Organ transplantation is established therapy for many patients with a variety of end-stage diseases. The survival benefits are remarkable, as are the improvements in quality of life. Unfortunately, the supply of donor organs remains insufficient to meet the need.

Recently, through participation in the breakthrough collaboratives of the Health and Human Resources Administration, organ procurement organizations (OPOs) have become engaged in systems change through application of the principles of continuous improvement. So-called best practices are being shared by OPOs. This sharing, in turn, has created a level of synergy among OPO professionals and hospitals alike that is having a positive impact on the donor supply (Table 1).
Given way to disillusionment. Thus, dictably, frustration eventually eludes people who are consumed by the search for a “magic bullet.” Preliminarily, there will never be a single solution but a stark reality must be confronted: what constitutes a potential donor. Attempts are being made to redefine donation. In addition, concerted efforts are being made to improve use existing donors by expanding the traditional criteria for organ donation. It should come as no surprise that the possibility of DCD. Fortunately, critical care medicine has evolved to a point where practitioners increasingly recognize their changing obligations to patients in life, dying, and death. From this perspective, the practitioners not only are responsible for treating disease and trauma but also are committed to managing a dying process that results in a dignified death.

Currently, approximately 90% of patients who die in intensive care units (ICUs) do so after a decision to limit therapy.1 As a result, the treatment objective shifts from a curative to a palliative model of care, a shift that is directly relevant to DCD.

DCD creates unfamiliar challenges for many critical care nurses. In DCD, organ donation is considered before an unequivocal pronouncement of death. Thus, when DCD is an option, critical care staff must have an in-depth knowledge of end-of-life decision making and must be committed to the goal of providing compassionate care.

Communications between caregivers and patients’ families are already complex without introducing the possibility of DCD. Fortunately, the focus of a growing body of work is the provision of high-quality, compassionate, interdisciplinary care in these circumstances.

Under the conditions described here, organ procurement professionals are most effective when they are “partnered in” as integral members of the end-of-life care team and are highly skilled in counseling patients’ families about opportunities for

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**Table 1** Number of deceased organ donors and DCD donors from 1994 through 2004*

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of deceased donors</th>
<th>DCD donors</th>
<th>No. of OPOs recovering organs from at least 1 DCD donor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>5099</td>
<td>57</td>
<td>1.1% 22</td>
</tr>
<tr>
<td>1995</td>
<td>5362</td>
<td>64</td>
<td>1.2% 22</td>
</tr>
<tr>
<td>1996</td>
<td>5416</td>
<td>71</td>
<td>1.3% 21</td>
</tr>
<tr>
<td>1997</td>
<td>5478</td>
<td>78</td>
<td>1.4% 19</td>
</tr>
<tr>
<td>1998</td>
<td>5794</td>
<td>75</td>
<td>1.3% 16</td>
</tr>
<tr>
<td>1999</td>
<td>5824</td>
<td>87</td>
<td>1.5% 20</td>
</tr>
<tr>
<td>2000</td>
<td>5985</td>
<td>118</td>
<td>2.0% 30</td>
</tr>
<tr>
<td>2001</td>
<td>6079</td>
<td>169</td>
<td>2.8% 33</td>
</tr>
<tr>
<td>2002</td>
<td>6190</td>
<td>189</td>
<td>3.1% 30</td>
</tr>
<tr>
<td>2003</td>
<td>6427</td>
<td>270</td>
<td>4.2% 35</td>
</tr>
<tr>
<td>2004</td>
<td>7151</td>
<td>395</td>
<td>5.5% 41</td>
</tr>
</tbody>
</table>

Abbreviations: DCD, donation after cardiac death; OPO, organ procurement organization.

* Data from the United Network for Organ Sharing and the Organ Procurement and Transplantation Network.
organ donation. In this role, organ procurement professionals serve as “dual advocates,” striking a delicate balance between their commitment to patients awaiting transplantation and their concern and care for patients’ families who are faced with the important end-of-life decision about organ donation. This dual advocacy is possible only if the procurement professional is sensitive to the needs of each donor patient, the donor patient’s family, and prospective transplant recipients.

As a dual advocate, an organ procurement professional should make certain that grieving families are given the empowering opportunity of sparing other families from a similar grief. Through their gift of life, a patient’s family members can make the tragic death of their loved one meaningful and allow their loved one to leave behind a life-long legacy.

Understanding DCD

DCD, also known as non–heart-beating organ donation, is not a novel concept; it is the very foundation of modern transplantation. Before the Harvard Committee report in 1968, which established acceptable criteria for the determination of death based on neurological findings, all deceased or cadaveric donors were pronounced dead on the basis of cessation of cardiopulmonary function.2

Criteria for brain death gained acceptance in the 1970s. By the 1980s, every state had passed legislation enabling the recovery of organs from “brain-dead” patients maintained by using mechanical ventilation.

Because of concerns about the quality of organs obtained after cardiac death and about the outcome of transplantation of these organs, interest in DCD diminished in the United States and elsewhere. However, in some countries, including Japan, which has continued to struggle with the concept of brain death, and some European countries, interest in the use of DCD has been sustained.

The early 1990s saw a renewed interest among OPOs in pursuing DCD more routinely. This interest was the result of both dramatic increases in the number of patients on the transplant waiting list and recurring requests from patients’ family members who had made the decision to withdraw life support from their loved ones. Recognizing that withdrawal of life support meant imminent death, family members were requesting the opportunity to donate their loved one’s organs as a way to bring meaning to the families’ losses and to help others.

