Ethics and Law of DCD Transplant

2

Annalisa Dolcet, Kristopher P. Croome, and Nigel Heaton

Throughout the world, the practice of organ donation for transplantation is governed by the dead donor rule, that is, non-paired vital organs can be retrieved only from patients who are dead. Prior to the development of the Harvard criteria for brain death in 1968, all deceased organ donors were declared deceased using circulatory arrest criteria and thus represented the first donation after circulatory death (DCD) organ transplants performed [1]. In the United States, most states have adopted the Uniform Determination of Death Act (UDODA) or a very close variant. According to the UDODA, an individual who has sustained either (1) irreversible cessation of circulatory or respiratory functions or (2) irreversible cessation of all functions of the entire brain, including the brainstem, is dead [2].

Following the acceptance of declaration of death according to neurological criteria as a legal entity, most countries including the United States preferentially utilized donation after brain death (DBD) donors until the 1990s. At that time, the ongoing shortage of donor organs led to renewed pursuit of potential donors following declaration of death from cardiorespiratory arrest. Potential controversies surrounding this form of organ donation caused the Department of Human Health Services (DHHS) to ask the Institute of Medicine to evaluate the medical and ethical issues surrounding DCD transplantation. In 1997, the Institute of Medicinve concluded that organs recovered from asystolic donors were a medically effective and ethically acceptable way of bridging the gap between demand and supply of human organs [3].

With DCD, the mode of death and donation is very different from DBD and raises a number of ethical considerations which include: the timing of the decision with regard to the withdrawal of treatment in patients who may be potential donors,

A. Dolcet · N. Heaton (✉)
Institute of Liver Studies, King's College Hospital, London, UK
e-mail: nigel.heaton@nhs.net

K. P. Croome
Department of Transplantation, Mayo Clinic Florida, Jacksonville, FL, USA

K. P. Croome et al. (eds.), *Donation after Circulatory Death (DCD) Liver Transplantation*, https://doi.org/10.1007/978-3-030-46470-7_2

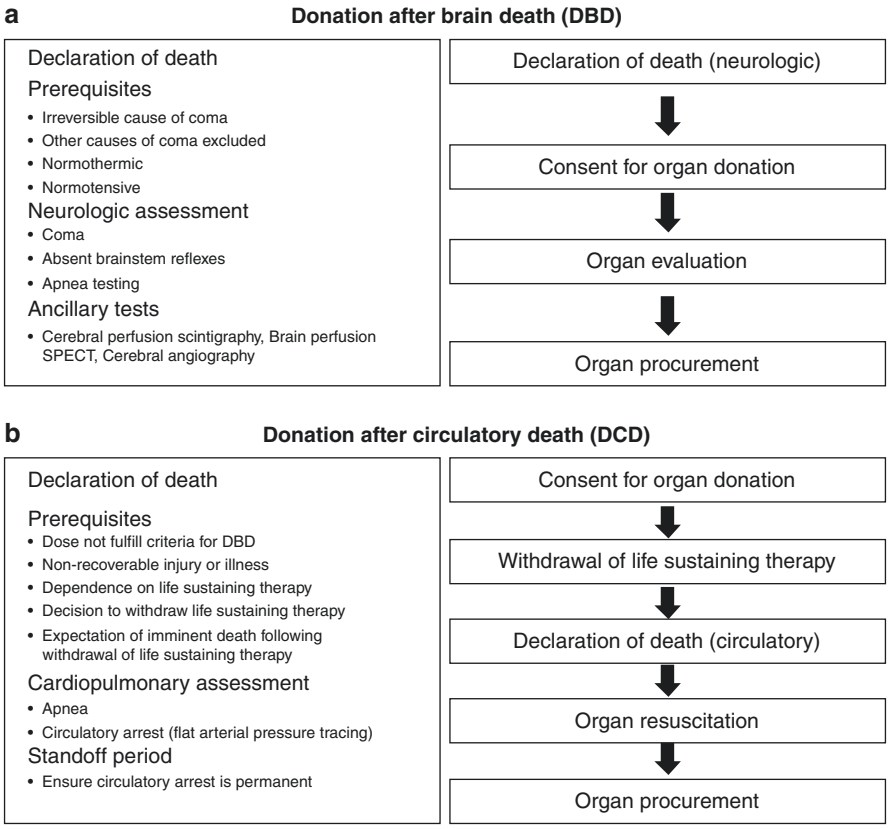

Fig. 2.1 (**a**, **b**) Deceased donation pathways

donor treatment prior to death to protect potential donor organs, site for withdrawal of treatment (based on access to theater), declaration of death, and stand-off time prior to starting retrieval and organ allocation/sharing and recipient outcomes (Fig. 2.1). Discussing the ethical issues of DCD is particularly important given the variations in aspects of clinical practice and DCD policies in different countries, not just worldwide but even within Europe. Common standards and operating policies have yet to be defined internationally to ensure the integrity of and public confidence in organ donation and transplantation.

The following are some of the key ethical principles that must be considered in all decisions surrounding DCD organ donation:

- *Altruism*: the voluntary stated wish of the individual to make the "gift" of donation of his/her organs upon death without expectation of reward
- *Autonomy*: the right of the individual to determine his/her own fate, including that of his/her organs after death

- *Dignity*: the unique and precious status of the human being and the ethical requirement to treat it respectfully without inflicting harm in both life and death
- *Non-maleficence*: the ethical principle that healthcare professionals should not cause harm or distress to their patients
- *Futility*: the contentious principle that it is unethical to perform interventions which cannot benefit the individual receiving them; the controversy focusing upon what does or does not constitute benefit

In addition, the following concepts must be considered with regard to how DCD organs are utilized or allocated:

- *Equity*: the concept of fairness or justice with respect to the way the organs donated are allocated and utilized.
- *Efficiency*: this ensures minimal waste of organs.
- *Utility*: distribution of organs maximizes benefit to recipients, "the greatest good for the most people".

Classification of DCD Donors

Initially, to describe donation from patients who died of cardiorespiratory arrest, the term *non-heart-beating donor* (NHBD) was used in Europe and was adopted at the First International Workshop on Nonheart-Beating Donors in Maastricht in 1995. At that time, donors after circulatory death were divided into four categories known as the Maastricht classification [4] (Table 2.1).

Attempts to improve the Maastricht classification have focused on adding more categories. A subsequent form of classification proposed by the Spanish national consensus to adjust the Maastricht classification included a number of subcategories [5] (Table 2.2). Further modifications to the classification were proposed by Detry et al. after the Eurotransplant organization including eight different countries formally recognized the possibility of organ donation after euthanasia in the Netherlands, Belgium, and Luxemburg [6]. In this classification, a fifth category, which consists of euthanasia or medically assisted cardiocirculatory death, was included (Table 2.3). Finally, following the DCD Conference in Paris in 2013, it was agreed to modify the original Maastricht classification and update according to new developments but attempt to keep its relative simplicity and straightforwardness (Table 2.4) [7].

