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COMMENTARIES

Defining Death: A Bioethical Examination of Donation by Circulatory Death (DCD) for Heart Transplantation

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The definition of death carries significant implications that reach far beyond the boundaries of social convention and age-old traditions, particularly in the context of organ transplantation. Donation after circulatory death (DCD) determines death based on the permanent cessation of circulatory function, whereas donation after brain death (DBD) is established by the irreversible loss of all brain activity. Healthcare systems worldwide apply these criteria differently, reflecting ongoing efforts to expand donor eligibility and address the severe organ shortage caused by rising demand for transplantation. Normothermic regional perfusion (NRP), a recently developed technique used exclusively within DCD protocols, restores oxygenated blood flow after cardiac arrest to reverse ischemia and preserve organ viability. Its introduction has sparked considerable ethical debate, particularly over whether reinstating circulation risks violating core principles that prohibit organ procurement before death is definitively established. The persistence of these unresolved questions highlights longstanding ambiguities in how death is defined under DCD compared with DBD and challenges the ethical framework underlying heart transplantation. In an effort to shed light on this ongoing debate, this article examines the legal, ethical, and medical arguments both supporting and opposing the use of NRP in DCD heart procurement.

INTRODUCTION

In 2023, there were 4545 heart transplants in the United States, the highest-ever number reported in a single year.[1] The number of patients requiring heart transplantation continues to rise as heart failure becomes increasingly prevalent. Although the United States achieved its highest number of heart transplants occurring annually since transplantation became available, the procedure remains out of reach for most patients with end-stage heart failure, as donor organ availability falls drastically short of clinical need.[2]

The first heart transplant, performed in 1967 by Dr. Christiaan Barnard, in South Africa, utilized donation after circulatory death (DCD). The donor was declared dead following the cessation of circulation, which involves permanent cessation of cardiac and respiratory function. This was the first and only standard of death during that time.

In contrast to DCD, the United States adopted the relatively stricter donation after brain death (DBD)—the irreversible loss of all functions of the entire brain and brainstem—as the sole legal criterion for determining death.[3] This was just one year after Dr Barnard's surgery, in 1968. Donation after brain death requires demonstration of coma, absence of brainstem reflexes, and complete cessation of breathing.[4,5] Furthermore, DCD remained unused as a heart transplantation criterion in the United States until the late 1990s, with only minimal adoption occurring between 1997 and 2007.[5]

There are five categories that result in DCD:

1. Death upon arrival to the hospital.
2. Unsuccessful resuscitation after cardiac arrest.
3. Planned withdrawal of life support treatment, resulting in circulatory arrest.
4. Circulatory arrest after declaration of brain death.
5. Euthanasia (where legal).

Heart organ donation is only performed in category three, planned withdrawal of life support. The criteria for DBD are less extensive than the criteria for DCD. Exploring both DCD and DBD offers insight into the complexities of defining death, highlighting how death determination standards vary across time and place, particularly when applied to heart transplantation.

Normothermic regional perfusion (NRP) is an emerging technology in organ transplantation that can be used for the recovery of organs in the abdominal or thoracic cavity after a donor is pronounced dead via DCD. Normothermic regional perfusion consists of in situ perfusion of a portion of the donor's body and is then aided with mechanical organ support.[6] One mechanical support often used is extracorporeal membrane oxygenation (ECMO). Originally developed for intraoperative cardiopulmonary bypass procedures, ECMO can also be used to preserve abdominal and thoracic organs after the death of the donor.[7] This emerging biomedical technology provides two key benefits: (1) reduced post transplantation complications that improve cost-effectiveness and (2) minimized ischemic damage to the transplant organ.[2]

There are two primary NRP subtypes. Thoraco-abdominal NRP (TA-NRP) perfuses both thoracic and abdominal organs, including the heart. While abdominal NRP (A-NRP) perfuses only abdominal organs, excluding the heart. The procedural subtypes not only differ in cannulation sites and the regions where perfusion occurs, but also in which organs can be safely procured. In TA-NRP, cannulas are placed in the aorta and right atrium, and the major cerebral arteries are occluded to prevent unintended reperfusion

of the brain. In A-NRP, cannulation is performed through the abdominal aorta and inferior vena cava, and an aortic occlusion balloon is used to prevent blood flow to the heart and brain.[8] After a mandatory five-minute observation period confirming permanent circulatory arrest, perfusion is initiated to preserve organ viability.