During the resurgence of DCD, a number of misinformed media reports created fear and trepidation in the donation and transplant community as well as in the general public. These reports led many healthcare professionals to question the practice of recovering organs after cardiac death. As a result of these concerns, the US Department of Health and Human Services asked the Institute of Medicine to review DCD procedures to ensure that interventions taken were in the best interest of the donor patient. The Institute of Medicine concluded that DCD is an ethically proper approach for recovering organs from a deceased patient for the purposes of transplantation.3,4 In addition, the ethics committee of the American College of Critical Care Medicine, Society of Critical Care Medicine published a position paper that not only indicated the ethical soundness of DCD but also offered a series of recommendations, including that donation of organs from infants and children after cardiac death should be offered routinely to patients’ families.2

Organ Donation After Brain Death

Approximately 95% of organ donations occur after the determination of brain death, which is defined as complete and irreversible loss of all brain and brain stem function. Upon determination of brain death, a patient is pronounced dead, and the time of death is established and recorded in the medical record. If the patient appears to be medically suitable for organ donation, hemodynamic and ventilatory support is continued until the patient’s family can be counseled about potential opportunities for organ donation. If the patient’s legal next-of-kin agrees to organ donation, these physiological support systems remain in place throughout organ evaluation and allocation and the surgical recovery of organs in the operating room.

Organ Donation After Cardiac Death

In contrast to organ donation after brain death, DCD is defined as the surgical recovery of organs after the pronouncement of death based on cessation of cardiopulmonary function. Patients considered for DCD most often have sustained a devastating and nonrecoverable neurological injury that does not culminate in brain death, and the patients’ family members have elected to withdraw life-sustaining therapies. Any patient who has sustained a nonrecoverable injury and for whom life support is being withdrawn can be considered for DCD; however,
most often only those patients who have sustained a nonrecoverable neurological injury are eligible.

After the decision to withdraw life support has been made, the patient is evaluated to determine whether death most likely will occur within a prede-termined period (generally 1 hour) after withdrawal of life support; this period is considered the maximum acceptable interval between withdrawal of support and recovery of organs for minimizing ischemic organ injury. If cessation of cardiorespiratory effort most likely will occur within this period and the patient otherwise seems to be medically suitable as an organ donor, then the patient’s family is counseled about the possibility of organ donation. In order to safeguard against conflicts of interest, the decision to withdraw life support must not be intertwined with the discussion of opportunities for organ donation.

If the patient’s legal next-of-kin agrees to donation, physiological support is continued through the evaluation-and- allocation phase, similar to the procedure in organ donation after brain death. Once the transplant teams arrive at the hospital, the patient is transferred to the operating room or a room close to the operating room for the withdrawal of life support. Life support is withdrawn in the presence of the caregiving team in the same fashion as it would be in the critical care unit. Once cardiorespiratory function has ceased, the patient is pronounced dead on the basis of cardiopulmonary criteria by the attending physician or the physician’s designee. After death is determined, the time of death is recorded in the medical record. The transplant team then waits for a preestablished time (5 minutes, according to Institute of Medicine guidelines, or up to 10 minutes, according to individual hospital protocols) and begins the surgical recovery of the organ or organs to be donated.

Procedures in DCD

Controlled Versus Uncontrolled DCD

In the United States, organ donations after cardiac death can be divided into 2 categories on the basis of the process and timing of the organ recovery: controlled and uncontrolled. Controlled donation most closely simulates the ideal conditions for organ recovery and therefore is the preferred scenario of most OPOs.

Although both controlled and uncontrolled situations are ethically appropriate, in this article, we primarily focus on controlled DCD, which is the preference covered in the critical pathway for DCD of the Organ Procurement and Transplantation Network/United Network for Organ Sharing. Table 2 compares and contrasts key elements of both controlled and uncontrolled DCD.

Critical Pathway for DCD

In 2001, the critical care advisory council of the Organ Procurement and Transplantation Network/United Network for Organ Sharing developed a critical pathway for DCD. The council consists of representatives not only from OPOs but also from the American Association of Critical-Care Nurses, American Association of Neuroscience Nurses, Society of Critical Care Medicine, National Medical Association, American Society of Transplant Surgeons, North American Transplant Coordinators Organization, and the Association of Organ Procurement Organizations. The pathway delineates roles and identifies courses of action to be taken in a brief, understandable format. It also encourages collaboration between the caregiving team and the OPO (Figure 1).

Preliminary Evaluation of Candidates for DCD

Potential organ donors after cardiac death, like potential donors after brain death, should be referred to an OPO when established clinical criteria or triggers are met. Also, as in donation after brain death, referral to an OPO is not synonymous with the request for donation; rather it is an opportunity to enter into dialog with the referring nursing and medical staff about the clinical situation of the potential donor. The established clinical trigger for referral to an OPO in neurologically injured patients is a score of 5 or less on the Glasgow Coma Scale. Because DCD is possible for patients with nonneurological injuries, all patients should be referred to an OPO when the patients’ families and physicians have decided that life-sustaining therapies will be withdrawn. Examples of potential DCD donors are patients with progressive neuromuscular degeneration such as amyotrophic lateral sclerosis and patients who have high spinal cord injuries (involving upper cervical cord segments C1 through C4) and are ventilator dependent. Other potential DCD donors are patients with significant cardiopulmonary diseases, such as patients who have cystic fibrosis or who use left ventricular assist devices, for whom the decision to withdraw life-sustaining therapies has been made. Referral of these potential donors allows the OPO, in collabora-
tion with the referring ICU team, to determine medical suitability and enables better counsel for the potential donors’ family members when the decision is made to discuss organ donation. Medical suitability of potential donors after cardiac death is determined by the OPO in the same manner as for potential donors after brain death.

