OPEN

First Scandinavian Protocol for Controlled Donation After Circulatory Death Using Normothermic Regional Perfusion

Stein Foss, RN,[1] Espen Nordheim, MD,[1,2] Dag W. Sørensen, MD,[3] Torgunn B. Syversen, RN,[3] Karsten Midtvedt, MD, PhD,[1,2] Anders Åsberg, PhD,[1,4] Thorleif Dahl, RN,[5] Per A. Bakkan, RN,[1] Aksel E. Foss, MD, PhD,[1,6,7] Odd R. Geiran, MD, PhD,[2,5] Arnt E. Fiane, MD, PhD,[2,5] and Pål-Dag Line, MD, PhD[1,2]

Background. Donation after circulatory death (DCD) can increase the pool of available organs for transplantation. This pilot study evaluates the implementation of a controlled DCD (cDCD) protocol using normothermic regional perfusion in Norway. **Methods.** Patients aged 16 to 60 years that are in coma with documented devastating brain injury in need of mechanical ventilation, who would most likely attain cardiac arrest within 60 minutes after extubation, were eligible. With the acceptance from the next of kin and their wish for organ donation, life support was withdrawn and cardiac arrest observed. After a 5-minute no-touch period, extracorporeal membrane oxygenation for post mortem regional normothermic regional perfusion was established. Cerebral and cardiac reperfusion was prevented by an aortic occlusion catheter. Measured glomerular filtration rates 1 year postengraftment were compared between cDCD grafts and age-matched grafts donated after brain death (DBD). **Results.** Eight cDCD were performed from 2014 to 2015. Circulation ceased median 12 (range, 6-24) minutes after withdrawal of life-sustaining treatment. Fourteen kidneys and 2 livers were retrieved and subsequently transplanted. Functional warm ischemic time was 26 (20-51) minutes. Regional perfusion was applied for 97 minutes (54-106 minutes). Measured glomerular filtration rate 1 year postengraftment was not significantly different between cDCD and donation after brain death organs, 75 (65-76) vs 60 (37-112) mL/min per 1.73 m^2 ($P = 0.23$). No complications have been observed in the 2 cDCD livers. **Conclusion.** A protocol for cDCD is successfully established in Norway. Excellent transplant outcomes have encouraged us to continue this work addressing the shortage of organs for transplantation.

(*Transplantation Direct* 2018;4: e366; doi: 10.1097/TXD.0000000000000802. Published online 13 June, 2018.)

Organ transplantation is a successful treatment for most end-stage organ failures, but patients die on the waiting list due to organ shortage. Oslo University Hospital is the only transplant center in Norway, but also 1 of 26 Norwegian donor hospitals. During the last 5 years, an increase in national waiting time for transplantation has been observed, especially for kidney transplantations due to declining donation after brain death (DBD) rates from 25.6 per million population (PMP) in 2011 to 20.2 PMP in 2016.[1] A fair number of patients with devastating brain injury do not develop cerebral tamponade with intracranial circulatory arrest. According to Norwegian law, patients who die should, if possible, be provided with the opportunity to donate.[2] Without a functioning nationwide donation after circulatory death (DCD) program, some patients lose this possibility. The World Health Organization has encouraged all societies to develop responsible policies concerning donation after death and the adoption of DCD worldwide.[3]

The introduction of a program for DCD has the potential to increase the donor pool and thereby provide the possibility for organ transplantation to more eligible patients and reduce

Received 26 April 2018. Revision requested 8 May 2018.

Accepted 9 May 2018.

[1] Department of Transplantation Medicine, Oslo University Hospital, Rikshospitalet, Oslo, Norway.

[2] Institute of Clinical Medicine, University of Oslo, Oslo, Norway.

[3] Division of Emergencies and Critical Care, Oslo University Hospital, Oslo, Norway.

[4] School of Pharmacy, University of Oslo, Oslo, Norway.

[5] Department of Cardiothoracic Surgery, Oslo University Hospital, Oslo, Norway.

[6] Section of Transplantation Surgery, Uppsala University Hospital, Uppsala, Sweden.

[7] Department of Surgical Sciences, Uppsala University Hospital, Uppsala, Sweden.