Debate around NRP intensified after the first NRP-assisted heart transplant (DCD-NRP) in the United States was performed at NYU Langone Health, whereas New York Presbyterian Hospital declined to adopt the technique following review by its ethics committee.[2] Supporters of DCD-NRP emphasize its potential to prevent ischemic injury, a major cause of donor heart nonuse, thereby expanding the pool of transplantable hearts and reducing preventable loss of viable organs. This article analyzes the legal, medical, and philosophical arguments on both sides of this debate.

DISCUSSION

The central ethical controversy surrounding NRP hinges on a fundamental question: What constitutes death? The Stanford Encyclopedia of Philosophy, which provides a comprehensive framework for the definition of death (both DCD and DBD), emphasizes a critical component: irreversible cessation of organismic functioning.[9] Medical and bioethical debates reveal considerable disagreement over the definition of death, particularly regarding the irreversibility criterion.[2] The ambiguity is introduced when distinguishing between DCD and DBD, as each employs distinct criteria regarding irreversibility that have evolved differently across medical institutions and legal jurisdictions. This article analyzes two perspectives: first, why physicians should *not* continue the use of DCD-NRP, exploring medical, legal, and philosophical implications that may challenge this procedure; and second, why physicians *should* continue the use DCD-NRP, exploring medical, legal, and social justifications that support it.

The Case Against NRP

Physicians should not be permitted to perform NRP procedures for heart transplantation. This technique has sparked considerable controversy within the medical community regarding whether it is ethically and medically sound to declare an individual dead, prepare their heart for donation, restore blood flow to the cardiac organ, and simultaneously prevent cerebral perfusion to avoid resumption of brain activity. The first part of the argument against NRP is regarding its contradiction to the definition of death and the irreversible cessation of organismic functioning. The second part of the argument against NRP is the ethical perspective that it is medically unsound to use one's body as *an incubator* when trying to preserve an organ, specifically the heart.

LEGAL PERSPECTIVE

The Uniform Law Commission (ULC) is a nonpartisan nonprofit organization that aims to study and review the laws of each state and determine what laws should be consistent in every state. The ULC drafted the Uniform Determination of Death Act (UDDA) of 1980. This Act provides two statutory definitions of death: "circulatory and respiratory functions irreversibly stopped, or all functions of the entire brain including the brainstem irreversibly stopped." The UDDA has been enacted in 37 of 50 states and has not been recognized at the federal level.[10] Furthermore, the use of DCD-NRP as a method for procuring hearts for organ transplantation raises ethical concerns from a legal standpoint. This procedure involves donors who have been declared dead following cardiac arrest, but then uses perfusion to restore heart function, raising concerns that NRP effectively reverses death and contradicts the definition of death.

PHILOSOPHICAL FOUNDATIONS

Some could argue that NRP violates two of the four principles of bioethics: beneficence and nonmaleficence. Beneficence requires that benefits be weighed against potential risks.[11] Critics could argue that when a procedure such as DCD-NRP provides clear benefits to recipients but carries uncertain risks to donors, particularly the unknown potential for reperfusion and restored consciousness in the donor. This scenario may violate beneficence by failing to ensure that the intervention does not harm the donor. Second, nonmaleficence, which states, above all or "first, do no harm,"[11] reinforces concerns about NRP, suggesting that the procedure may violate this foundational principle if the donor's death is not truly irreversible. In addition, for this reason, death by DCD is still against the law in several countries, including Switzerland, the Netherlands, Japan, and Australia.[12]

MEDICAL PERSPECTIVE

Research on patients with brain injury suggests the possibility for residual consciousness or pain perception in patients with compromised neurological states. In one study,[13] researchers found that patients who had had an extreme brain injury and could not physically respond to verbal commands were unresponsive; however, patients were able to create brain wave activity in response to those demands, meaning there were some levels of consciousness for patients in severe critical states, called cognitive motor disassociation or covert consciousness. Although still rare, out of a total of 193 patients in the research study, 27 (14%) were detected as having covert consciousness. Within one year, an estimated 79 (41%) had secret consciousness recovery, where brain wave activity was detected by customized artificial intelligence software applied to standard electroencephalogram signals while patients listened to specific mobility commands.[13]