Of note, discussion of organ donation does not occur until a patient’s physician and family have made a determination to forgo life-sustaining therapies. As with organ donation after brain death, organ donation in the DCD setting should be offered only after the patient’s family has processed the gravity of the clinical situation involving their family member. The conversation about organ donation should not be initiated by the family; it should, in all instances, be initiated by a certified requestor. However, sometimes the family members of a patient inquire about organ donation before the discussion of withdrawing life-sustaining treatment. Each situation is different, and the physician caring for the patient may elect to defer the discussion of organ donation or may call the OPO to provide additional information to the family. Also, when a referral is made in the DCD setting, a discussion of the stability of the patient’s hemodynamic condition is important. With potential donors after cardiac death, in contrast to potential donors after brain death, a do-not-resuscitate order has often been entered before any discussion has occurred about withdrawal of life support or organ donation. In these instances, adequate physiological support must be maintained for organ preservation in the event that organ donation is ultimately the choice of the patient or the patient’s family.

**Prediction of Death**

After the decision has been made to withdraw life-sustaining therapy

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Differentiation of controlled and uncontrolled donation after cardiac death (DCD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
<td><strong>Controlled</strong></td>
</tr>
<tr>
<td>Case characteristics</td>
<td>Patient sustains nonrecoverable injury</td>
</tr>
<tr>
<td></td>
<td>Family elects to withdraw support in collaboration with hospital care team</td>
</tr>
<tr>
<td></td>
<td>If organ procurement organization (OPO) not previously notified, patient referral is made</td>
</tr>
<tr>
<td></td>
<td>Overall stability of patient’s condition is aggressively maintained</td>
</tr>
<tr>
<td>Withdrawal decision/family approach</td>
<td>Once the family has communicated its decision to withdraw life support, the OPO presents the opportunity for DCD in a supportive environment.</td>
</tr>
<tr>
<td></td>
<td>Withdrawal typically occurs in a progressive, controlled fashion</td>
</tr>
<tr>
<td></td>
<td>Time to discuss all aspects of the process may be unlimited</td>
</tr>
<tr>
<td>Withdrawal of support/recovery process</td>
<td>All aspects of withdrawal and organ recovery are collaboratively planned among the family, caregiving team, and OPO</td>
</tr>
<tr>
<td></td>
<td>Possibility for coordination of ideal circumstances exists</td>
</tr>
<tr>
<td></td>
<td>Withdrawal is done in the operating room</td>
</tr>
<tr>
<td></td>
<td>Caregiving staff are in attendance</td>
</tr>
<tr>
<td></td>
<td>Recovery teams are present, and organ preservation process is ready</td>
</tr>
<tr>
<td></td>
<td>Family has adequate time for closure and rituals</td>
</tr>
</tbody>
</table>
The following health care professionals may be involved in the Donation After Cardiac Death (DCD) donation process:

- Physician (MD)
- Critical Care RN
- Nurse
- Medical Examiner
- Respiratory Therapist (RT)
- Laboratory
- Pharmacy
- Radiology
- Anesthesiology
- OR/Surgery Staff
- Clergy
- Social Worker
- Organ Procurement Coordinator (OPC)
- Organ Procurement Organization (OPO)

### Phase I: Identification & Referral

- Prior to withdrawing life support, contact local OPO for any patient who fulfills the following criteria:
  - Devastating neurologic injury and/or other organ failure requiring mechanical ventilatory or circulatory support
  - Family and/or critical care giving team initiate conversation about withdrawal of support

- Following referral, additional evaluation is done collaboratively to determine if death is likely to occur within one hour (or within a specified timeframe as determined by care giving team and OPO) following withdrawal of support

- Patient conditions might include the following:
  - Ventilator dependent for respiratory insufficiency: apneic or severe hypopnic; tachypnea ≥ 30 breaths /min after DC ventilator
  - Dependent on mechanical circulatory support (LVAD; RVAD; V-A ECMO; Pacemaker with unassisted rhythm < 30 beats per minute
  - Severe disruption in oxygenation: PEEP ≥ 10 and SaO₂ ≤ 92%; FiO₂ ≤ .50 and SaO₂ ≤ 92%; V-V ECMO requirement
  - Dependent upon pharmacologic circulatory assist: Norepinephrine, epinephrine, or phenylephrine ≥ 0.2 ug/kg/min; Dopamine ≥ 15 ug/kg/min
  - IABP and inotropic support:
    - IABP 1:1 and dobutamine or dopamine ≥ 10 ug/kg/min and CI ≥ 2.2 L/min/M²; IABP 1:1 & CI ≤ 1.5 L/min/M²

### Phase II: Preliminary Evaluation

- Physician
  - Supportive of withdrawal of care and has communicated grave prognosis to family
  - Review DCD procedure with OPC
  - Will be involved in withdrawal/pronouncement

