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Kidney transplantation with grafts from type III Maastricht death cardiac donors

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ABSTRACT

Kidney transplantation (KT) with kidneys from death cardiac donors (DCD) is a growing trend in Spain. The majority of these kidneys come from type II Maastricht patients, although in recent years, organ donations from patients awaiting cardiac arrest following limitation of life-sustaining therapy has already been in practice in certain European and North American countries, involving type III Maastricht patients. We present a series of 6 KT using kidneys obtained from DCD as a consequence of limitation of life-sustaining therapy in three different hospitals in the sector of Malaga. After agreeing upon a protocol for evaluating the potential of a patient for organ donation after the decision for limiting life-sustaining therapy, the patients' families were given the option of organ donation. Kidneys were preserved using a Porges double balloon catheter, which was placed prior to cardiac arrest. In two cases, the limitation of life-sustaining therapy took place in the intensive care unit, and in the third case, in the operating room. The interval between limitation of life-sustaining therapy and cardiac arrest ranged between 15 minutes and 40 minutes, with an interval of circulatory arrest prior to perfusion of 5-11 minutes. Perfusion-cooling of the kidneys was initially carried out using saline solution, followed by organ preservation solution (Celsior or Belzer) and extraction of the kidney using a rapid surgical technique. True or functional hot ischaemia times were 60 minutes, 59 minutes, and 50 minutes, respectively, for each of the three donors. Kidneys were evaluated for viability using time intervals for the procedure (including hypotension prior to cardiac arrest), macroscopic appearance, and histopathology of a sample taken from each kidney. The recipients of these 6 kidneys had given their consent to receive organs from expanded-criteria donors. Cold ischaemia lasted between 9 hours and 20 hours (mean: 14.6 hours). One recipient developed haemorrhagic complications during the immediate postoperative period and required a transplantectomy. The other five currently retain functioning grafts. All had delayed graft function, necessitating haemodialysis. The range of estimated glomerular filtration rates at the most recent follow-up evaluation was 23.0-106ml/min/1.73m^2. In conclusion, type III Maastricht donors provide valid kidneys for transplantation, although this series showed that supported functional hot ischaemia was very important, the consequence of accumulated ischaemic damage starting in the agonal phase, circulatory arrest, and organ preservation using cold solutions. As such, to improve the quality of results obtained using kidneys from these types of donors would involve a very careful selection of optimal donors and minimisation of total functional ischaemia times.

Keywords: Non heart-beating donor. Death cardiac donor. Expanded criteria donor. Kidney transplant death cardiac donor.

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Trasplante renal con injertos procedentes de donantes en parada cardíaca Maastricht tipo III

RESUMEN

El trasplante renal (TR) con riñones de donantes fallecidos en parada cardíaca (PC) está creciendo en nuestro país. La mayoría procede de donantes con los criterios de Maastricht tipo II, si bien en los últimos años el donante fallecido tras limitación de tratamientos de soporte vital (LTSV) es una realidad en algunos países europeos y norteamericanos y constituye el Maastricht tipo III. Se presenta una serie de 6 TR con riñones de donantes fallecidos tras PC como consecuencia de LTSV en tres hospitales del Sector Málaga. Tras consensuar protocolo de actuación en el que la valoración como donante fue siempre posterior a la decisión de LTSV, se planteó a las familias la opción de donación. La preservación de los riñones se realizó mediante sonda de doble balón tipo Porges que se colocó antes de la PC. En dos casos la LTSV se realizó en la Unidad de Cuidados Intensivos y en el tercero en quirófano. Los tiempos desde inicio LTSV hasta la PC oscilaron entre 15 y 40 minutos, con un tiempo de parada circulatoria antes del inicio de la perfusión entre 5 y 11 minutos. La perfusión-enfriamiento de los riñones se realizó inicialmente con solución salina y posteriormente con solución preservadora de órganos (Celsior o Belzer) para a continuación proceder a la extracción renal con técnica quirúrgica rápida. Los tiempos de isquemia caliente verdadera o funcional fueron de 60, 59 y 50 minutos respectivamente para cada uno de los tres donantes. La validación de los riñones se produjo tras valorar tiempos totales del procedimiento (incluida la hipotensión previa a la PC), macroscopia renal y anatomía patológica de una cuña extraída a cada riñón. Los trasplantados con estos 6 riñones dieron su consentimiento para recibir riñones de donante expandido. La isquemia fría osciló entre 9 y 20 horas (media: 14,6 horas). Uno de los receptores presentó complicaciones hemorrágicas en el posoperatorio inmediato que precisó trasplantectomía. Los otros cinco mantienen los injertos funcionantes en la actualidad. Todos presentaron retraso funcional del injerto y necesitaron hemodiálisis. El rango del filtrado glomerular estimado en la última revisión se encuentra entre 23,0 y 106 ml/min/1,73 m^2. Como conclusión de esta experiencia, los donantes Maastricht tipo III proporcionan riñones válidos para trasplante, aunque esta serie muestra que la isquemia caliente funcional soportada fue importante, consecuencia del daño isquémico acumulado desde la fase agónica, la parada circulatoria y la preservación con soluciones frías. Por ello, mejorar la calidad de los resultados de los trasplantes renales realizados con este tipo de donantes pasa por una cuidadosa selección de donantes y acortar los tiempos de isquemia funcional total.