Table 2.1 Maastricht classification of donors after circulatory death 1995

Category	Description	Procurement
I	Dead on arrival	Uncontrolled
II	Unsuccessful resuscitation	Uncontrolled
III	Awaiting cardiac arrest	Controlled
IV	Cardiac arrest while brain dead	Uncontrolled

Table 2.2 Modified Maastricht classification for donors after circulatory death (Madrid 2011)

Uncontrolled DCD	I	Dead in the out-of-hospital setting	Includes victims of a sudden death, whether traumatic or not, occurring out of the hospital and who, for obvious reasons, have not been resuscitated
	II	Unsuccessful resuscitation	Includes patients who suffer a CA and in whom CPR has been applied and resulted unsuccessful
			II. a. Out-of-hospital CA occurs in the out-of-hospital setting and is attended by an extra-hospital emergency service which transfers the patient to the hospital with cardiac compression and ventilatory support
			II. b. In-hospital CA occurs within the hospital, being attended by healthcare personnel with immediate initiation of CPR
Controlled DCD	III	Awaiting cardiac arrest	Includes patients in whom withdrawal of life-sustaining therapies is applied∗, as agreed upon within the healthcare team and with the relatives or representatives of the patient
	IV	Cardiac arrest while brain dead	Includes patients who suffer a CA in the process of the determination of death by neurological criteria or after such determination has been performed, but before the transfer to the operating theatre. It is likely that restoration of cardiac activity is first attempted, with a switch to the protocol of donation after circulatory death, if this fails

Table 2.3 Modified Maastricht classification for donors after circulatory death (Detry, 2012)

Uncontrolled DCD	I	Dead in the out-of-hospital setting	IA. Cardiocirculatory death outside hospital with no witness. Totally uncontrolled
			IB. Cardiocirculatory death outside hospital with witnesses and rapid resuscitation attempt. Uncontrolled
	II	Unsuccessful resuscitation	IIA. Unexpected cardiocirculatory death in ICU. Uncontrolled
			IIB. Unexpected cardiocirculatory death in hospital (ER or ward), with witnesses and rapid resuscitation attempt. Uncontrolled
Controlled DCD	III	Awaiting cardiac arrest	IIIA. Expected cardiocirculatory death in ICU. Controlled
			IIIB. Expected cardiocirculatory death in OR (withdrawal phase>30 min). Controlled
			IIIC. Expected cardiocirculatory death in OR (withdrawal phase<30 min). (highly) controlled
	IV	Cardiac arrest while brain dead	IVA. Unexpected cardiocirculatory arrest in a brain-dead donor (in ICU). Uncontrolled
			IVB. Expected cardiocirculatory arrest in a brain-dead donor (in OR or ICU). (highly) controlled
	V	Euthanasia	VA. Medically assisted cardiocirculatory death in ICU or ward. Controlled
			VB. Medically assisted cardiocirculatory death in OR. Highly controlled

Table 2.4 Modified Maastricht classification for donors after circulatory death (Paris 2013)

Category I Uncontrolled	Found dead IA. Out-of-hospital IB. In-hospital	Sudden unexpected CA without any attempt of resuscitation by a life medical team; WIT to be considered according to national life recommendations in place; reference to in- or out-of-hospital (IH-OH) life setting
Category II Uncontrolled	Witnessed cardiac arrest IIA. Out-of-hospital IIB. In-hospital	Sudden unexpected irreversible CA with unsuccessful resuscitation by a life medical team; reference to in- or out-of-hospital (IH-OH) life setting
Category III Controlled	Withdrawal of life-sustaining therapy	Planned withdrawal of life-sustaining therapy[a]; expected CA
Category IV Uncontrolled Controlled	Cardiac arrest while brain dead	Sudden CA after brain death diagnosis during donor life management but prior to planned organ recovery

Avoiding Conflicts of Interest

DCD donors are unique in that prior to declaration of irreversible cessation of circulatory or respiratory function, they are still a living patient. In this setting, there are many interventions that may improve the successful donation of organs but may not directly benefit or may even hasten the death of the potential donor. In order to avoid actual or perceived conflict of interest, the transplant team members should not be involved in decisions related to patient prognosis, withdrawal of ventilatory or organ-perfusion support, or determination of death [8].

Potential of DCD

As a result of public campaigns and information to gain support and understanding, the contribution of DCD to overall deceased donor numbers has increased but still varies internationally. Differences in medical practices, public attitudes, legislature, and resources all influence DCD practice worldwide. In some countries such as the United Kingdom, the Netherlands, and Spain, DCD accounts for a substantial proportion of overall deceased organ donors, whereas in other countries it is unusual because of legal restrictions (e.g. Italy where the death of a patient is declared only after a 20-minute flat ECG that proves asystole). In Holland, Australia, and the United Kingdom, the numbers of controlled DCD donors have been increasing substantially over the last decade and now represent more than one-third of all deceased organ donors (Fig. 2.2) [9].

In the United Kingdom, intensivists are comfortable with making decisions regarding the futility of continued interventions and support, accounting for as many as 60% of deaths in the UK ICUs after a decision to limit or withdraw treatments that are judged to be of no overall benefit to the patient [10].

This creates the potential for controlled DCD in contrast to countries such as Spain and other Southern European countries where decisions to limit life-sustaining

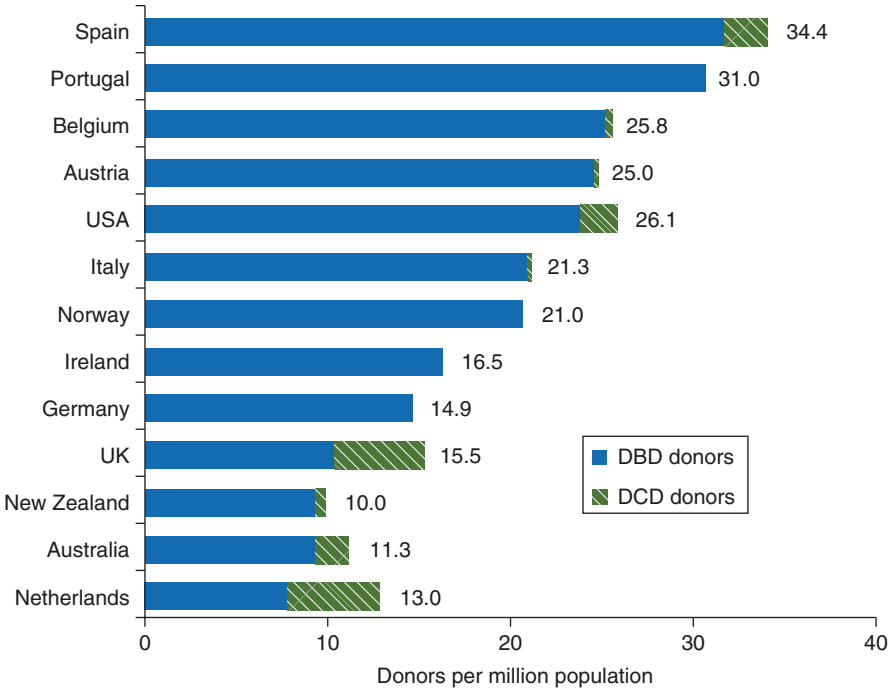

Fig. 2.2 Donors per million population in different countries. (Reprinted from Murphy and Smith [9]. With permission from Elsevier)

treatments (particularly with regard to admission to ICU) are less common and the potential for controlled DCD is lower. The reasons for these differences are complex, besides social acceptance of treatment withdrawal and medical care issues, and many focus on the striking international variation in the ICU bed capacity. For instance, there are 27 ICU beds per million population (pmp) in the United Kingdom compared with 76 in Australia and 87.5 ICU beds pmp in Spain; it seems inevitable that intensivists in the United Kingdom may both avoid admitting patients to ICU with a hopeless prognosis (including those with acute catastrophic brain injury) and also consider withdrawing treatments that are no longer beneficial sooner than colleagues in other countries with greater critical care capacity [11].