- Will designate a person to be involved with withdrawal and/or pronouncement

- Family
  - Has received grave prognosis
  - Understands prognosis
  - In conjunction with care giving team, decide to withdraw support

- Patient
  - Age __________
  - Weight __________
  - Height __________
  - ABO __________
  - Medical Hx ______
  - Surgical Hx ______
  - Social Hx ______
  - Death likely < 1 hour following withdrawal (determined collaboratively by evaluating: injury, level of support, respiratory drive assessment)

### Phase III: Family Discussion & Consent

- Support services offered to family
- OPC/Hospital staff approach family about donation options
- Legal next-of-kin (NOK) fully informed of donation options and recovery procedures
- Legal NOK grants consent for DCD following withdrawal of support
- Family offered opportunity to be present during withdrawal of support
- OPC obtains Witnessed consent from legal NOK for DCD
- Signed consent
- Time ______
- Date ______
- Detailed med/sec history

### Phase IV: Comprehensive Evaluation & Donor Management

- MD, in collaboration with OPO, implements management guidelines
- Establish location and time of withdrawal of support
- Review plan for withdrawal to include:
  - Pronouncing MD (should be in attendance for duration of withdrawal of support, determination of death, and may not be a member of the transplant team)
  - Comfort Care
  - Extubation and discontinuation of ventilator support
  - Establish plan for continued supportive care if pt survives > one hour or predetermined time interval after withdrawal of support

- Notify OR/Anesthesia
  - Review patient’s clinical course, withdrawal plan and appropriate organ recovery procedures
  - Schedule OR time

- Notify recovery teams
- Prepare patient for transport to prearranged area for withdrawal of support

### Phase V: Withdrawal of Support / Pronouncement of Death/Organ Recovery

- Withdrawal occurs in:
  - OR
  - ICU
  - Other

- Family present for withdrawal of support:
  - yes
  - no

- OR/Room prepared and equipment set up
- Transplant team in the OR (not in attendance during withdrawal)
- Care giving team present
- Administration of pre-approved medication (e.g., Heparin/Regitine)
- Withdrawal of support according to hospital/MD practice guidelines

- Time ______
- Date ______

- Vital signs are monitored and recorded every minute (see attached sheet)
- Pt pronounced dead and appropriate documentation completed

### Phase VI: Transplant Team Initiates Surgical Recovery

- Transplant Team
  - Surgical recovery at prescribed time following pronouncement of death

- Allocation of organs per OPTN/UNOS policy

- If cardiac death not established within 1 hour or predetermined time interval after withdrawal of support – Stop Pathway. Patient moved to predetermine area for continuation of supportive care.

- Post mortem care administered

---

*Continued*
and the OPO has determined the medical suitability of a patient for organ donation, a determination must be made about whether the patient will die within a time frame consistent with donation. Hypoxia and hypotension develop within variable periods after a patient is extubated and all other life-sustaining...
therapies (eg, use of vasopressors) are withdrawn, a situation that results in some ischemic damage to vital organs. A period of 1 hour from extubation and withdrawal of support to pronouncement of death is usually considered consistent with organ donation; this time frame may also be increased depending on the stability of the patient’s condition after withdrawal of life support. If the patient does not experience circulatory arrest within the designated time frame, organ recovery does not proceed because of the high likelihood that the organs will not function after transplantation.

When the option of DCD is discussed with a patient’s family, the requestor for donation must accurately convey that additional time will be necessary to get a surgical team on site, run the necessary serological tests required for organ donation, and allocate recovered organs to appropriate recipients.

Because many patients referred as potential DCD donors are not suitable candidates, the question of how suitability is determined is of paramount importance. Information about the clinical situation of a patient may be helpful but is often not predictive. In an effort to develop objective criteria for determining whether a patient is a suitable candidate for DCD, a scoring tool was developed by the University of Wisconsin. This tool is essentially an assessment of respiratory drive that is used to predict the likelihood of continued spontaneous respirations beyond 1 and 2 hours after extubation. Figures 2 and 3 depict the information collected and the scoring system used to make the prediction. Because this assessment requires that mechanical ventilation be stopped for a brief time, the procedure should be clearly explained to the patient’s family, and consent should be obtained.

In 2003 and 2004, the University of Wisconsin OPO had 83 referrals for DCD in which the evaluation tool

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**Figure 2** Information collected from referring hospitals for evaluation of a patient’s suitability for organ donation after cardiac death.

Abbreviations: BP, blood pressure; pulse ox, pulse oximetry; RT, respiratory therapist.

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was used. On the basis of the findings with the tool, 27 patients were not considered potential candidates for DCD. For the remaining 56 patients, the scores provided an accurate prediction that 53 (94.6%) would die within 1 to 2 hours. When the option of DCD is discussed with patients’ families, as well as with medical and nursing staff, it is important to communicate that 5% to 10% of patients will not have circulatory arrest in a time frame consistent with organ donation, and in such instances, the primary team responsible for the patient will continue end-of-life care.

