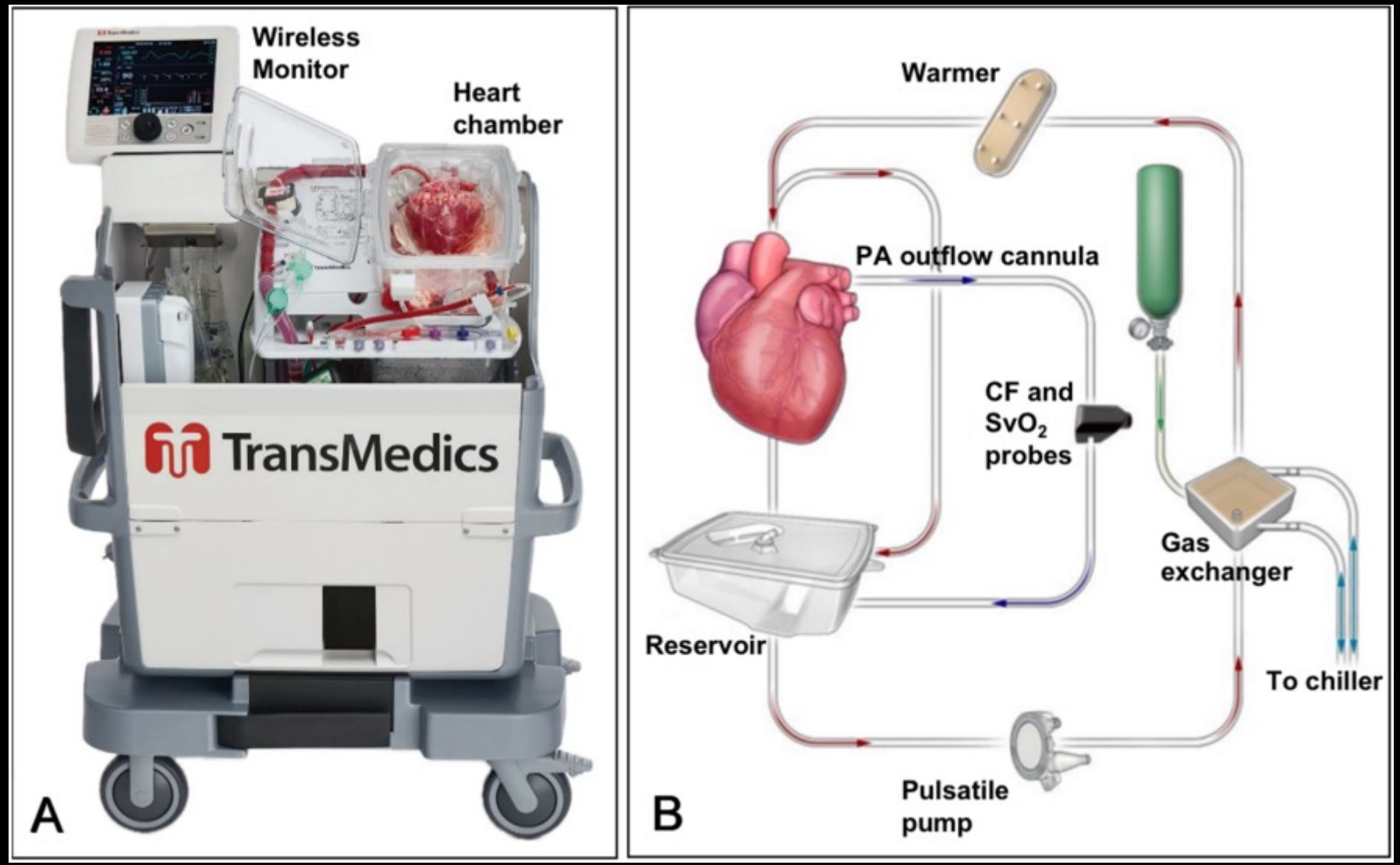

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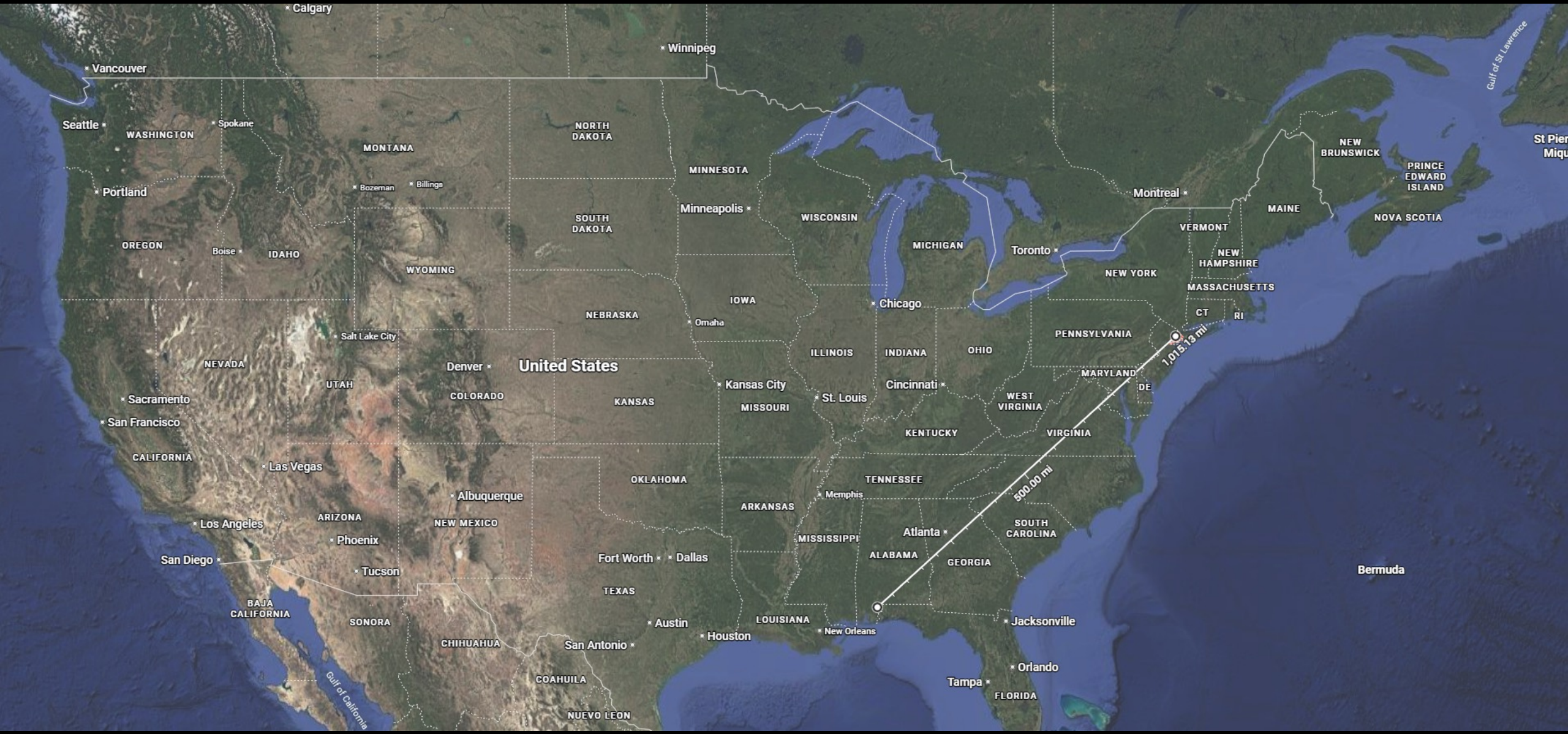
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BRIEF REPORT

Genetically Modified Porcine-to-Human Cardiac Xenotransplantation

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SUMMARY

A 57-year-old man with nonischemic cardiomyopathy who was dependent on venoarterial extracorporeal membrane oxygenation (ECMO) and was not a candidate for standard therapeutics, including a traditional allograft, received a heart from a genetically modified pig source animal that had 10 individual gene edits. Immunosuppression was based on CD40 blockade. The patient was weaned from ECMO, and the xenograft functioned normally without apparent rejection. Sudden diastolic thickening and failure of the xenograft occurred on day 49 after transplantation, and life support was withdrawn on day 60. On autopsy, the xenograft was found to be edematous, having nearly doubled in weight. Histologic examination revealed scattered myocyte necrosis, interstitial edema, and red-cell extravasation, without evidence of microvascular thrombosis — findings that were not consistent with typical rejection. Studies are under way to identify the mechanisms responsible for these changes. (Funded by the University of Maryland Medical Center and School of Medicine.)