Difference in Treatment Withdrawal

Decision-Making

All DCD guidelines recommend that the decision to withdraw cardiorespiratory support should always be independent and made before any consideration of organ donation. Most also advise separation of these discussions in time and that the approach should be made by staff experienced in organ donation and with

appropriate training in managing grieving families. No member of the transplant or donor coordination team should be involved in decision-making around withdrawal of treatment. Specialist Nurses-Organ Donation should not provide medical care for the potential donor while they are still alive.

Timing of Treatment Withdrawal

Treatment withdrawal is delayed until a retrieval team has travelled to the donor hospital and completed their necessary preparations in theatre. It is vital that those responsible for organ allocation and retrieval do all they can to minimize unnecessary delay, recognizing the needs of the donor and their family at this time. This is particularly important in circumstances when it is proposed to delay withdrawal until the recipients of particularly vulnerable organs (e.g. liver, pancreas, and lung) have been identified and admitted to the transplant center.

Manner of Treatment Withdrawal

There is a significant variation in how treatment withdrawal is managed in adult critical care units, particularly with regard to airway management and the use of medication to provide comfort. Although guidelines have been published regarding the withdrawal of treatment, these documents do not provide a specific protocol for how end-of-life care should be managed. Many DCD guidelines recommend that treatment withdrawal should follow the standard protocols of the intensive care unit, to ensure that ICU practitioners do not have a conflict of interest in treatment withdrawal decisions and practice. The interests of a patient as a donor are better served by sedation and extubation, as this makes donation more likely and, importantly, does no harm to the patient. However, while it is widely held that terminal extubation promotes the possibility of DCD, evidence to support this view is limited and not supported by data from the "UK Potential Donor Audit." In any event, there is currently no consensus within adult ICU practice in the United Kingdom on how the airway should be managed during treatment withdrawal for DCD or on the use of adjuvant sedation, anxiolysis, and analgesia. It is therefore usually left to individual ICUs to formulate their own protocols. Our experience is that planned extubation should be included in withdrawal protocols. Although the need to develop and adhere to such protocols applies to all end-of-life care decisions, it is of particular importance that all units with DCD programs have such protocols and that clinicians work within them in a consistent and transparent manner.

Location of Treatment Withdrawal

To standardize the approach to DCD organ donation, local written policies are key to avoiding misunderstandings. Withdrawal of treatment within the operating

theatre reduces the potential warm ischemic time (WIT) after the diagnosis of death. Units planning for withdrawal in the operating theatre must have systems in place to ensure that a patient's right to comfort, dignity, and privacy is guaranteed and that this care is delivered by appropriately trained and experienced healthcare professionals such as members of the ICU or theater team. The transfer of the care of a dying patient to theatre staff, who may not be trained and inexperienced in end-of-life management, is unacceptable and unethical. Similarly, it is important that unlimited access for close family, friends, and those meeting the religious or spiritual needs of the patient are ensured within this environment. It is also important that the medical professional responsible for confirming death is suitably experienced and readily available and that a plan for the subsequent care of the patient should be in place should death not occur. In Australia, withdrawal of cardiorespiratory support is almost always undertaken in ICU as it is considered that death in the operating theatre is a rare and difficult event for staff. Such an approach ensures that if cessation of the circulation does not occur in a time frame compatible with donation, further disruption to the family and patient is avoided and distress minimized. Members of the transplant team, including donor transplant coordinators, must not be involved in any aspect of the end-of-life care.

Premortem Interventions

Potential DCD donors invariably lack capacity at the time of their final illness, although there are occasions where patients with neurological illness such as motor neurone disease, high cervical cord injury, and end-stage respiratory failure have consented themselves for donation. In circumstances where patients lack capacity for decision-making, ICU clinicians in the United Kingdom have an obligation to limit treatments to those which offer some overall benefit to their patient. In the past, such assessments have focused heavily upon what might be considered to be in the medical best interests of an individual, an approach that might appear to render interventions to promote deceased donation for the benefit of a third-party transplant recipient unethical and even unlawful. However, it is now recognized that what is of "overall benefit" to an individual within the context of their end-of-life care is much broader than this and should include an assessment of factors such as their emotional, cultural, family, and religious interests and also the patient's medical condition. These interests, including those relating to organ donation, are usually determined by discussions with the patient's family and by consulting the organ donor register in countries that have one. Once it is established that an individual wished to be an organ donor, then certain interventions can be considered to be in their best interests if they facilitate donation and do not cause distress or harm.

Interventions that may or may not represent potential harm should be assessed on an individual basis. What might be the correct course of action for one individual might not be for another. Using this approach, obtaining blood samples, maintaining life-sustaining treatment, and altering the time and place of treatment withdrawal may all be considered to be in a patient's best interests if they had given an

expressed desire to be an organ donor and they represent no harm, whereas interventions such as systemic heparinization (which might promote the expansion of an intracerebral hematoma), cardiopulmonary resuscitation, and femoral cannulation that might inflict pain or distress to a patient or the close family or accelerate death are unlikely to be considered in the patient's best interests in most societies. However, interpretation of these aspects of "care" vary across the world (the utilization of premortem heparin is acceptable in the United States but not in the United Kingdom), and hence the view of what is ethical is not consistent and varies between countries, hospitals, and clinicians.

Absence of Circulation Before the Diagnosis of Death

One of the most debated areas in the practice of DCD is at what point death can be declared after loss of the circulation and respiration. DCD requires that death is declared at the earliest possible time after circulatory arrest that is medically, ethically, and professionally acceptable to minimize warm ischemic time while ensuring that the dead donor rule is not breached, that is, the patient is not unintentionally killed as a result of donating their organs. Perhaps surprisingly, there has until recently been very little professional guidance on how and when to declare death after loss of the circulation and respiration. This is despite the fact that globally, circulatory criteria are the most commonly used and accepted criteria for determination of death. However, the introduction of DCD programs and reports of autoresuscitation (spontaneous return of the circulation after circulatory arrest) have brought these criteria into sharp focus and resulted in the publication of many national guidelines.

Much controversy surrounds the precise time that needs to elapse after the onset of circulatory arrest before "irreversible" death can be declared. There is a significant variation around the world, with some believing that the criteria for the determination of death are being manipulated to facilitate transplantation while apparently not breaching the dead donor rule. Others have suggested that the dead donor rule has resulted in the definition of death being revised inappropriately and should therefore be abandoned, permitting the removal of vital organs while a donor was still alive. They argue that with proper safeguards, no patient will die from organ donation who would not otherwise die as a result of the withdrawal of life support [12].

Most countries allow death to be confirmed (and therefore organ retrieval to begin) after 5 minutes of continuous cardiorespiratory arrest (stand-off time). Five minutes of continuous asystole is sufficient to ensure that both consciousness and respiration have ceased and that the possibility of spontaneous resumption of the circulation has passed. However, the brain may at this time remain to some degree responsive to the artificial restoration of its blood supply, be this as a result of continued CPR and the introduction of extra-corporeal circulatory support or as a result of post-mortem interventions that inadvertently provoke the return of ventricular function. It follows that at this time, that is, after 5 min of continuous asystole,

irreversibility depends in part upon prohibiting restoration of the cerebral circulation rather than an absolute inability to restore cerebral function. This contrasts with circumstances in which neurological criteria for the determination of death are applied. In these circumstances, the pathology leading to the irreversible loss of consciousness and respiration has been established for several hours before the diagnosis is made.

The challenges in this area are considerable. Irreversibility in such circumstances might be considered to be weaker than when death is confirmed by neurological criteria because here it depends upon intent and pathophysiology. Others suggest that the loss of circulation should be described as permanent rather than irreversible, and propose that for the purposes of DCD, death should only be recognized when the risk of autoresuscitation has passed, when CPR will not be attempted, and when there is an absolute prohibition on interventions that may restore the cerebral circulation being undertaken after the declaration of death. A recent systematic review of autoresuscitation showed that this has only been reported in the context of abandoned CPR and not when invasive treatment is withdrawn [13].