The authors declare no funding or conflicts of interest.

Clinical Trial Notation: Norwegian regional committee for medical and health research ethics (1.2008.832).

S.F., E.N, D.W.S., T.B.S., T.D., P.A.B., A.E.F., O.R.G., A.E.F., and P.D.L. participated in research design. S.F., E.N., D.W.S., K.M., A.Å., A.E.F., O.R.G., A.E.F., and P.D.L. participated in the writing of the article.

Correspondence: Stein Foss, RN, Section for Transplantation Surgery, Department of Transplantation Medicine, Oslo University Hospital, Rikshospitalet, Sognsvannsveien 20, 0372 Oslo, Norway. (stein.foss@ous-hf.no).

ISSN: 2373-8731

DOI: 10.1097/TXD.0000000000000802

waiting lists. Successful DCD programs are already established in Spain, United Kingdom, Belgium and in The Netherlands with 7.8 to 10.7 DCD donors PMP in 2016.[4] Additionally, USA, Australia, Latvia, and France have well-developed DCD programs with 1.4 to 5.5 DCD donors PMP.[4] A higher incidence of delayed graft function (DGF) among DCD kidney recipients has been reported compared with DBD recipients, and inferior results with DCD liver transplantation have been associated with warm ischemic injury.[5-7] Currently, the majority of European centers performing controlled DCD (cDCD) defined as Maastricht class III use a rapid organ recovery technique by laparotomy or by double balloon catheter.[8] Using abdominal normothermic regional perfusion (NRP) by means of extracorporeal membrane oxygenator (ECMO) may improve the quality of DCD organs and reduce the incidence of DGF by avoiding prolonged warm ischemia and possibly reversing ischemic damage.[9-15]

The ETHICUS study showed that withdrawal of life sustaining treatment (WLST) on the basis of futility is frequently done in intensive care units (ICU) and are more applied in northern than southern European countries.[16] Forty-five to 50 years ago, in the early era of transplantation, cDCD was used in Norway to provide organs for kidney transplantation,[17] but this practice ended when the transplantation law was implemented in 1973.[18]

The objective of this pilot study is to evaluate the clinical results of the first cDCD protocol in Scandinavia using NRP.

MATERIALS AND METHODS

A single-center pilot study was approved by the Norwegian regional committee for medical and health research ethics (1.2008.832) and given institutional support by Oslo University Hospital. Inclusion criteria for protocol eligibility were patients aged 16 to 60 years in a coma with documented devastating brain injury, and on mechanical ventilation that on the basis of clinical assessment were most likely to attain cardiac arrest within 60 minutes after extubation. Potential cDCD donors were recruited in cases where the next of kin already had accepted WLST and where the donor criteria for brain death where unlikely to be met. The potential donors were referred to the national organ procurement organization for evaluation. The families were approached regarding possible DCD donation if the potential donors were considered to be medically suitable. After consent for donation was granted, the NRP team was notified. Premortem patient management was conducted by the ICU team not affiliated with the organ donation service. The cDCD protocol used NRP support of abdominal organs by an ECMO circuit. After permission was granted, central lines were placed in the common femoral artery and vein. 5000 international units Heparin® was given intravenously at WLST. Preparations for abdominal NRP were performed bedside in the ICU but without cannulation for perfusion before declaration of death. After a minute of silence, life-support was withdrawn and symptomatic directed measures continued as needed. The patients were extubated and intravenous support and vasoactive medications were stopped. Upon wish, the next of kin could be present bedside during the agonal period. After cardiac and respiratory arrest, and a 5-minute observation constituting a "no-touch period," the primary responsible intensive care physician made the declaration of death. The next of kin left the room after the observation period. Using Seldinger percutaneous technique, cannulas were rapidly placed for the NRP circuit thereby providing an organ preservation flush line. To avoid cardiac reanimation and cerebral reperfusion, the thoracic aorta was occluded with a double-lumen 7-Fr inflated balloon catheter which in addition allowed pressure measurements above the balloon to verify total occlusion of aorta (Figure 1) when perfusion was initiated. A strategy to confirm correct balloon catheter placement by radiopaque contrast was introduced during the study period. Functional warm ischemic time (fWIT) for organs was defined as the time from mean blood