A key medical concern surrounding DCD-NRP is the mandatory timeframe required between death declaration and perfusion for preservation of the donor's heart, which is five minutes. This narrow window of time raises the question of unintentional reperfusion that could potentially cause return of spontaneous cerebral and cardiac activity (ROSCCA). The return of spontaneous activity would invalidate the declaration of death, thereby also invalidating the donor's consent to donate their organ and prevent the physician from continuing transplantation. Shapey et al[14] described the two current clamping methods that prohibit ROSCCA when using NRP: the inflated occlusion balloon method and cross-clamping. The inflated occlusion balloon is placed in the thoracic aorta to prevent the reperfusion of organs above the diaphragm, except for the heart or the organ being transplanted. It also has the benefit of being minimally invasive. Cross-clamping is the most common method used in NRP and refers to the clamping of the thoracic aorta, preventing reperfusion.[14] Concerns remain that NRP with or without inflation of an intra-aortic occlusion balloon still does not assure that ROSCCA would not occur. Although safety measures have been implemented to prevent ROSCCA through noninvasive methods of observing cerebral and coronary blood flow, this does not eliminate the concern that such methods may lack the sensitivity to detect whether blood flow is truly occurring.[14] Furthermore, it raises the question of whether small amounts of blood flow might still be reaching the brain, undetected from the limitations of current technology.

REBUTTAL

Heart transplant surgeons often face the emotional burden of supporting families desperate to find a suitable donor for a loved one with heart failure. Securing a donor heart requires meeting specific objective criteria, including matching blood type, body size, urgency of the recipient's condition, and medical history. A criterion not often discussed is the race of donor or recipient. According to one study, 36,801 patients were waiting for their first heart transplant from 2005 to 2016 in the United States; 67% were white, 22% were African American, and 8% were Hispanic. African American patients had to wait the longest time, roughly 19.8 months—disproportionately longer compared with white and Hispanic patients, who waited an average of 12 and 12.3 months, respectively.[15] Addressing this gap requires expanding donation rates across all communities, particularly through targeted outreach and education in underrepresented populations, while maintaining equitable allocation systems based on medical need and free from implicit biases. More social and legal changes may need to be uncovered to ensure the disproportionately long waiting time experienced by African American patients does not continue to widen. New technologies or DCD-NRP may provide an additional supply of organs.

After the first-ever heart transplant using DCD donation, performed by Dr. Christiaan Barnard in 1967 in South Africa, the United States established in 1968 the criteria for DBD. These guidelines remained the standard for decades. However, as increasing numbers of patients died while waiting for transplants, the determination of death was revisited. Alamouti-fard et al[16] reported that in 2018, about 20% of organ donations in the United States came from DCD donations. The introduction of DCD with NRP created a new opportunity to expand the donor pool.

The Case for NRP

Physicians should be permitted to perform DCD-NRP as a standard for heart transplantation, allowing for the heart donation pool to substantially increase. Specifically, in recent years, DCD has increased the number of heart transplants by 15% to 30% and reduced the death rate in hospital waiting lists by 40%.[15] As noted in the previous rebuttal, the first-ever heart transplant was based on DCD, highlighting that the procedure was considered ethical from the beginning.

Another study indicates that DCD could again increase the heart transplant pool by 30% if widely adopted.[16] The philosophical principle of nonmaleficence is upheld through strict medical protocols that prevent cerebral reperfusion, ensuring donors experience no harm as they remain irreversibly dead without brain activity. Furthermore, the procedure aligns with beneficence by significantly increasing the number of available organs by expanding the transplant pool, thereby maximizing the life-saving potential for critically ill transplant recipients.