There seems to be a growing consensus that a minimum of 5 minutes of continuously observed and appropriately monitored absence of the circulation, apnea, and coma will define the point at which death can be diagnosed. The development of such consensus will increase confidence in the way death is determined and prevent a repetition of practices in DCD that have previously aroused much concern and criticism, such as retrieval of a heart from a neonatal DCD donor after only 75 seconds of loss of the circulation [14]. However variations in practice exist around the world with a stand-off time of up to 20 minutes being used [15]. However, with extended stand-off time, the subsequent graft function may be compromised resulting in non-use or graft dysfunction in the recipient. Further discussions regarding the ethics of stand-off times are needed to develop internationally recognized criteria that the general public can have confidence in.

Interventions After Death

As noted above, warm ischemic injury is a major limiting factor for DCD, and it is legitimate for retrieval teams to consider the benefits of reversal of such processes before cold perfusion and how this might be achieved. It is mandatory for critical care teams to evaluate such proposals within the pathophysiological context of the criteria used to diagnose death. This is particularly relevent to uncontrolled DCD that allows CPR to continue after the declaration of death [16]. A recent study has revealed that 3 patients in a series of 48 had a return of spontaneous circulation when a mechanical device was used during transfer of potential DCD donors from the community to the transplant center, one of whom went on to make a good neurological recovery [17].

There is now a growing consensus that no intervention that might potentially restore cerebral circulation at a time when nervous tissue might be responsive to such restoration should be allowed under any circumstances, given the time-sensitive way in which death is diagnosed in the setting of DCD.

Protocols for uncontrolled DCD raise further specific ethical issues regarding post-mortem interventions, including how much information families receive and the acceptability of applying invasive measures to preserve organs before obtaining consent from the family or establishing the patient's wishes, particularly with uncontrolled DCD. The legal framework for donation in Spain, which is one of presumed consent, is interpreted in practice to support such interventions, while in the United Kingdom, the Human Tissue Act specifically allows the placement of femoral perfusion cannulae ahead of the family approach.

Reinforcing Donation Supply: DBD Versus DCD

In the United Kingdom, currently an average of 3.6 organs is transplanted per DBD donor compared with 2.1 organs per DCD donor [18]. While the number of organs transplanted from DCD donors may increase in the future, they are unlikely to fully match those transplanted after DBD, either in terms of the number of organs transplanted or their quality. Therefore, the focus of DCD programs should be to provide the option of deceased donation for patients who will never meet the neurological criteria for the diagnosis of death, rather than an option for clinical staff and families to support donation without the need for lengthy neurological evaluations and subsequent donor optimization. However, many involved in transplantation express the view that DCD programs do indeed detract from DBD and thereby jeopardize cardiothoracic and to a lesser extent liver and kidney transplant programs and point to the falling number of DBD donors in countries with active controlled DCD programs.

Detailed analysis in the United Kingdom does not support this view, with the registry data indicating that the incidence of DBD was declining for several years before the expansion of the DCD program (Fig. 2.3) [18]. However, in other countries such as the Netherlands, DCD does appear to have partially replaced DBD. The decrease in the incidence of death diagnosed by neurological criteria, and therefore the potential for DBD, over the last 6 years, is primarily a consequence of improved road safety and changes in the neurosurgical care management and improved outcomes of acute traumatic brain injury and intracranial hemorrhage.

It is important to ensure that DBD are identified and their potential for donation is maximized. Of note, it is disconcerning to observe that 10% of DCD donors in the United Kingdom appear to fulfill the pre-conditions for brainstem death testing but were not tested. The reasons for this need to be understood and addressed. Audit and performance management review can lead to further improvement in the cycle of identifying potential donors and approaching families appropriately to increase organ donation and graft utilization.

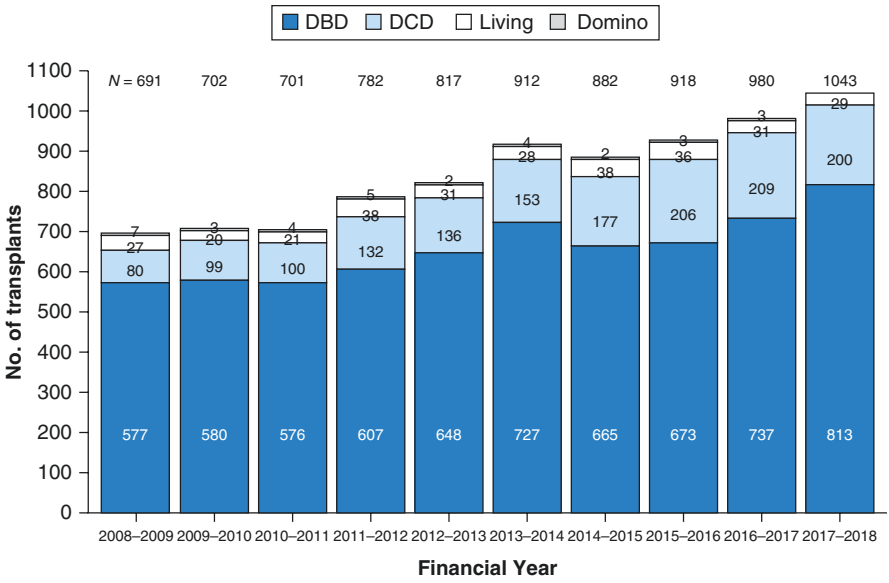

Fig. 2.3 Total number of liver transplants by donor type, 1 April 2008–31 March 2018, Annual Report NHSBT. (Adapted from Ref. [18])

Professional training and education programs reinforce the importance of testing potentially brain-dead patients irrespective of whether they are to become donors, particularly because it allows clinicians to give the patient's family a definitive diagnosis of death rather than a prognosis that death will follow the withdrawal of treatment.

Donation After Euthanasia

Euthanasia is a controversial topic with complex ethical arguments well beyond the scope of this book. In many countries, euthanasia is not a legal practice, and therefore any discussion surrounding organ transplantation and euthanasia in places where it is not legally performed is irrelevant. In both Belgium and the Netherlands, euthanasia is legally allowed, and organ donation from DCD donors following euthanasia has been performed [19–21]. In both countries, combining euthanasia and subsequent organ donation is feasible on legal and medical grounds and is increasingly gaining social and ethical acceptance [22, 23]. In Belgium, if the patient is ill, but is not expected to die within the near future, a third physician, with specific expertise regarding the condition from which the patient suffers, needs to consult the patient, and a period of at least 1 month between the request for euthanasia and the euthanasia procedure itself has to be respected [22, 23]. In the Netherlands, the patient should be hopelessly and unbearably suffering, and other

reasonable solutions should be non-available. In this process, a second independent physician should be consulted. The euthanasia procedure should be carried out "carefully," according to the latest standards [22, 23].

Heart Transplantation from Donation After Circulatory Death Donors

Although this book is focused on liver transplantation from DCD donors, it is likely that moving forward, liver procurement teams will be faced with concomitant heart procurements taking place from DCD donors. There is currently a clinical trial underway investigating heart transplantation from DCD donors utilizing the OCS Heart System (TransMedics) [24].