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A 57-YEAR-OLD MAN WITH CHRONIC MILD THROMBOCYTOPENIA, HYPERtension, nonischemic cardiomyopathy, and previous mitral valve repair was hospitalized for severe heart failure with a left ventricular ejection fraction (LVEF) of 10%. His care was escalated to include multiple intravenous inotropic agents, and the placement of an intraaortic balloon pump was added on hospital day 11. Despite these measures, he had multiple ventricular arrythmias with arrests leading to resuscitation and began to receive peripheral venoarterial extracorporeal membrane oxygenation (ECMO) on hospital day 23.

The patient was deemed to have poor adherence to treatment, which is an exclusion criterion for allotransplantation and mechanical circulatory support. At the time that his condition was assessed by our hospital selection committee for advanced circulatory support, he had a 3-week history of nonambulatory status. His case was reviewed by two regional and two prominent national heart-transplantation programs, and the request for a transplant was denied by all four programs. Our selection committee agreed to consider experimental xenotransplantation. To offset the patient's history of poor adherence to treatment, enhanced postprocedure oversight was planned by the transplantation team. Although the patient favored a heart transplant from a human donor, he was informed of his options and agreed to undergo xenotransplantation.

Despite his biventricular heart failure, the patient had preserved renal function

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Article

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Pig-to-human heart xenotransplantation in two recently deceased human recipients

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Genetically modified xenografts are one of the most promising solutions to the discrepancy between the numbers of available human organs for transplantation and potential recipients. To date, a porcine heart has been implanted into only one human recipient. Here, using 10-gene-edited pigs, we transplanted porcine hearts into two brain-dead human recipients and monitored xenograft function, hemodynamics and systemic responses over the course of 66 hours. Although both xenografts demonstrated excellent cardiac function immediately after transplantation and continued to function for the duration of the study, cardiac function declined postoperatively in one case, attributed to a size mismatch between the donor pig and the recipient. For both hearts, we confirmed transgene expression and found no evidence of cellular or antibody-mediated rejection, as assessed using histology, flow cytometry and a cytotoxic crossmatch assay. Moreover, we found no evidence of zoonotic transmission from the donor pigs to the human recipients. While substantial additional work will be needed to advance this technology to human trials, these results indicate that pig-to-human heart xenotransplantation can be performed successfully without hyperacute rejection or zoonosis.

Heart failure is one of the leading causes of morbidity and mortality around the world, with more than 1 million new patients diagnosed with heart failure each year in the United States[1]. Despite maximal medical therapy, the mortality of heart failure patients is 50% within 5 years of diagnosis[2,3]. The definitive treatment for end-stage heart failure is orthotopic heart transplant, however, of the 6.2 million Americans living with this disease, approximately 3,500 patients receive a heart transplant annually[4,5]. An unlimited, renewable supply of organs independent of human donation could fundamentally transform the management of heart failure. The pig in particular is considered an ideal source of transplantable organs given the compatible anatomic size match, similar organ physiology, as well as ease of breeding and the favorable public perception of pigs as a source of life-saving organs[6–8].

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Transplantation of a genetically modified porcine heart into a live human

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Following our previous experience with cardiac xenotransplantation of a genetically modified porcine heart into a live human, we sought to achieve improved results by selecting a healthier recipient and through more sensitive donor screening for potential zoonotic pathogens. Here we transplanted a 10-gene-edited pig heart into a 58-year-old man with progressive, debilitating inotrope-dependent heart failure due to ischemic cardiomyopathy who was not a candidate for standard advanced heart failure therapies. He was maintained on a costimulation (anti-CD40L, Tegoprubart) blockade-based immunomodulatory regimen. The xenograft initially functioned well, with excellent systolic and diastolic function during the first several weeks posttransplantation. Subsequently, the xenograft developed rapidly progressing diastolic heart failure, biventricular wall thickening and, ultimately, near-complete loss of systolic function necessitating initiation of extracorporeal membranous oxygenation on day 31. Given these setbacks, the patient chose to transition to comfort care after 40 days. As with our first patient, histology did not reveal substantial immune cell infiltration but suggested capillary endothelial injury with interstitial edema and early fibrosis. No evidence of porcine cytomegalovirus replication in the xenograft was observed. Strategies to overcome the obstacle of antibody-mediated rejection are needed to advance the field of xenotransplantation.