The scores on the tool were also predictive, but at a somewhat lower rate, of those patients who would have spontaneous respirations beyond 2 hours after extubation. The scores were accurate in 22 (81.5%) of 27 cases; 5 potential donations were missed. The current policy of the University of Wisconsin OPO is to send a team for patients with scores greater than 12 on the evaluation tool, because scores of 12 or less are less predictive. At the request of the patients’ families, the OPO sent recov-

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Assigned points</th>
<th>Pt. score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spontaneous respirations after 10 min.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate &gt;12</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Rate &lt;12</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>TV &gt;200 cc</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>TV &lt;200 cc</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>NIF &gt;20</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>NIF &lt;20</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>No spontaneous respirations</strong></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
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<td></td>
</tr>
<tr>
<td>&lt;25</td>
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<td></td>
</tr>
<tr>
<td>25-29</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&gt;30</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Vasopressors</strong></td>
<td></td>
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</tr>
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<td>No vasopressors</td>
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</tr>
<tr>
<td>Single vasopressor</td>
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<td></td>
</tr>
<tr>
<td>Multiple vasopressors</td>
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<td></td>
</tr>
<tr>
<td><strong>Patient age</strong></td>
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</tr>
<tr>
<td>0-30</td>
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<td></td>
</tr>
<tr>
<td>31-50</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&gt;30</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Intubation</strong></td>
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</tr>
<tr>
<td>Endotracheal tube</td>
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<tr>
<td>Tracheostomy</td>
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<td></td>
</tr>
<tr>
<td><strong>Oxygenation after 10 minutes</strong></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>O₂ sat &gt;90%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O₂ sat 80-89%</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>O₂ sat &lt;79%</td>
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</tr>
<tr>
<td><strong>Final score</strong></td>
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<td></td>
</tr>
<tr>
<td>Date of extubation</td>
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</tr>
<tr>
<td>Time of extubation</td>
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<td>Date of expiration</td>
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<td></td>
</tr>
<tr>
<td>Time of expiration</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total time</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3** Scoring system for Donation After Cardiac Death Evaluation Tool.

Abbreviations: BMI, body mass index; NIF, negative inspiratory force; O₂ sat, oxygen saturation; Pt, patient; TV, tidal volume.

Reprinted with permission from the University of Wisconsin Hospitals and Clinics Authority.
ery teams in 6 instances in which the score was 12 or less, and although organs were not recovered, each family was appreciative of the OPO’s efforts and support, and each instance was an educational opportunity for the nursing and medical staff of the referring hospital.

Medical Management

Medical management of potential donors after cardiac death is similar to that for potential donors after brain death. However, because patients suitable for DCD have not progressed to brain death and therefore have not experienced the catecholamine release induced by brain death, their hemodynamic status tends to be more stable. In one study, 76.9% of patients who donated organs after brain death required vasopressor support, whereas only 33% of those who donated after cardiac death required such support. As previously mentioned, even if a do-not-resuscitate order is in place, physiological support of the major organ systems should be maintained in potential donors after cardiac death to preserve the option for donation. Once a patient has been determined to be a suitable candidate for DCD and the patient’s family has consented to donation, the do-not-resuscitate status should be discussed. The family should be informed that physiological support must continue until the team arrives for the withdrawal of support and recovery of organs. Consideration should be given to suspending the do-not-resuscitate order during this period.

Because potential candidates for DCD cannot be declared brain dead, the primary treating team, not the OPO, is responsible for medical management of these patients. Medical management consists of maintaining good oxygenation, a systolic blood pressure greater than 90 mm Hg, adequate urine output, a normal electrolyte balance, and hematological and coagulation profiles within normal reference ranges. Assessment of individual organ function for kidney, pancreas, liver, and lung donation is similar to that for patients who donate organs after brain death.

Withdrawal of Physiological Support and Determination of Death

Once a patient is determined to be a suitable candidate for DCD, a number of logistic issues must be considered. Unlike donation after brain death, in which death is declared on the basis of neurological criteria and all donors are conveyed to the operating room, withdrawal of support and declaration of death in DCD may occur in a number of locations before the donor is conveyed to the operating room for organ recovery. The decision about where support will be withdrawn should always be based on the needs of the patient’s family. Support may be withdrawn in the operating room, with or without the family in attendance; in the ICU; or in a room near or adjacent to the operating room. All options should be discussed with the family, including which organs may or may not be recovered.

If support is withdrawn in the ICU and additional warm ischemia occurs during transport to the operating room after the patient dies, organ viability may be affected. Generally, kidneys can be recovered in all cases, but because use of extrarenal organs from DCD donors is fairly new, most extrarenal organs are recovered from patients who have had support withdrawn in the operating room. Because medical and nursing personnel in the operating room may not be familiar with the potential organ donor and may not know why life-sustaining therapies are being withdrawn, it is important for the OPO staff to discuss this information, in addition to the actual logistics of withdrawal of life support and surgical recovery, with operating room personnel.

If withdrawal of support occurs in the operating room with the patient’s family in attendance, additional logistical considerations must be addressed. In this setting, the nursing and surgical organ recovery teams should not be in the operating room, and only a limited number of people should be present, namely, the physician responsible for withdrawing life support, the patient’s family, an OPO staff member, and the ICU nurse who was caring for the patient. The patient may or may not be draped, depending on the family’s wishes; the family members should wear operating room suits over street clothes, usually with surgical hats and masks.