Early transplant programs utilized organs from DCD donors, including the first heart transplants performed by Christiaan Barnard [25]; however, this practice was largely abandoned following the acceptance of brain-death criteria. As of late the ethics surrounding heart transplantation from DCD donors has been thoroughly debated [26]. In 2012, the American Thoracic Society, the International Society for Heart and Lung Transplantation, and the United Network for Organ Sharing (among others) published an official statement in support of DCD [27]. Moreover, DCD heart transplant programs already exist in the United Kingdom, Belgium, and Australia.

Previous Legal Controversy

As is stated above, it is imperative that procurement team members are not involved in decisions regarding patient care in potential DCD donors prior to their death. A procuring surgeon in California, USA, was previously charged with three felony counts for allegedly becoming involved in administration of narcotic and anxiolytic medication during an attempted DCD procurement [28]. Although the surgeon was ultimately acquitted, this case highlights the importance of even perceived attempts to influence patient care in potential DCD donors [29].

Executed Prisoners and DCD Transplant

In China, numerous previous international human rights violations related to organ procurement practices have been described [30, 31]. Historically over 90% of the organs transplanted in China were from prisoners. Since China does not have a law recognizing brain death, cardiac death is the standard determination of death for organ donors in China [32]. Chinese sources claim that all hospitals have terminated using organs from executed prisoners and the civilian organ donation has been the sole source for an organ transplant in China since January 2015 [32].

Country-Specific Laws

As has previously been stated, significant variability exists in DCD organ donation practices across the world [33]. Table 2.5 [33, 34] provides a list of countries that have published data on DCD organ procurement activity. Figure 2.4 provides data on total DCD donors by country from 2017; however, this data is not specific to DCD liver transplantation [35]. In seven European countries (Finland, Germany, Greece, Bosnia-Herzegovina, Hungary, Lithuania, Turkey), there is currently no DCD activity, mainly because of legal restriction. The following section provides country-specific information on both laws and practices surrounding DCD organ donation.

Australia

DCD donors in Australia are performed in a controlled fashion (Maastricht category III). A national protocol for donation after circulatory death donors in Australia has previously been published [36]. In Australia, the mandatory "no-touch" time is 2–5 minutes.

Table 2.5 DCD programs and transplant activity 2008–2016 [33, 34]

Continent	Country	Year started (uDCD/cDCD)	"No-touch" time	DCD liver transplants performed 2008–2016[1, 2]
Europe	Austria	1990s	10	5
	Belgium	2006/2005	5	440
	Czech Republic	2002/2015	5	1
	France	2007/2015	5	48
	Ireland	NA/2011	10	0
	Israel	2014/NA	5	0
	Italy	2007/2015	20	14
	Latvia	1973/NA	5	0
	Lithuania	2016/NA	5	0
	The Netherlands	1980s	5	336
	Norway	NA/2010	5	4
	Poland	2015/NA	5	0
	Portugal	2016/NA	10	0
	Russia	1967/NA	30	0
	Spain	1980s/2009	5	339
	Switzerland	1985/1985	5	45
	United Kingdom	2013/1985	5	1268
North America	Canada	2006	5	NA
	USA	1992	2 to 5	2885
Asia	China	NA	NA	NA
	Japan	NA	NA	NA
Oceania	Australia	2004	2 to 5	NA
	New Zealand	2008	5	NA

uDCD uncontrolled DCD; *cDCD* controlled DCD

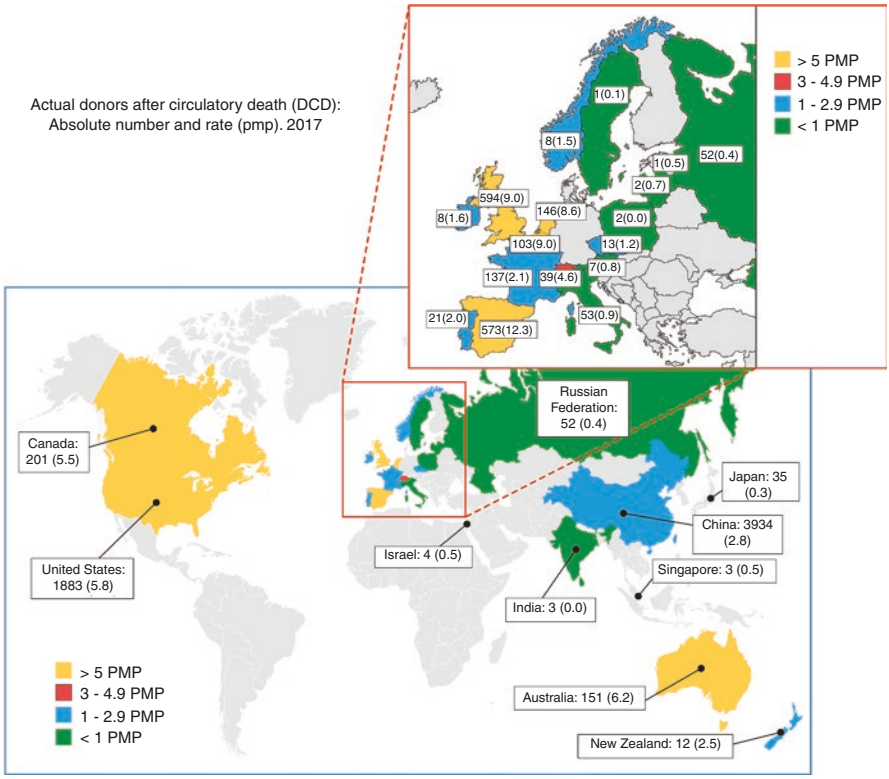

Fig. 2.4 Global DCD donors in 2017 (includes all non-liver DCD organ donors). (Data of the WHO-ONT Global Observatory on Donation and Transplantation. All Rights Reserved © 2017 Global Observatory on Donation and Transplantation)

Belgium

Both controlled (Maastricht III) and uncontrolled (Maastricht II) DCD donors are pursued in Belgium. Donation following euthanasia is legal in Belgium. Antemortem systemic heparinization is allowed in Belgium. In Belgium, the mandatory "no-touch" time is 5 minutes.

Canada

A Canadian national forum was held in February 2005 to discuss and develop recommendations on the principles, procedures, and practice related to DCD, including ethical and legal considerations [37]. DCD organs have been actively pursued in Canada since 2006. DCD donors in Canada are performed in a controlled fashion (Maastricht category III). Premortem administration of heparin is allowed in Canada, and mandatory "no-touch" time is 5 minutes.

China

The current cultural traditions of China have precluded a public consensus on brain death. Chinese culture and law recognize the circulatory death criteria, but concepts such as vegetative state and brain death remain vague for many Chinese citizens [32]. In China, there is presently no law recognizing brain death. Since cardiac death is the standard determination of death, all deceased donors in China are DCD donors. These donors would likely be considered as Maastricht IV (death by cardiac arrest after brain death) [38].

China has long been criticized for commercial and unethical use of organs from executed prisoners among the international community [39]. China has received a significant amount of international pressure with regard to their organ donation practices. In 2010 a citizen-based voluntary organ donor system was initiated. With the success of implementing the voluntary citizen-based organ donation program, all hospitals have terminated using organs from executed prisoners, and the civilian organ donation has been the sole source for an organ transplant in China since January 2015 [40].

France

Historically DCD donors were not pursued in France. Procurement from DCD donors was re-examined in France in 2003–2004, taking into account the feasibility, results, and ethical and legal consequences. The terms of the law were changed to authorize donation after circulatory death, but only for a limited number of pilot centers with a single national medical protocol issued by the Agence de la biomédecine [41]. Initially, the End of Life Law, which had only just been passed in 2005, ruled out Maastricht category III donors at the start of the program. In 2010, the parliamentary information mission on the revision of the bioethics law invited the Intensive Care Societies to debate and make recommendations for controlled donation after circulatory death.