Twenty-one months following the first genetically modified pig-to-human cardiac xenotransplant[1], we elected to perform a second procedure on 20 September 2023. Our decision was based on a lengthy evaluation of the first patient's 60 day survival[2]. We learned that the genetically modified pig heart was a good physiologic substitute for a human heart and that our previous screening protocol for porcine cytomegalovirus (PCMV) was not sufficient for the detection of latent virus. We also determined that the constellation of the first patient's preoperative frailty and pancytopenia limited full dosing of our preferred immunosuppressive and prophylactic antiviral regimen translated from our successful non-human primate (NHP) studies[3–6]. In the end, we could not definitively determine the contributions of PCMV and rejection to xenograft failure[2]. In this second case, we hoped to avoid these confounding factors. We used a more sensitive screening strategy for the detection of PCMV in the donor animal and accepted a patient with sufficient physiologic reserve to tolerate treatment.

Results

Patient characteristics

The patient was referred for xenotransplantation evaluation 3 months before the transplant as a limitedly ambulatory 58-year-old man with deteriorating heart failure due to ischemic cardiomyopathy and an ejection fraction (EF) of 15% after a previous three-vessel coronary artery bypass. His candidacy for standard allotransplant and mechanical circulatory support was curtailed by severe peripheral and central atherosclerotic vascular disease necessitating multiple percutaneous interventions. For this reason and for a severe recent gastrointestinal bleed, his case was declined for allotransplantation

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Meeting Report

OPEN

Advancing Hope Through Science: The Inaugural Richard Slayman International Workshop on Xenotransplantation

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Abstract. The inaugural Richard Slayman Clinical Xenotransplantation Workshop convened >140 participants from North America, Europe, and Asia to discuss emerging advances and challenges in translating xenotransplantation from bench to bedside. This report summarized key discussions spanning kidney, heart, and liver xenotransplantation, with an emphasis on clinical readiness and future directions. Core themes included the importance of patient selection, the role of genetic editing to reduce immune incompatibility, adaptive immunosuppressive strategies, novel molecular tools for immune and infectious surveillance, and the growing recognition of innate immune activation as a barrier to long-term graft survival. The workshop highlighted decedent models as a translational bridge, the use of machine perfusion in liver xenograft applications, and progress in living recipients. Notably, 1 patient achieved 9 mo of kidney xenograft function, underscoring the feasibility of extended survival in carefully selected candidates. Perspectives from patients and families, including a reflection honoring Richard Slayman, the first living recipient of a genetically edited pig kidney, framed the scientific dialogue within the broader human impact of this emerging field. The workshop marked a pivotal moment in aligning scientific, ethical, and regulatory efforts to advance safe and equitable access to xenotransplantation.

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CONSENSUS STATEMENT

The 2026 International Society for Heart and Lung Transplantation Consensus Statement on clinical cardiac xenotransplantation

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KEYWORDS:
Cardiac xenotransplantation; Gene-edited pigs; Immunosuppression; Zoonoses; Regulatory framework; Clinical trial readiness

1. THE ISHLT 2000 CONSENSUS REPORT

In the year 2000, the International Society of Heart and Lung Transplantation (ISHLT) issued a report from the xenotransplant advisory committee on the role of xenotransplantation in the treatment of end-stage cardiac and pulmonary diseases.[1] The consensus report acknowledged the urgent need for more thoracic organs and highlighted xenotransplantation as one potential solution. Significant hurdles were identified including challenging