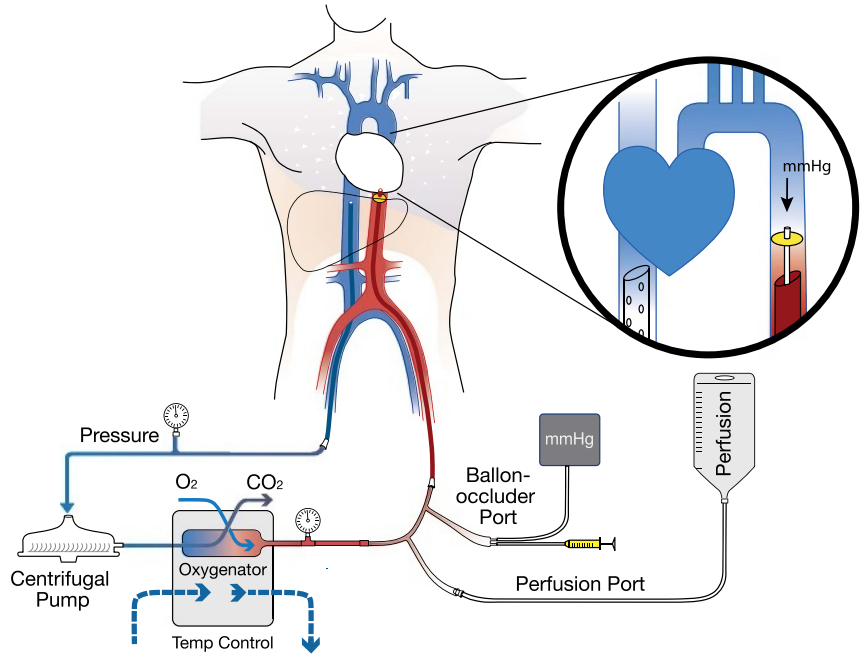

FIGURE 1. ECMO setup for cDCD.

TABLE 1.

Donor characteristics

	cDCD (n = 8)	DBD (n = 114)	*P*
Age, y	50.3 (34-60)	46.0 (16-60)	0.15
Male sex, n (%)	8 (100%)	69 (61%)	0.02
BMI, kg/m^2	26.9 (22.2-35.1)	24.7 (14.3-48.6)	0.32
Creatinine, mmol	72.0 (36.0-81.0)	69.0 (29-469)	0.53
Cause of death			
CVA, n (%)	2 (25)	41 (36)	0.71
Anoxia, n (%)	3 (37.5)	16 (14)	0.10
TBI, n (%)	3 (37.5)	24 (21)	0.39
Others, n (%)	0	33 (29)	0.11
Days in ICU	4 (2-18)	2 (0-30)	0.15
Asystole, min	12 (6-24)		
fWIT min	26.5 (20-49)		
NRP surgical procedure, min	10.5 (8-34)		
Total NRP (start-stop), min	97 (54-106)		
Drop in lactate during NRP, mmol/L	5 (2.2-7.7)		

Values are median (range) unless otherwise specified.

BMI, body mass index; CVA, cerebrovascular accident; TBI, traumatic brain injury.

pressure (BP) less than 50 mm Hg and/or oxygen saturation less than 80% (5 minute of "no-touch period" included) to NRP start. Organs were accepted for transplantation according to EDQM guidelines[19] with a maximum fWIT of 60 minutes for kidneys and 30 minutes for livers.

Potential cDCD recipients were recruited from 2009 to 2015 after obtaining written informed consent accepting to receive a cDCD organ. In total, 278 recipients were subsequently registered on an "expanded" waiting list for kidney transplantation. The clinical outcome of the cDCD protocol was evaluated by comparing renal function in cDCD recipients with a group of DBD recipients matched for donor age. Renal function was evaluated as measured glomerular filtration rate assessed by 2-point iohexol serum clearance at week 8 and week 52 after transplantation. Delayed graft function was defined as the need for dialysis during the first week after transplantation. Clinical parameters for the 2 cDCD liver transplants were collected from patient charts.