Italy

In Italy, a "no-touch" time of 20 minutes is required following cardiac arrest as certified using continuous ECG prior to commencement of organ procurement. This long "no-touch" period has long prevented the development of any DCD LT program in Italy [42]. The first Italian series of DCD LT was initiated in September 2015 using normothermic machine perfusion (NRP). Systemic heparinization is only allowed during the agonal period. In Italy, a presumed consent law (opt-out) has been approved but not enforced, primarily because of lack of data about public opinion.

Japan

For many years, the concept of brain -death was not recognized culturally or legally in Japan. For this reason, the majority of liver transplants performed in Japan have

been from living donors. In 1997, Japan's Organ Transplant Law (OTL) was enacted, which legalized organ donation from brain-dead donors in Japan [43]. Despite the legalization of donation from brain- dead donors, the small numbers of deceased donors in Japan continue to be predominantly DCD donors, given the lack of cultural acceptance of brain -death.

The Netherlands

The Netherlands was one of the first European countries to transplant organs (kidneys) from DCD donors, starting in the early 1980s [44, 45]. The Netherlands has also been transplanting livers from DCD donors since 1999 [45]. The majority of DCD donors in the Netherlands are controlled DCD (Maastricht category III). Donation following euthanasia is legal in the Netherlands. Both controlled (Maastricht III) and uncontrolled (Maastricht II) DCD donors are pursued in the Netherlands. In the Netherlands, the mandatory "no-touch" time is 5 minutes.

New Zealand

Following approval from the multi-region ethics committee in 2007, the Organ Donation New Zealand (ODNZ) commenced introducing DCD in donor hospital throughout New Zealand. DCD donors in New Zealand are performed in a controlled fashion (Maastricht category III).

Spain

Spain has been one of the pioneering countries for utilization of uncontrolled DCD donors. Currently both uncontrolled and controlled DCD donors are performed in Spain (Maastricht categories I, II, and III). The country is well known for their high rates of organ donation as well as opt-out donor system. Controlled DCD organ donation was initiated in Spain in 2009 [46]. Antemortem systemic heparinization and cannulation are allowed in Spain. The mandatory "no-touch" time in Spain is 5 minutes.

Switzerland

In Switzerland, DCD was introduced in 1985, but it was stopped after the introduction of the national transplant law in 2007 due to legal uncertainty [47–49]. The law had apparent inconsistences with the Swiss Academy of Medical Sciences (SAMS). Subsequently the Federal Office of Public Health (FOPH) made clear that DCD was authorized by law and that the SAMS guidelines ought to be adjusted to allow

preparatory medical measures with regard to DCD [48, 49]. After the analysis of the legal situation and the adaption of the SAMS guidelines, the Zurich University Hospital was the first to reintroduce a DCD program in late 2011 (Maastricht category III; procurement of lungs, livers, pancreas, and kidneys) [50]. The mandatory "no-touch" time in Switzerland is 5 minutes.

United Kingdom

The United Kingdom has seen a significant increase in the number of organ donors from 2003 to present. This rise in organ donors has been almost solely because of a rise in DCD. This has been almost solely a result of an increase in donation after circulatory death (DCD) from 1.1 to 7.9 donors per million population (pmp) between 2003 and 2012 [51]. The United Kingdom now performs one of the highest numbers of DCD transplants in the world. The majority of DCD donors in the United Kingdom are performed in a controlled fashion (Maastricht category III). The mandatory "no-touch" time is 5 minutes in the United Kingdom. DCD practice in the United Kingdom does not allow antemortem systemic heparinization to be given.

United States

Prior to the development of the Harvard criteria for brain death in 1968, all deceased organ donors in the United States were declared deceased using circulatory arrest criteria. Following the development and acceptance of brain death, virtually all deceased donors in the United States were DBDs. DCD organ transplantation was reintroduced by the University of Pittsburgh in 1992 [52]. Both the University of Pittsburgh and the University of Wisconsin described their pioneering work with controlled DCD kidney and liver transplantation in 1995 [53, 54]. Since that time, the number of DCD organs in the United States has continued to increase. DCD donors in the United States are almost exclusively performed in a controlled fashion (Maastricht category III). Antemortem systemic heparinization is performed for the majority of DCD donors in the United States. "No-touch" time in the Unites States is between 2 and 5 minutes. The Society of Critical Care Medicine recommends at least 2 minutes of observation and the Institute of Medicine recommends 5 minutes [55]. A previous report by Light et al. described an uncontrolled DCD program in Washington, D.C., that recovered 26 kidneys, of which 21 were transplanted [56]. This program has since been discontinued. More recently an uncontrolled DCD protocol was investigated at two academic centers in Pittsburgh [57]. While four organs were recovered as part of that program (three kidneys and one liver), none of the organs were ultimately used for transplantation.

Conclusion

The ethical framework for the transplant surgeon and the extended multidisciplinary team, when utilizing DCD, is important and poorly understood. The onus is on the accepting surgeon to utilize DCD grafts and to achieve "acceptable outcomes". How are these grafts utilized? There is evidence of bias in allocation with reports, for example, of DCD liver grafts being used disproportionately in patients with Hepatocellular carcinoma (HCC), women, and low Model for end-stage liver disease (MELD) recipients [34]. The decision not to use a graft may be straightforward; however, the tipping point for use is determined by surgeon experience, recipient urgency and anticipated surgical difficulty, whether the graft was an import, and the potential cold ischemic time and the likelihood of rescue in the event of primary graft nonfunction. Are these decision improved by consulting within a multidisciplinary team? How do surgeons "safely build experience" with DCD within the surgical team? It may be considered that decisions regarding use may be more transparent, but consistency of decision-making will also depend on team size and composition and is likely to err on the side of conservative behavior when confronted by marginal grafts. What constitutes ethical behavior in deciding to utilize a graft and risk poor outcome in the recipient? This may only become "obvious" in retrospect when the outcome is known. Therefore it is important to have mandatory audit recording outcomes such as marginal graft utilization, graft outcome, the incidence of ischemic cholangiopathy, and waiting list mortality.

Selection and consent of appropriate recipients may also raise ethical issues. The selection of potential recipients as suitable by the multidisciplinary team for DCD grafts could permit the use of a young or old DCD liver graft with very different risk profiles. The consent of the recipient for the use of the liver and the risk profile should be explicit; otherwise, the ethical behavior of the surgeon will be questioned. The formulation of algorithms for characterizing risk/benefit of the specific donor-recipient pairings would be valuable and help the patient understand risk and provide a benchmark to surgical team to assess their performance.

Informing the recipient of the risk of not being transplanted if the DCD liver is turned down should also be explicit. In the United Kingdom, not accessing the DCD donor pool reduces the likelihood of transplantation by 11% [18]. Thus understanding decision-making and graft use is complex and challenging, and there is little data on surgeon and team performance.

Centre-specific outcome monitoring should include organ utilization, waiting list mortality, and graft and patient outcomes. Organ allocation schemes appear to be a greater challenge for DCD compared with DBD because of the risk involved in their use and the potential for prolonging cold ischemia if organs are "exported." Machine perfusion will offer an alternative way forward. For patients who develop ischemic cholangiopathy after DCD transplant who require retransplantation, there is evidence that they are less likely to be retransplanted in a timely manner and often receive another marginal graft. This is because the mode of graft failure is different

with recurrent cholangitis leading to malnutrition and physical frailty and is not recognized by the majority of allocation schemes as a high priority [58]. Recognition of this pattern should lead to a facilitation of retransplantation to avoid the disadvantage of receiving second marginal grafts.