Before withdrawal of support, a clear plan should be devised to determine who will withdraw support and declare death. The physician who withdraws support should be experienced in end-of-life care and cannot be a member of the OPO team or the transplant team. This physician may be the patient’s primary physician or an intensivist, an on-call physician, or an ICU fellow with end-of-life training. Physicians inexperienced in end-of-life care, as well as residents and interns, should not be called on in DCD.

In addition, before withdrawal of life support and during the dis-
discussions with a patient’s family about the process of DCD, separate consent should be obtained for any medications or invasive procedures that are required before withdrawal. The administration of any medications that are not usually given in the care of a dying patient but may improve the likelihood of a successful transplant should be discussed with the patient’s family. This discussion should include a disclosure of potential risks to the donor. The most common medications administered before withdrawal of support are heparin, an anticoagulant, and phentolamine, an α-adrenergic blocker. Heparin prevents thrombosis of small blood vessels, and phentolamine prevents vasospasm, allowing improved flushing of the solution used to preserve organs. The patient’s family as well as medical and nursing staff must understand that the intent of the administration of these medications and procedures is to improve organ function after recovery and not to hasten the death of the potential donor.

Although the majority of patients who donate organs after cardiac death are adults, both the University of Wisconsin and the Gift of Life Donor Program have successfully coordinated DCD in children; infants and children have accounted for approximately 30% of all donations after cardiac death in the combined experience of the 2 organizations. The logistic considerations in children in DCD are similar to those in adults; however, most parents and family members choose to be with their child when life support is withdrawn, and some choose to be with the child after organ recovery. Also, the DCD evaluation tool is not applicable to small children and infants and, as a result, is currently being modified for use in such patients. The potential for DCD in children is significant. In an analysis of deaths in a children’s hospital, Koogler and Costarino\(^4\) found that routine use of DCD had the potential to increase organ donation by 42% in a single center.

Once consent is obtained and logistic considerations are addressed, life support is withdrawn by discontinuing any medications (eg, vaso-pressors) and extubating the patient. During the withdrawal phase of the process, the patient’s oxygen saturation, blood pressure, and urine output are recorded. These data will help determine the amount of warm ischemic injury to the recovered organs. Because circulatory arrest is essential in the determination of death, an arterial catheter and monitor are necessary to determine the time of circulatory arrest. If use of an arterial catheter is not possible, bedside cardiac echocardiography may be used.

Once circulatory arrest occurs and respiration ceases, a period of observation is required before organ recovery can begin. For most OPOs, this period is 5 minutes, as recommended by the Institute of Medicine, and is used to observe the patient for autoresuscitation. However, because no recorded cases of autoresuscitation have occurred after 65 seconds, a few OPOs use 2 minutes as the observation period. (Autoresuscitation refers to the return of any cardiac mechanical activity; if this rare event occurs, the observation period is reset to zero and begins again after loss of circulatory activity.) Of note, the observation period begins with documentation of circulatory arrest and not with electrocardiographic silence.

After the observation period and declaration of death by the physician who is withdrawing life support, the surgical recovery team can immediately begin flushing preservation solutions and then start the surgical procedure, if withdrawal occurred in the operating room. If withdrawal of support occurred in the ICU or in a room near the operating room, transport to the operating room may begin during or after the observation period, in accordance with the family’s wishes, with organ recovery beginning after the conclusion of the observation period and the declaration of death.

Perfusion of the organs with cold preservation solutions is achieved via aortic cannulation. The time from extubation to the start of perfusion of the organs with cold solution is also recorded as the warm ischemic time and is used to help guide the determination as to which organs are suitable for transplantation.

The organs recovered after cardiac death may be kidneys only or kidneys and extrarenal organs such as the liver, pancreas, and lungs. Patients 50 years and older are considered for kidney donation only; patients less than 50 years old are considered for both kidney and extrarenal donation. However, no absolute age cut-off exists, and extrarenal organs from patients more than 50 years old have been successfully transplanted. The recovery of extrarenal organs also depends on the time from withdrawal of support to the start of perfusion with cold solutions. If that time exceeds 30 minutes, the liver may not be recovered, and if it exceeds 45 minutes, the pancreas may not be recovered. In the majority of donors, this time does not exceed 1 hour.
However, a small number of donors may have a period of relative stability after withdrawal of life support, and in such cases, this time may be extended beyond 1 hour without additional warm injury to the organs.

If kidneys are the only organs being recovered, the surgical procedure is similar to kidney recovery in donation after brain death and occurs after the kidneys are flushed with preservation solution (predominantly the conventional solution developed by the University of Wisconsin or, as done recently in a few cases, histidine-tryptophan-ketoglutarate solution). Machine preservation of kidneys appears to substantially reduce the rate of delayed graft function, especially in DCD.9

If extrarenal organs are being recovered in addition to the kidneys, the procedure differs substantially from that used in donation after brain death. Because warm ischemia may injure organs obtained after cardiac death, the organs must be flushed and removed rapidly by using en bloc techniques of recovery. This procedure differs from procedures in donation after brain death, in which individual organs are dissected in situ. In DCD, the organs are dissected ex vivo after they are removed en bloc.

The University of Wisconsin has developed the en bloc technique depicted in Figure 4.10 Briefly, after the chest and abdomen are opened, the thoracic aorta is clamped, and all abdominal organs are removed, beginning at the diaphragm. The distal ureters, aorta, and vena cava are divided, and the distal esophagus and sigmoid colon undergo gastrointestinal anastomotic stapling. Additional preservation solution is infused ex vivo into the renal, superior mesenteric, and celiac arteries and into the superior mesenteric vein. If lungs are being recovered, after the surgical procedure has begun, the physician replaces the endotracheal tube to oxygenate and inflate the lungs before stapling the bronchus so that the lungs can be preserved and transported while they are inflated.