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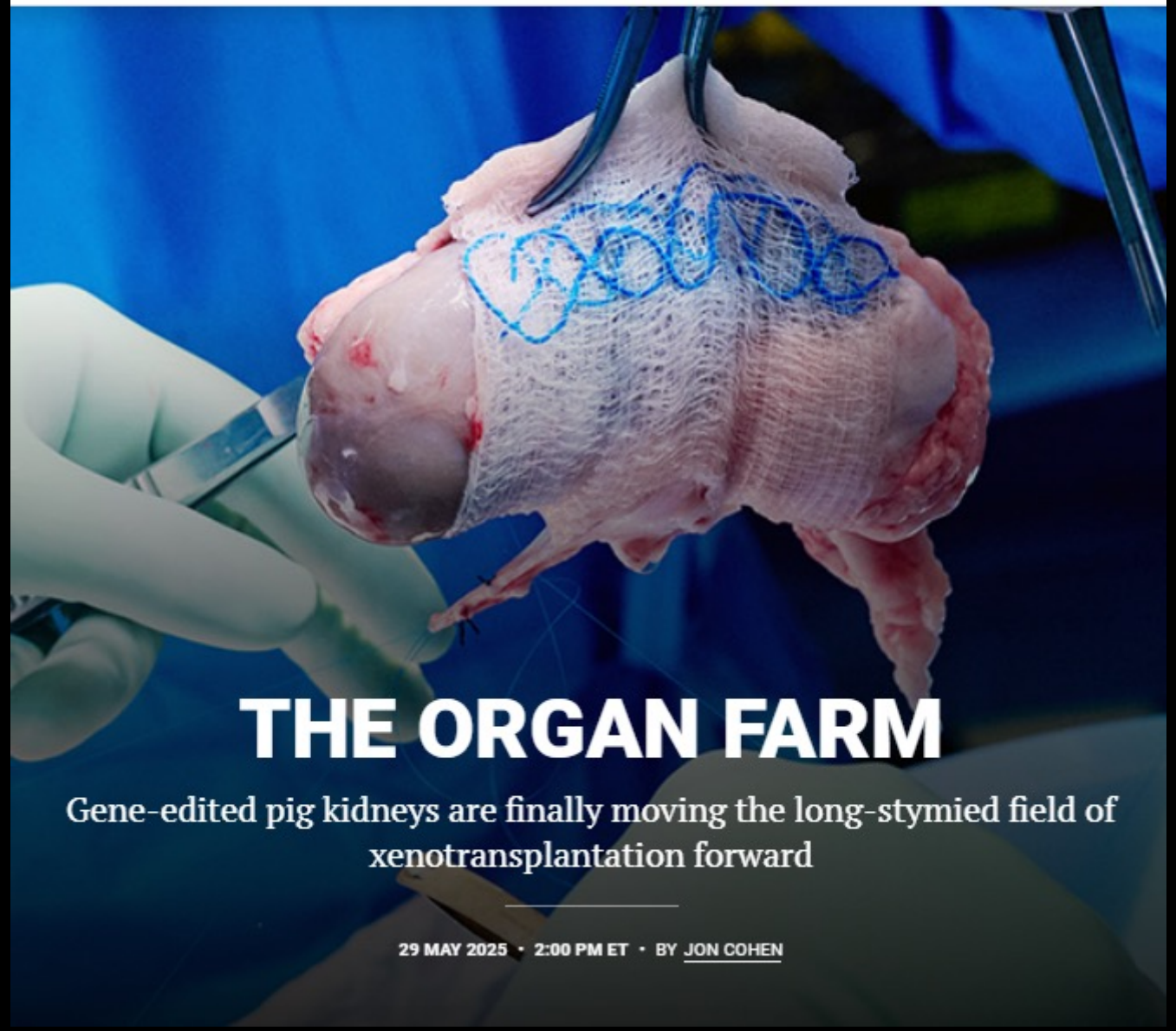
Science



THE ORGAN FARM

Gene-edited pig kidneys are finally moving the long-stymied field of xenotransplantation forward

29 MAY 2025 • 2:00 PM ET • BY JON COHEN

Surgeons make history, perform world's first fully robotic heart transplant

Michael Walter | *September 13, 2024* | *Cardiovascular Business* | *Cardiac Surgery*

Image courtesy of King Faisal Specialist Hospital & Research Center.