Utilizing organs from DCD donors has now become commonplace in the West in contrast to the East where living donation remains the main form of donation. The ethical problems associated with their use are very different. DCD grafts should be considered as marginal grafts except in highly selected donors (less than 40 years, no steatosis, warm ischemia <30 minutes, cold ischemia >8 hours). The risk of graft dysfunction/nonfunction is borne by the recipient in contrast to living donation where the primary risk is for the donor.

The advent of machine perfusion either in situ or ex situ using hypothermic or normothermic perfusion offers a way forward. The ability to ameliorate ischemia-reperfusion injury reduces the risk of early graft failure and cholangiopathy. Normothermic perfusion allows for monitoring organ function prior to transplantation which would lessen some of the ethical issues clinicians face when considering using these grafts. Increased utilization would also help the transplant community in terms of how DCD transplantation is viewed. The low utilization rates that are currently experienced are expensive in financial and personnel terms. It risks the burnout of retrieval teams who work hard often for no tangible output. Hopefully the advent of new technologies to improve or restore potential graft function prior to transplantation will usher in an era of increasing rates of donor utilization with excellent clinical outcomes. Machine perfusion should help and improve utilization of DCD grafts. A number of randomized controlled trials have been completed, and further studies are planned to assess their impact on DCD liver transplant. This represents an ethical approach to the evaluation and introduction of new technology in transplantation. Robust data will provide a robust framework for future clinical practice. The standardization of DCD across the world should decrease the ethical issues faced by transplant teams today. Ethical challenges will continue to exercise the transplant community in DCD transplantation, and continuing audit and the publication of robust outcome measures will reassure donor families and the general public where support is critical to the future provision of organ donation.

References

1. A definition of irreversible coma. Report of the ad hoc committee of the Harvard medical school to examine the definition of brain death. JAMA. 1968;205:337–40.
2. UDODA – Guidelines for the determination of death: report of the medical consultants on the diagnosis of death to the President's Commission for the Study of Ethical Problems in Medical and Biomedical and Behavioral Research. JAMA. 1981;246:2184–6.
3. Institute of Medicine. Non-heart-beating organ transplantation: medical and ethical issues in procurement. Washington, DC: The National Academies Press; 1997. https://doi.org/10.17226/6036. Accessed 10 Feb 2020.

4. Kootstra G, Daemen JHC, Oomen APA. Categories of non-heart-beating donors. Transplant Proc. 1995;27:2893.
5. Donation after circulatory death in Spain: current situation and recommendations. National Consensus Document. 2012. http://www.ont.es/infesp/Paginas/DocumentosdeConsenso.aspx. Accessed 10 Feb 2020.
6. Detry O, Le Dinh H, Noterdaemer T, et al. Categories of donation after cardiocirculatory death. Transplant Proc. 2012;44:1189.
7. Thuong M, Ruiz A, Evrard P, et al. New classification of donation after circulatory death donors definitions and terminology. Transpl Int. 2016;29:749–59.
8. Reich DJ, Mulligan DC, Abt PL, Pruett TL, Abecassis MM, D'Alessandro A, Pomfret EA, Freeman RB, Markmann JF, Hanto DW, Matas AJ, Roberts JP, Merion RM, Klintmalm GB, ASTS Standards on Organ Transplantation Committee. ASTS recommended practice guidelines for controlled donation after cardiac death organ procurement and transplantation. Am J Transplant. 2009;9(9):2004–11.
9. Murphy PG, Smith M. Towards a framework for organ donation in the UK. Br J Anaesth. 2012;108 Suppl 1:i56–67.
10. Wunsch H, Harrison DA, Harvey S, et al. End of life decisions: a cohort study of the withdrawal of all active treatment in intensive care units in the United Kingdom. Intensive Care Med. 2005;31:823–31.
11. Manara R, Murphy PG, O'Callaghan G. Donation after circulatory death. Br J Anaesth. 2012;108(S1):i108–21. https://doi.org/10.1093/bja/aer357.
12. Truog RD, Miller FG. The dead donor rule and organ transplantation. N Engl J Med. 2008;369:674–5.
13. Hornby K, Hornby L, Shemie SD. A systematic review of autoresuscitation after cardiac arrest. Crit Care Med. 2010;38:1246–53.
14. Boucek M, Dunn SM, et al. Pediatric heart transplantation after declaration of cardiocirculatory death. N Engl J Med. 2008;359:709–14.
15. De Carlis R, Di Sandro S, Lauterio A, Botta F, Ferla F, Adorno E, Bagnardi V, De Carlis L. Liver grafts from donors after circulatory death on regional perfusion with extended warm ischemia compared with donors after brain death. Liver Transpl. 2018;24(11):1523–35.
16. Rix BA. Brain death, ethics, and politics in Denmark. In: Youngner SJ, Arnold RM, Schapiro R, editors. The definition of death: contemporary controversies. Baltimore: John Hopkins University Press; 1999. p. 227–38.
17. Mateos-Rodrıguez A, Pardillos-Ferrer L, Navalpotro-Pascual JM, Barba-Alonso C, Martin-Maldonado ME, Andrés-Belmonte A. Kidney transplant function using organs from non-heart-beating donors maintained by mechanical chest compressions. Resuscitation. 2010;81:904–7.
18. National Health Service Blood and Transplant (NHSBT). Organ specific reports. Annual report 2018. Retrieved from: https://www.odt.nhs.uk/statistics-and-reports/organ-specific-reports/. Accessed 27 Feb 2020.
19. Ysebaert D, Van Beeumen G, De Greef K, et al. Organ procurement after euthanasia: Belgian experience. Transplant Proc. 2009;41:585–6.
20. Gilbo N, Jochmans I, Jacobs-Tulleneers-Thevissen D, Wolthuis A, Sainz-Barriga M, Pirenne J, Monbaliu D. Survival of patients with liver transplants donated after euthanasia, circulatory death, or brain death at a single center in Belgium. JAMA. 2019;322(1):78–80.
21. van Dijk G, Giezeman A, Ultee F, Hamers R. [Organ donation after active euthanasia in a patient with a neurodegenerative disease]. Ned Tijdschr Geneeskd. 2013;157(39):A6548.
22. Bollen JAM, Shaw D, de Wert G, Ten Hoopen R, Ysebaert D, van Heurn E, van Mook WNKA. Euthanasia through living organ donation: ethical, legal, and medical challenges. J Heart Lung Transplant. 2019;38(2):111–3.
23. Bollen J, Ten Hoopen R, Ysebaert D, van Mook W, van Heurn E. Legal and ethical aspects of organ donation after euthanasia in Belgium and the Netherlands. J Med Ethics. 2016;42(8):486–9.
24. ClinicalTrails.gov. Donors after circulatory death heart trial. Retrieved from: https://clinicaltrials.gov/ct2/show/NCT03831048. Accessed 10 Feb 2020.