Data Collection and Statistical Analyses

Data analysis was performed using MS Excel and statistical analyses using SPSS (version 22; IBM, Armonk, NY). Categorical outcomes were described using frequencies and proportions while continuous variables were described using median (minimum, maximum range). Group comparisons were performed by a χ^2 test or Fisher exact test when appropriate. Continuous variables not normally distributed were compared using the Mann-Whitney *U* test. *P* values were reported according to 2-tailed analysis, and *P* values less than 0.05 were considered statistically significant.

RESULTS

cDCD Donors

During 2014 and 2015, 8 male donors were eligible and included in the study after next-of-kin consent to donation. Median donor age was 50 years and median body mass index 27 kg/m^2. Cardiac arrest occurred after a median of 12 minutes (6-24 minutes), and no episodes of autoresuscitation were observed. Seven donors were cannulated using Seldinger technique, while 1, due to difficult vascular access, was converted to a cut-down procedure. The median fWIT was 26 minutes (20-51 minutes). Median NRP time at 37°C was 97 minutes (54-106 minutes) with median circuit flow of 3.0 L/min (1.7-4.0 L/min). All but 1 patient required SAG transfusion to keep hemoglobin levels above 8 g/dL; with a median of 2 unites (0-5 units). No severe bleeding was observed. During NRP, the pH values normalized, the venous saturation kept above 60% and the active clotting times kept above 350 seconds. In all but 1 case, a substantial drop in lactate values during NRP was observed with a median of 5.0 (2.2-7.7) mmol/L. One donor had the aortic occlusion catheter misplaced at the level of the left renal artery, resulting in increased lactate values from 10.4 to 17.0 mmol/L during NRP. These ischemic organs could not be used for transplantation. Fourteen kidneys and 2 livers were retrieved and subsequently transplanted from cDCD donors. As the pilot study was designed to retrieve kidneys and livers, only a mean of 2.3 organs from each cDCD donor were transplanted. In simultaneously performed DBDs, the number was 4.4 (including heart, lungs, and pancreas). As shown in Table 1, there were no significant differences regarding the characteristics between cDCD and age-matched DBD donors.

cDCD Kidneys

The characteristics of the cDCD kidney recipients and clinical outcomes are presented in Table 2. One DCD recipient had DGF and lost the graft due to chronic rejection 4 months after transplantation. Cold ischemia time (CIT) for cDCD kidneys were significantly lower than that in the DBD control group.

There were no significant differences in measured glomerular filtration rate between cDCD and DBD kidney recipients at 8 weeks and 1 year after transplantation; 66 vs 59 mL/min

TABLE 2.

Kidney recipients' characteristics and outcomes

	cDCD (n = 14)	DBD (n = 163)	*P*
Age, y	58 (34 71)	52 (2-80	0.22
Male sex, n (%)	10 (71.4%)	111 (68%)	0.79
CIT, min	360 (174-624)	767 (233-1685)	<0.005
DGF, n (%)	1 (7.1%)	8 (4.9%)	0.53
Iohexol GFR week 8 posttransplant (mL/min per 1.73 m^2)	665 (51-78)	59 (31-106)	0.19
Iohexol GFR week 52 posttransplant (mL/min per 1.73 m^2)	75 (65-76)	61 (37-112)	0.23
Graft loss at 12 mo, n (%)	1 (7.1%)	8 (4.9%)	0.53

Values are median (range) unless otherwise specified.

DGT, delayed graft function.

per 1.73 m^2 at 8 weeks and 75 vs 61 mL/min/1.73 m^2 at 1 year posttransplant, respectively. The 1-year graft survival of cDCD and DBD group was 93% and 95%, respectively.

DCD Livers

Two of 5 livers accepted for transplantation were transplanted. The fWIT was 23 and 26 minutes, the CIT was 225 and 428 minutes, respectively. Both liver grafts had primary function, and at 2 years posttransplant, both recipients had normal liver function tests without signs of biliary complications.