A heart team at King Faisal Specialist Hospital and Research Center (KFSHRC) in Riyadh, Saudi Arabia, made a bit of history, completing the world's first fully robotic heart transplant.

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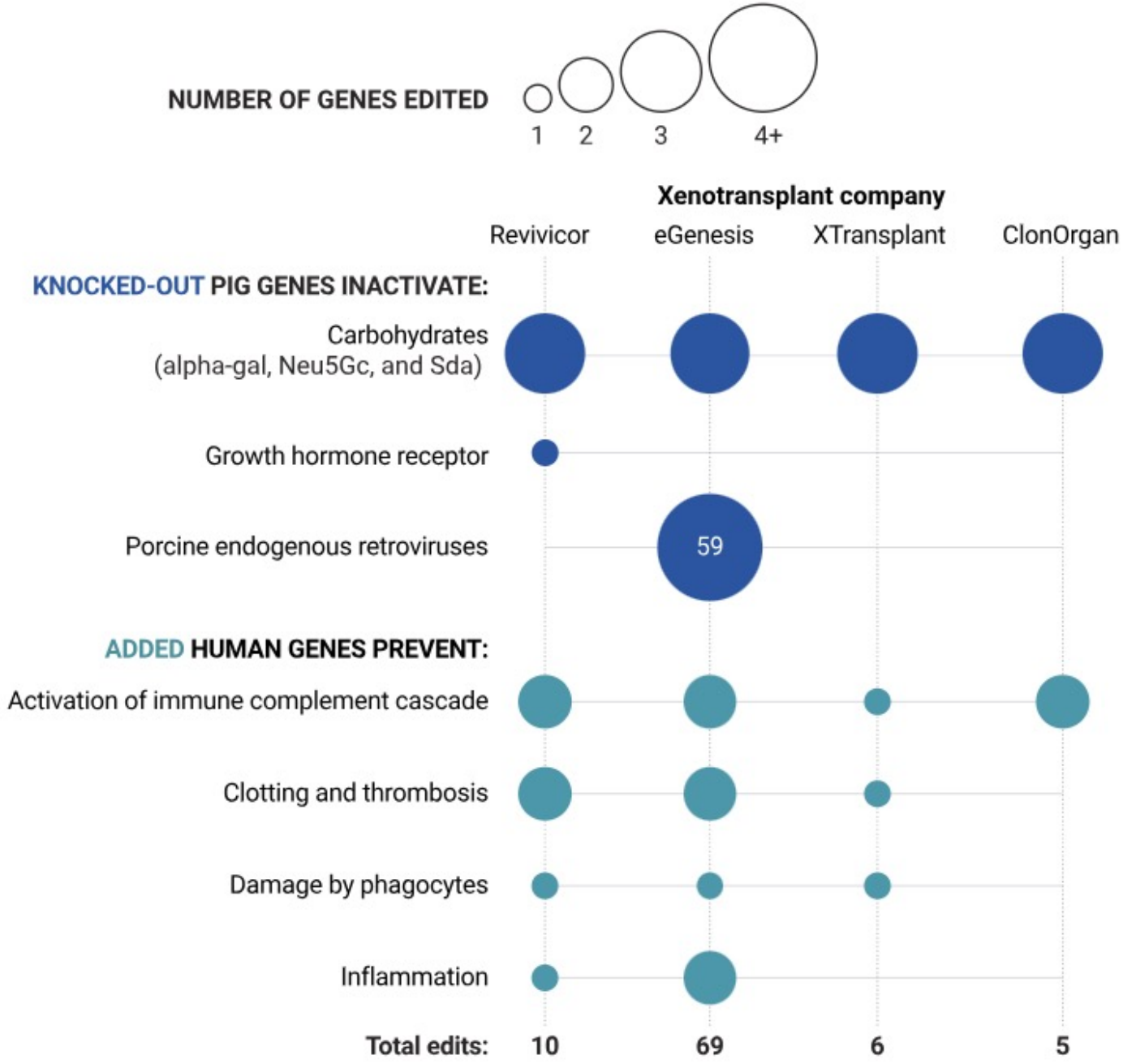

(GRAPHIC) M. HERSHER/*SCIENCE*; (DATA) REVIVICOR; EGENESIS; XTRANSPLANT; CLONORGAN