Transplant Outcomes in DCD

Kidney Transplantation

The results of transplantation of kidneys from DCD donors have been similar to results with kidneys obtained after brain death. In an analysis in 2002 of data from the Scientific Registry of Transplant Recipients, Rudich et al11 compared 97,990 recipients of kidneys from heartbeating deceased donors with 708 recipients of kidneys from non–heart-beating donors (ie, DCD donors). The results showed no differences between the 2 groups in 6-year death-censored survival of recipients (cases in which the recipient died with functioning kidneys were not treated as graft failures) and grafts.11 However, recipients of kidneys from DCD donors had higher rates of delayed graft function and primary nonfunction, whereas recipients of kidneys from living donors had higher rates of thrombosis and graft loss from rejection. Cooper et al12 compared 382 recipients of kidneys obtained after cardiac death with 1089 recipients of kidneys obtained after brain death. Although recipients of kidneys

Figure 4 En bloc technique of abdominal organ recovery in organ donation after cardiac death.
Reprinted from D’Alessandro et al,10 with permission from Lippincott Williams & Wilkins.
from DCD donors had a higher rate of delayed graft function (27.5% vs 21.3%, \(P=.02\)) and a higher creatinine level at discharge (1.9 vs 1.7 mg/dL, \(P=.001\)), the 2 groups of recipients did not differ in primary graft nonfunction, rate of complications, or 5- and 10-year graft survival (65% and 45%, respectively, vs 71% and 48% for kidneys obtained after brain death). Weber et al\(^\text{13}\) likewise found no difference in delayed graft function and higher creatinine levels at 7 days in recipients of kidneys from nonliving donors. In a more recent analysis,\(^\text{14}\) the Scientific Registry of Transplant Recipients found no difference in the relative rate of graft failure when 35,290 kidneys from non-DCD donors were compared with 1258 kidneys from DCD donors (hazards ratio 1.00 vs 1.05, \(P=.48\)); 3-year adjusted graft survival also did not differ between the groups. Clearly, on the basis of these studies as well as others,\(^\text{11-13}\) all OPOs and donor hospitals should be offering the option of DCD to patients’ families and all transplant centers should be using organs obtained after cardiac death for transplantation. Because the largest number of patients on national waiting lists are potential kidney recipients, DCD renal donation could have a major impact on reducing the number of patients in need of a kidney transplant.

Pancreas Transplantation

The first series of simultaneous pancreas-kidney transplants from DCD donors was reported by D’Alessandro et al\(^\text{10}\) in 2000. This series was followed by a comparison of 31 recipients who received transplants obtained after cardiac death with 45 who received transplants obtained after brain death.\(^\text{16}\) The University of Wisconsin has subsequently performed an additional 16 simultaneous pancreas-kidney transplants for a total of 47 transplantations of these organs from DCD donors. As in renal transplantation, the rate of delayed graft function was higher for transplants from DCD donors (25.8% vs 5.3%, \(P=.001\)); however, no differences were detected in pancreatic function as measured by postoperative serum levels of amylase, glucose, and hemoglobin \(A_1C\).

Except for a higher rate of urinary tract infections in recipients of organs from DCD donors, the 2 groups of recipients had no differences in postoperative complications. Serum levels of glucose and hemoglobin \(A_1C\) 6 months after transplantation also did not differ between the groups. In addition, 5-year graft survival rates did not differ; pancreas and kidney survival rates were 79.1% and 79.2%, respectively, for organs obtained after cardiac death and 79.2% and 81.8%, respectively, for organs obtained after brain death.

In this study,\(^\text{16}\) the mean warm ischemic time (ie, time from extubation until the start of perfusion with cold solution) for organs from DCD donors was 15.3 minutes; the cold ischemic time (ie, time from the cross clamping of the aorta to reperfusion) was similar for both groups (approximately 16 hours for the pancreas and 17 hours for the kidney).

These results indicate that transplantation of pancreases from DCD donors yields results that are no different from those for pancreases from donors with brain death. Although pancreases from donors with brain death currently may be underused in the United States, pancreases from DCD donors have the potential to markedly decrease the size of the waiting list for pancreas transplantation, particularly if DCD donors are also considered as a source for islet cell transplants.\(^\text{17}\)

Liver Transplantation

Transplantation of livers from DCD donors is more complex because of the susceptibility of the liver parenchyma and biliary epithelia to warm ischemia and the severity of illness in patients in need of a liver transplant. In an early study,\(^\text{15}\) from the University of Wisconsin on 19 liver transplants from non–heart-beating donors, no difference was noted in recipient and graft survival or rate of biliary complications between recipients of livers from non–heart-beating donors and recipients of livers from heart-beating donors. Other early single-center reports were similar,\(^\text{18-21}\) although Abt et al\(^\text{22}\) found an increased incidence of biliary tract complications in recipients of livers from non–heart-beating donors.