LEGAL PERSPECTIVE

According to the UDDA of 1980, the first criteria for death requires that the arrest of circulatory and respiratory functions must be irreversible. However, the Act does not specify whether irreversibility means that cessation cannot be reversed by any means, including the help of ECMO, or only that it cannot reverse spontaneously without intervention. The technical ambiguity creates a loophole: if irreversibility is interpreted as ruling out spontaneous reversal, then restoring circulation via bypass machines or ECMOs could technically comply with the UDDA, even though it contradicts the essence of requiring permanent cessation.[17] New York Code section 400.16 B states, "a determination of death must be made by accepted medical standards."[18] This allows us to conclude that the medical leaders at NYU Langone Health, where DCD-NRP was first used, were allowed to determine those medical standards, since the institution is within the state of New York, and whether those medical standards met the "determination of death of an individual who has sustained either: (1) irreversible cessation of circulatory and

respiratory functions; or (2) irreversible cessation of all functions of the entire brain, including the brainstem, is dead."[18] The DCD-NRP procedure and determination of death are deemed ethical.

PHILOSOPHICAL FOUNDATIONS

This moral argument has its foundation in *casuistry*, derived from the Latin *casus*, for case, a term now used primarily to refer to a method of using cases to analyze and propose solutions for moral problems.[10] Dr. Moazami, MD, the surgeon who performs DCD-NRP at NYU Langone Health, said that he has received negative feedback from ethicists who do not spend as much time or even little time with patients who are stuck on transparent lists, waiting months and even years for a matched organ donor. He stated in an interview in *The New York Times*,[2] "... if you have ever experienced that in your life, you will never tell me what I'm doing is unethical." Some argue that principles must still be weighed and balanced per the demands and nuances of the circumstances. From this perspective, beneficence is not violated by the law of bioethics.

Medical practitioners are carefully examining the risks and benefits of providing care to patients who obtain organ donations at a specific time, as well as making sure those organs are healthy enough to be transplanted. For this reason, philosophers such as John Mackie argue that ethics is "invented." Mackie does not mean that individuals create personal moral policies, but that "intersubjective standards" are built up over time through agreements and decision-making for bioethics. He states,[11] "What is morally demanded, enforced, and condemned is less a matter of what we discover in already available basic principles and more a matter of what we decide by reference to and in development of those principles." John Mackie's premise is exemplified by the shift in heart donation determination standards, when DCD was the criterion when the first heart transplant took place. However, technology changed, and DBD became the norm. This approach of ethical decision-making illustrates a broader pattern: standards do not merely change but often cycle to earlier frameworks as contexts evolve, a pattern reflected in transplantation practice.

MEDICAL PERSPECTIVE

Most donated hearts come from the small proportion of deaths involving brain-dead donors maintained on life support, which allows continuous circulation of oxygenated blood through the heart. The advent of DCD-NRP significantly expands the donor pool[16]—by up to 30%—making hearts available to many more patients in need. More importantly, DCD-NRP can recover hearts that would be nonviable under DBD protocols owing to ischemic damage from oxygen deprivation. The heart is an extremely oxygen-sensitive organ, requiring constant perfusion to maintain structural and functional integrity. Without continuous oxygenated blood flow, cardiac

tissue rapidly deteriorates, rendering the organ unsuitable for transplantation. Normothermic regional perfusion addresses this limitation by restoring circulation quickly after circulatory death, minimizing ischemic time and preserving organ quality.

According to NYU Langone Health's protocols, during an organ transplant, there must be a 5-minute interval between the heart of the donor stopping and the declaration of death; it must then be verified by a clinical observation, then by an electrocardiographic monitor.[19] This machine can track the electrical activity of direct blood pressure monitoring. The five-minute interval of non-resuscitation of the circulatory system falls within the parameters of the dead donor rule, which is the legal criteria for physicians to procure organs ethically, and the ULC's UDDA of 1980 and New York's regulation in the declaration of death.[17] After five minutes of noninterference and observation to confirm death along with no spontaneous resuscitation of the heart, the donor patient is considered a deceased organ donor. The law permits death determination by accepted medical standards, allowing medical institutions to establish protocols for the interval between death declaration and organ procurement. This broad statutory language grants individual medical teams and institutions the ability to determine whether procedures like NRP are ethically permissible, resulting in a variation of practices across healthcare systems. Lastly, when the donor heart relies on cardiopulmonary bypass support, this dependence demonstrates the irreversible nature of cardiac cessation, as the patient cannot survive without mechanical assistance. From January 2020 to May 2022, NYU Langone Health performed 18 heart transplants using the DCD-NRP protocol. The hospital has performed this procedure on 18 heart donors with a 100% organ recovery success rate, meaning all procured hearts met viability standards and were successfully transplanted.[19]