DISCUSSION

We have reintroduced and refined a previously used method that provides an opportunity to pursue organ donation as end-of-life care, an option otherwise not used in Norway for decades. The initial clinical results of the new protocol are in line with other reports and support the postulation that NRP seems favorable in a cDCD setting.[9-15]

After the first cDCD in April 2014, the remaining 7 donations were done within 1 and a half years. The pilot study was originally accepted by the Regional Ethical Committee and started in December 2009. From 2009 to 2014, several patients were initially evaluated but were found to be uneligible due to social, cultural, or language difficulties. Besides, we experienced resistance toward cDCD within and between different medical, ethical, and legal professions. The concept is now under scrutiny and being evaluated by a governmental-appointed official body before a national implementation may take place.

There were several reasons for choosing NRP as retrieval technique. Normothermic regional perfusion allows end-of-life care to be performed with minimal deviation, within the ICU, bedside, and by healthcare staff familiar to the next of kin. Furthermore, the NRP procedure can be done efficiently and the donor transferred to the operating room with minimal urgency. Consequently, in contrast to a rapid recovery technique, the NRP procedure offers the next of kin the possibility to bid a last farewell before leaving the ICU. We have previously published results on the importance of careful planning, good practices, and attention to individual needs for both the patients and their families.[20] Our results found that bereaved families of cDCD donors where NRP are used to demonstrate an overall positive experience during the different phases of the donation process.[20]

Additionally, compared with a rapid removal technique, NRP provides a controlled environment and reanimation of ischemic organs, also allowing careful visual inspection and excellent quality control, helping to avoid iatrogenic damage to organs and may also reduce the risk of staff injury during surgery. After abdominal inspection, NRP, during retrieval, allows the transplant teams to start the recipient operation and thereby minimize CIT. As the importance of keeping CIT short especially for kidneys with long WIT/fWIT has been documented[5,21] we focused on keeping the CIT as low as possible for the cDCD organs. Median CIT for cDCD kidneys ended up significantly lower than that in the DBD control group which may have contributed to our low reported DGF rate after cDCD.

Like most cDCD programs, our protocol includes a 5-minute observation "no-touch period" after asystole to ensure permanent cessation of circulation.[8] In line with the experience of others,[22] we did not encounter any signs of autoresuscitation after asystole.

In the United Kingdom, nearly 40% of cDCD donations are aborted after treatment withdrawal, usually because the time limit is exceeded.[23] In our series, all patients went into cardiac arrest within the 60-minute stand down time. Evaluation tools with scoring systems have been developed in an attempt to predict the time of progression to cardiorespiratory arrest.[24-25] These tools are yet to be validated prospectively and remain of uncertain benefit. They do not take into account the use of pharmacological symptomatic care with analgesics and/or sedatives after life support withdrawal.[23,26-27] For these reasons, we decided not to use any scoring system, but relied on the clinical judgment by the intensive care physician. We restrictively selected potential donors only implementing those most likely to proceed to asystole within 60 minutes. However, in the future, when a broader range of cDCD candidates are accepted as donors, we must expect that donations could be aborted due to exceeding stand down time limits. Our new protocol has a 90-minute limit, but due to the good results in the United Kingdom,[5,28] showing little effect on prolonged stand down time and without using NRP, we will consider expanding to 120 minutes.

We experienced 1 misplacement of the aortic balloon catheter, consequently, no organs from this donor were used. This incident taught us to follow lactate values carefully and to verify the aortic balloon position by radiologic imaging.

The cutoff limits for accepting organs for transplantation was based on fWIT, using the definition of a drop to mean BP less than 50 mm Hg and/or oxygen saturation less than 80%. After the pilot study was carried out, the more common definition of fWIT (mean BP, <50 mm Hg for a longer period than 2 minutes) has been used.[29] If we apply this definition on our data set, the median fWIT would have been 18 minutes (15-40 minutes) versus 27 minutes (20-51 minutes).

The numbers of used organs per donor were lower in the cDCD group (mean, 2.3 organs) compared with the DBD control group (mean, 4.4 organs). The difference is in line with previous experiences from similar protocols[8-9,30] and is partly due to the fact that the lungs and pancreas were not used according to our protocol. However, the difference indicates that the lower yield of transplantable grafts could be expected during the learning curve. We acknowledge the fact that lungs and pancreas are retrieved and successfully transplanted in centers with similar NRP protocols.[9]

Prolonged warm ischemia is particularly harmful for liver grafts where increased incidence of ischemic cholangiopathy has been reported.[7] Recent publications have shown favorable posttransplant results using NRP to improve organ quality after ischemic damage.[9-15] We had hoped to gain more experience from liver transplantation after NRP, but disappointingly, in 3 cDCD cases, the livers were not used because there were no blood group-compatible patients on the expanded waiting list. The pretransplant written information to recipients indicated a slightly lower expected result in comparison to DBD which may have affected the recruitment of cDCD liver recipient candidates. Our good experiences with the 2 liver transplants performed are encouraging, but does not justify any conclusions.