Subsequently, Foley et al\(^\text{7}\) compared 36 liver transplants from DCD donors with 553 liver transplants from donors with brain death and found that as the number of liver transplants from DCD donors increased, certain patterns began to emerge. On the first postoperative day after transplantation, as well as the day of discharge, levels of hepatocellular enzymes and canalicular enzymes (eg, \(\gamma\)-glutamyl transferase and alkaline phosphatase) were higher in recipients of livers from DCD donors, as was use of blood products in the operating room. In this analysis, the incidence of hepatic artery stenosis was higher in livers from...
DCD donors (16.6% vs 5.4%, \(P = .001\)), and biliary strictures developed in 5 of 6 patients with hepatic artery stenosis. Likewise, the overall rate of biliary stricture rate was increased in recipients of livers from DCD donors (27.8% vs 10.3%, \(P = .001\)), and the retransplantation rate was higher (19.4% vs 7.1%, \(P = .01\)). However, the rate of primary graft nonfunction did not differ between the 2 groups of recipients (5.5% vs 1.3%). Also, 3-year recipient and graft survival rates were lower in recipients of livers from DCD donors (68% vs 84%, \(P = .002\), and 56% vs 80%, \(P = .006\), respectively), but when results from recipients of livers from DCD donors less than 40 years old were compared with those in recipients of livers from DCD donors more than 40 years old, the rates of recipient and graft survival were higher and the rate of biliary complications decreased. Abt et al23 had similar results in a study in which they compared 144 liver transplants obtained after cardiac death with 26,856 liver transplants obtained after brain death. Rates of primary nonfunction and retransplantation were higher and 3-year graft survival was significantly lower in recipients of livers from DCD donors, but 3-year recipient survival did not differ between the 2 groups.

In a more recent analysis24 by the Scientific Registry of Transplant Recipients in which 277 liver transplants from DCD donors were compared with 17,533 liver transplants from non-DCD donors for transplants done from January 1, 2000, through October 31, 2003, the hazards ratios were 1.45 for recipient survival and 1.85 for graft survival for recipients of livers from DCD donors. Likewise, DCD donor age of 50 years or more was associated with a higher hazards ratio for graft loss than was donor age less than 50 years.

Recommendations for improving the results of liver transplantation for livers from DCD donors include using livers from donors aged less than 50 years, limiting warm ischemic time to 30 minutes or less and cold ischemic time to less than 8 hours (preferably <6 hours), and avoiding use of livers from DCD donors in technically challenging recipients, such as recipients who have had previous multiple abdominal procedures or retransplants.

In addition, when livers from DCD donors are transplanted, consideration should be given to the benefit a recipient will receive from the transplant compared with the risk of dying while on the waiting list. The system currently used to prioritize patients who are waiting for liver transplantation is based on statistical formulas used to predict death in patients with liver disease. In this system, the model for end-stage liver disease, scores range from 6 (less ill) to 40 (gravely ill). Patients with scores greater than 17 may be more appropriate candidates for transplantation of livers from DCD donors, because patients with lower scores can wait longer and have lower risk of mortality while on the waiting list.

**Lung Transplantation**

The first successful lung transplants from non–heart-beating donors were reported by Love et al24 and Steen et al.25 Little has been published since these studies, but surgeons at the University of Wisconsin have done 16 transplantations of lungs from DCD donors, 6 single and 5 double, in 11 recipients (unpublished data). All recipients were critically ill in the ICU; 1 recipient was receiving extracorporeal membrane oxygenation at the time of transplantation. The 1-year patient survival rate is 71%; 1 patient was alive 8 years after transplantation of lungs from a DCD donor.

**Heart Transplantation**

One transplantation of a heart obtained after cardiac death has been performed in a child at the University of Colorado, and although the patient is currently alive after transplantation, few details about this case are known.

**Summary**

Current results of transplantation of kidneys from DCD donors indicate an increased rate of delayed graft function but a long-term graft survival rate similar to that in recipients of kidneys from donors with brain death. This similarity in rates also appears to be true for pancreas transplantation, but the number of transplants performed is substantially smaller than for kidney transplantation. The results of transplantation of livers from DCD donors are less favorable than those of transplantation of livers from donors with brain death, but with reductions in donor age and both warm and cold ischemia times and improvements in the selection of donors and recipients, these results should improve. Also, improvements in preservation and in methods used to abrogate warm ischemia injury may result in fewer biliary complications. Finally, the outcomes of lung transplantation in a few critically ill patients have been surprisingly good and may be applicable to less critically ill patients.
Conclusions

Transplantation is remarkably successful for many patients with a variety of end-stage diseases. Unfortunately, the supply of donor organs remains insufficient to meet demand. Although impressive steps have been taken to address this issue, more work remains to be done.

DCD is an option that can help narrow the gap between need and supply. The concept is not novel; it has served as the clinical basis for modern transplantation. Unfortunately, the supply of donor organs remains insufficient to meet demand. Fortunately, however, recovering organs from DCD donors is particularly challenging, resource intensive, and ethically debatable. Despite considerable controversy, DCD is considered ethically defensible, but if this approach to organ donation is to be successful on a large scale, it must be fully integrated into the decision-making processes for end-of-life care.

From the evidence we have presented, 2 conclusions can be clearly stated. First, all OPOs and donor hospitals should be offering the option of DCD to patients’ families, and all transplant centers should be using organs obtained after cardiac death for transplantation. Second, clinical practices and public policies will inevitably evolve on the basis of further experience with DCD.

References