REBUTTAL

Medically speaking, regardless of whether the recirculation of blood comes from the donor or from the cardiopulmonary bypass machine, it violates the definition of death given in the UDDA and the New York Code, which state that death requires the irreversible cessation of circulatory and respiratory functions, or irreversible cessation of all functions of the entire brain, including the brainstem. Furthermore, the definition used for death must be in accordance with medical standards, meaning that criteria one and two (irreversible cessation of circulatory and respiratory functions and irreversible cessation of all functions) must be met for the definition to be acceptable. Regardless of *how* the cessation is reversed, it has been reversed.[17] Technological advancements are still unable to ensure that electrical activity of the brain does not occur. It remains unknown whether the clamping method of NRP (TA-NRP) definitively prevent cerebral reperfusion during cardiac resuscitation. The ability of irreversible cessation means that

circulation and respiration are prevented; therefore, the heart cannot restart spontaneously or be restored by any available technology. Bioethicists claim that the recirculation of blood invalidates any earlier declaration of death.

The first heart transplant was performed before advances in biomedical technologies such as cardiopulmonary resuscitation and tracheal positive pressure ventilation. These life-support technologies altered the definition of permanent cessation of breathing and heartbeat, requiring medical professionals to establish new criteria for death, because these advancements allowed for the reversal of respiratory and circulatory functions. At the same time, the brain function remains the only vital organ that was not reversible through current technologies at that time. Then in 1968, this medical breakthrough allowed for DBD as the standard for heart transplants.[19]

CONCLUSION

Despite medical advances, no single diagnostic tool or framework can definitively determine the precise moment of human death. This article illustrates how broad the definition of death truly is. The ULC recognizes that establishing the UDDA across nearly all states helps address a fundamental question at the center of ongoing debate: what constitutes death? The Commission also acknowledge that advancements in biotechnology have made the criteria for defining death increasingly complex, particularly in adhering to the requirement of irreversibility. Emerging technologies demonstrate an interesting paradox: they may provide solutions to complex dilemmas, but they sometimes exacerbate the original problem while exposing a deeper underlying issue that was never fully resolved. Heart transplantation technology exemplifies this phenomenon perfectly. Initially, it provided a solution by developing advanced surgical techniques that saved more lives than was possible before. However, these medical breakthroughs created other problems, such as organ shortages and bioethical dilemmas surrounding donor selection criteria and allocation priorities. The transplant technology exposed issues including inequities in healthcare access across different populations and fundamental philosophical questions about how society defines death itself. These are questions that are becoming increasingly urgent as medical technology advances beyond traditional means. Open discussion about the definition of death is essential in fostering dialogue on how death should be conceptualized within emerging healthcare modalities.

From the medical perspective, many in the field believe that the event of death has brought about a strict and rigid biological approach to its meaning: the process of a dying person, the process in between the two states, and the dead person. To this day we cannot determine when that exact time of death is. In the legal sense, time of death will follow the advancements of biomedical research and the most convincing evidence. The primary way of solving a complex issue such as this is to have as many different perspectives

as possible, including bioethicists, lawyers, hospital administrators, surgeons, physician specialists, patients, and representatives from civil society. They all play a vital role in the determination of what death is, especially as it pertains to DCD or DBD, making it important to hear information from different points of views that influence decision making, which can then be put into action by creating evidence-based policy. Addressing this starts with inquiry into what death is and whether it can be changed by external factors, like the environment, technology, or the supply and demand of organs.

The critical challenge remains: How do we define death in the current context, and what collaborative frameworks among medical professionals, researchers, ethicists, and policymakers must be developed to continuously refine this evolving definition as emerging biotechnologies and medical capabilities inevitably expand?

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