Prolonged CIT and DGF have previously shown little impact on long term cDCD kidney graft survival.[5,28] Our

current protocol resulted in few DGF numbers compared with results from cDCD without NRP, showing results comparable to those obtained with DBD donation.[5-6] However, the DGF observed might be due to the short CIT compared with other experiences.

In a paired kidney analysis, Lim et al[6] have challenged the previously held belief that DGF has no deleterious effect on graft outcome. They showed that 3-year death-censored graft survival for DCD recipients was 14% lower in the absence of DGF compared with those who did experience DGF. Normothermic regional perfusion and low CIT might be an effective method to minimize the detrimental effects of warm ischemia during DCD donation and potentially improve graft survival.

Our study has shown that NRP allows a comprehensive assessment of organ viability, converts a stressful rush during retrieval, and provides valuable time saved for the transplant teams to minimize CIT. The gained experience implementing an in-house technique was crucial when expanding cDCD outside our hospital using a mobile NRP team covering travel distances up to 250 km.

CONCLUSIONS

The results indicate that NRP can be an effective method to restore abdominal organ perfusion and help increase the number of grafts obtainable for transplantation. Controlled DCD provides an opportunity to pursue organ donation in clinical settings where DBD is not possible, thereby providing the patients with the option of fulfilling their last will. The introduction of well-established selection criteria of DCDs worldwide is likely to increase significantly the pool of good quality organs for transplantation. Further studies are required to fully assess the impact on organ recovery rate and results in Norway.

ACKNOWLEDGMENTS

The authors would like to acknowledge the substantial contribution from Scandiatransplant and of all involved healthcare workers (physicians, surgeons, nurses, perfusionists, and transplant coordinators) for their enthusiasm and support.