25. Barnard CN. The operation. A human cardiac transplant: an interim report of a successful operation performed at Groote Schuur Hospital, Cape Town. S Afr Med J. 1967;41:1271–4.
26. Parent B, Moazami N, Wall S, Carillo J, Kon Z, Smith D, Walsh BC, Caplan A. Ethical and logistical concerns for establishing NRP-cDCD heart transplantation in the United States. Am J Transplant. 2020 Jan 8. https://doi.org/10.1111/ajt.15772. [Epub ahead of print].
27. Gries CJ, White DB, Truog RD, et al. An official American Thoracic Society/International Society for Heart and Lung Transplantation/Society of Critical Care Medicine/Association of Organ and Procurement Organizations/United Network of Organ Sharing statement: ethical and policy considerations in organ donation after circulatory determination of death. Am J Respir Crit Care Med. 2013;188:103–9.
28. McKinley J. Surgeon accused of speeding a death to get organs. New York Times, 27 Feb 2008. https://www.nytimes.com/2008/02/27/us/27transplant.html. Accessed 10 Feb 2020.
29. Rubenstein S. California surgeon cleared of hastening organ donor's death. The Wall Street Journal, 19 Dec 2008. https://blogs.wsj.com/health/2008/12/19/california-surgeon-cleared-of-hastening-organ-donors-death/. Accessed 10 Feb 2020.
30. Allison KC, Caplan A, Shapiro ME, Els C, Paul NW, Li H. Historical development and current status of organ procurement from death-row prisoners in China. BMC Med Ethics. 2015;16(1):85.
31. Paul NW, Caplan A, Shapiro ME, Els C, Allison KC, Li H. Human rights violations in organ procurement practice in China. BMC Med Ethics. 2017;18(1):11.
32. Huang J, Millis JM, Mao Y, Millis MA, Sang X, Zhong S. Voluntary organ donation system adapted to Chinese cultural values and social reality. Liver Transpl. 2015;21(4):419–22.
33. Lomero M, Gardiner D, Coll E, Haase-Kromwijk B, Procaccio F, Immer F, Gabbasova L, Antoine C, Jushinskis J, Lynch N, Foss S, Bolotinha C, Ashkenazi T, Colenbie L, Zuckermann A, Adamec M, Czerwiński J, Karčiauskaitė S, Ström H, López-Fraga M, Dominguez-Gil B, European Committee on Organ Transplantation of the Council of Europe (CD-P-TO). Donation after circulatory death today: an updated overview of the European landscape. Transpl Int. 2020;33(1):76–88. https://doi.org/10.1111/tri.13506. Epub 2019 Oct 7.
34. Health Resources and Services Administration (HRSA). SRTR DATA. https://srtr.transplant.hrsa.gov. Accessed 10 Feb 2020.
35. Global Observatory on Donation and Transplantation (GODT). Actual donors after circulatory death (DCD): absolute number and rate (pmp). 2017. Retrieved from: http://www.transplant-observatory.org/countdcd/. Accessed 10 Feb 2020.
36. Australian Government: National Protocol for Donation after Cardiac Death. https://donatelife.gov.au/sites/default/files/DCD%20protocol%20020311-0e4e2c3d-2ef5-4dff-b7ef-af63d0b-f6a8a-1.PDF. Accessed 10 Feb 2020.
37. Shemie SD, Baker AJ, Knoll G, Wall W, Rocker G, Howes D, Davidson J, Pagliarello J, Chambers-Evans J, Cockfield S, Farrell C, Glannon W, Gourlay W, Grant D, Langevin S, Wheelock B, Young K, Dossetor J. National recommendations for donation after cardiocirculatory death in Canada: donation after cardiocirculatory death in Canada. CMAJ. 2006;175(8):S1.
38. Huang J, Millis JM, Mao Y, Millis MA, Sang X, Zhong S. A pilot programme of organ donation after cardiac death in China. Lancet. 2012;379(9818):862–5.
39. Hillman H. Harvesting organs from recently executed prisoners: practice must be stopped. BMJ. 2001;323(7323):1254.
40. Chen W, Yadav DK, Bai X, Lou J, Que R, Gao S, Li G, Ma T, Wang J, Huang B, Liang T. Liver transplantation from voluntary organ donor system in China: a comparison between DBD and DCD liver transplants. Gastroenterol Res Pract. 2019;2019:5736702.
41. Antoine C, Mourey F, Prada-Bordenave E, Steering committee on DCD program. How France launched its donation after cardiac death program. Ann Fr Anesth Reanim. 2014;33(2):138–43.
42. Bruzzone P. Ethical and legal issues in donation after cardiac death in Italy. Transplant Proc. 2010;42(4):1046–7.
43. Akabayashi A. Japan's parliament passes brain-death law. Lancet. 1997;349:1895.
44. Kootstra G, Wijnen R, Van Hooff JP, Van der Linden CJ. Twenty percent more kidneys through a non-heart-beating program. Transplant Proc. 1991;23:910.

45. Domínguez-Gil B, Haase-Kromwijk B, Van Leiden H, Neuberger J, Coene L, Morel P, Corinne A, Muehlbacher F, Brezovsky P, Costa AN, Rozental R, Matesanz R, European Committee (Partial Agreement) on Organ Transplantation. Council of Europe (CD-P-TO). Current situation of donation after circulatory death in European countries. Transpl Int. 2011;24(7):676–86.
46. Corral E, Maynar J, Saralegui I, Manzano A. Nonbeating heart donors: Maastricht type III – a real option. Med Intensiva. 2011;35:59–60.
47. Weber M, Dindo D, Demartines N, Ambühl PM, Clavien PA. Kidney transplantation from donors without a heartbeat. N Engl J Med. 2002;347(4):248–55.
48. Beyeler F, Wälchli-Bhend S, Marti HP, Immer FF. Wiedereinführung des Non-Heart-Beating-Donor-Programms in der Schweiz? Schweiz Ärzteztg. 2009;23:899–901.
49. Wälchli-Bhend S, Beyeler F, Weiss J, Immer FF. How an existing donation after circulatory death program was grounded and re-started in Switzerland. Organs, Tissues & Cells. 2011;14:25–6.
50. Inci I, Schuurmans MM, Boehler A, Weder W. Zurich University Hospital lung transplantation programme: update 2012. Swiss Med Wkly. 2013;143:w13836.
51. Johnson RJ, Bradbury LL, Martin K, Neuberger J, UK Transplant Registry. Organ donation and transplantation in the UK-the last decade: a report from the UK national transplant registry. Transplantation. 2014;97 Suppl 1:S1–S27.
52. DeVita MA, Vukmir R, Snyder JV, Graziano C. Procuring organs from a non-heart-beating cadaver: a case report. Kennedy Inst Ethics J. 1993;3(4):371–85.
53. Casavilla A, Ramirez C, Shapiro R, Nghiem D, Miracle K, Fung JJ, Starzl TE. Experience with liver and kidney allografts from non-heart-beating donors. Transplant Proc. 1995;27(5):2898.
54. D'Alessandro AM, Hoffmann RM, Knechtle SJ, Eckhoff DE, Love RB, Kalayoglu M, Sollinger HW, Belzer FO. Successful extrarenal transplantation from non-heart-beating donors. Transplantation. 1995;59(7):977–82.
55. Institute of Medicine. Non-heart-beating organ transplantation: practice and protocols. Washington, DC: National Academy Press; 2000: 174.3.
56. Light JA, Barhyte DY, Gage FA, Sasaki TM, Aquino AO. Long-term graft survival after transplantation with kidneys from uncontrolled nonheart-beating donors. Transplantation. 1999;68(12):1910–1.
57. DeVita MA, Callaway CW, Pacella C, Brooks MM, Lutz J, Stuart S. Experience with a new process - condition T - for uncontrolled donation after circulatory determination of death in a university emergency department. Prog Transplant. 2016;26(1):21–7.
58. Selck FW, et al. Utilization, outcomes, and retransplantation of liver allografts from donation after cardiac death: implications for further expansion of the deceased-donor pool. Ann Surg. 2008;248(4):599–607.