REFERENCES

1. Scandiatransplant. Transplantation and Waitinglist 2011 to 2016. http://www.scandiatransplant.org/data/scandiatransplant-figures. Accessed March 13, 2018.
2. LOVDATA. Lov om donasjon og transplantasjon av organer, celler og vev. 2015. [Act on Donation and Transplantation of Organs, Cells and tissues. 2015]. https://lovdata.no/dokument/NL/lov/2015-05-07-25?q=Transplantasjon. Accessed March 13, 2018.
3. WHO; Transplantation Society (TTS); Organizatión Nacional de Transplantes (ONT). Third WHO Global Consultation on Organ Donation and Transplantation: striving to achieve self-sufficiency, March 23-25, 2010, Madrid, Spain. *Transplantation*. 2011;91(Suppl 11):S27–S29.
4. EDQM Council of Europe. Newsletter Transplant, International figures on donation and transplantation vol 22. 2016. https://www.edqm.eu/en/news/2017-issue-newsletter-transplant-now-available.
5. Summers DM, Watson CJ, Pettigrew GJ, et al. Kidney donation after circulatory death (DCD): state of the art. *Kidney Int*. 2015;88:241–249.
6. Lim WH, McDonald SP, Russ GR, et al. Association between delayed graft function and graft loss in donation after cardiac death kidney transplants—a paired kidney registry analysis. *Transplantation*. 2017;101:1139–1143.
7. Tang JX, Na N, Li JJ, et al. Outcomes of controlled donation after cardiac death compared with donation after brain death in liver transplantation: a systematic review and meta-analysis. *Transplant Proc*. 2018;50:33–41.
8. Domínguez-Gil B, Haase-Kromwijk B, Van Leiden H, et al. Current situation of donation after circulatory death in European countries. *Transpl Int*. 2011;24:676–686.
9. Miñambres E, Suberviola B, Dominguez-Gil B, et al. Improving the outcomes of organs obtained from controlled donation after circulatory death donors using abdominal normothermic regional perfusion. *Am J Transplant*. 2017;17:2165–2172.
10. Hessheimer AJ, Garcia-Valdecasas JC, Fondevila C. Abdominal regional in-situ perfusion in donation after circulatory determination of death donors. *Curr Opin Organ Transplant*. 2016;21:322–328.
11. Oniscu GC, Randle LV, Muiesan P, et al. *In situ* normothermic regional perfusion for controlled donation after circulatory death—the United Kingdom Experience. *Am J Transplant*. 2014;14:2846–2854.
12. Magliocca JF, Magee JC, Rowe SA, et al. Extracorporeal support for organ donation after cardiac death effectively expands the donor pool. *J Trauma*. 2005;58:1095–1101.
13. Rojas-Pena A, Sall LE, Gravel MT, et al. Donation after circulatory determination of death: the University of Michigan experience with extracorporeal support. *Transplantation*. 2014;98:328–334.
14. Shapey IM, Muiesan P. Regional perfusion by extracorporeal membrane oxygenation of abdominal organs from donors after circulatory death: a systematic review. *Liver Transpl*. 2013;19:1292–1303.
15. Antoine C, Legendre C. Organ transplantation in France. *Transplantation*. 2017;101:445–448.
16. Sprung CL, Cohen SL, Sjokvist P, et al. End-of-life practices in European Intensive care units: the Ethicus Study. *JAMA*. 2003;290:790–797.
17. Enger E, Bergan F, Hoeg K, et al. Kidney transplantation at Ullevål hospital. A 7 year material. *Tidsskr Nor Laegeforen*. 1971;91:1113–1130.
18. Act of 9 Feb.1973 nr.6 on Transplantation, Hospital Autopsies and Donation of Bodies m.m. LOV-1973-02-09-6.
19. EDQM Council of Europe. Guide to the quality and safety of organs for transplantation. EDQM 6th edition. 2016. https://www.edqm.eu/freepub/.
20. Syversen TB, Sørensen DW, Foss S, et al. Donation after circulatory death - an expanded opportunity for donation appreciated by families. *J Crit Care*. 2018;43:306–311.
21. Gill J, Rose C, Lesage J, et al. Use and outcomes of kidneys from donation after circulatory death donors in the United States. *J Am Soc Nephrol*. 2017;28:3647–3657.
22. Hornby L, Dhanani S, Shemie SD. Update of a systematic review of autoresuscitation after cardiac arrest. *Crit Care Med*. 2018;46:e268–e272.
23. Murphy P, Boffa C, Manara A, et al. In-hospital logistics: what are the key aspects for succeeding in each of the steps of the process of controlled donation after circulatory death? *Transpl Int*. 2016;29:760–770.
24. Lewis J, Peltier J, Nelson H, et al. Development of the University of Wisconsin donation after cardiac death evaluation tool. *Prog Transplant*. 2003;13:265–273.
25. DeVita MA, Brooks MM, Zawistowski C, et al. Donors after cardiac death: validation of identification criteria (DVIC) study for predictors of rapid death. *Am J Transplant*. 2008;8:432–441.
26. Munshi L, Dhanani S, Shemie SD, et al. Predicting time to death after withdrawal of life-sustaining therapy. *Intensive Care Med*. 2015;41:1014–1028.
27. Bradley JA, Pettigrew GJ, Watson CJ. Time to death after withdrawal of treatment in donation after circulatory death (DCD) donors. *Curr Opin Organ Transplant*. 2013;18:133–139.
28. Nagaraja P, Roberts GW, Stephens M, et al. Influence of delayed graft function and acute rejection on outcomes after kidney transplantation from donors after cardiac death. *Transplantation*. 2012;94:1218–1223.
29. Thuong M, Ruiz A, Evrard P, et al. New classification of donation after circulatory death donors definitions and terminology. *Transpl Int*. 2016;29:749–759.
30. Hodgson R, Young AL, Attia MA, et al. Impact of a national controlled donation after circulatory death (DCD) program on organ donation in the United Kingdom: a 10-year study. *Am J Transplant*. 2017;17:3172–3182.