Palabras clave: *Donación en asistolia. Donante en parada cardíaca. Donante con criterios expandidos. Trasplante renal de riñones en asistolia.*

INTRODUCTION

In the last few years, we have seen a decrease in the number of patients deceased by brain death (BD) in Intensive Care Units (ICU) in Spain. This tendency seems to be influenced by the lower numbers of cranioencephalic trauma due to traffic or occupational accidents and to the emergence of more aggressive treatments for cerebrovascular accidents (CVA).[1]

In parallel, the limitation of life-support treatments (LSTL) is a clinical practice that is growing in Spanish hospitals for patients admitted to the ICU with neurological injuries that have severe and extensive brain damage, with fatal prognosis and not completing BD criteria.[2] Under this circumstances and in consensus with the patients family, LSTL is decided and we expect death by cardiac arrest. In this way, we take into account the desires expressed by the patient through the Registry of Anticipated Vital Wills or, where applicable, through the closest family members as representatives of the patient's expectations and lifestyle. LSTL opens up the opportunity to offer the choice of organ donation to the family upon the patient's death. This kind of donor is grouped under controlled donors (type III Maastricht) death cardiac donors.[3] Along this same topic, some hospitals in our country have started to explore this additional source of organs for transplantations,[4] usual in some European[5] and North American[6,7] hospitals. In Spain, we currently have a consensus document sponsored by the National Transplant Organisation (ONT).[8]

We present a series of six kidney transplants obtained from CA donors (type III) as a consequence of LSTL.

PATIENTS, METHOD AND ACTION PROTOCOL

After the creation of a clinical protocol about LSTL by Intensive Care doctors, a protocol to approve type III Maastricht donors and improve the extraction of kidneys was implemented in the Transplant Coordination Unit of Malaga sector (Malaga, Almeria, Ceuta and Melilla, Spain).

One of the points of emphasis was to avoid any conflicts of interest. Therefore, it was decided that LSTL be agreed upon by the ICU staff responsible for the patient and that it should be written in the patients evolution independently of whether they were accepted as donors or not after CA.

The three families that we presented with the LSTL choice accepted it after being informed of the patient's neurological lesions, their fatal prognosis and no signs of brain death. One of the donors had expressed the decision of donating organs through the Registry of Anticipated Vital Wills.

Once LSTL had been decided, transplant coordinators interviewed the families and presented the possibility of

donation after CA. All three families agreed and accepted also the placing of a premortem Porges 12 F double balloon arterial catheter, manufactured in Denmark by Coloplast, and a venous drain catheter similar to the ones used in haemodialfiltration which would preserve kidneys after death by cardiopulmonary causes was confirmed.

Donor number 1 passed away of natural causes due to haemorrhagic CVA at the hospital Carlos Haya (Malaga). Donor number 2 died due to cerebral anoxia after CA at the hospital Torrecardenas (Almeria) and donor number 3, due to haemorrhagic CVA at the hospital Virgen de la Victoria (Malaga) (Table 1).

Catheters were placed by vascular surgeons through arteriotomy and inguinal venotomy; they were left closed with the balloons deflated and flushed with saline and heparin. In donor number 1, catheters were placed in the bed of the patient in ICU; on number 2, in the operating room and in donor number 3 in a room next to the ICU room that had OR conditions. These differences were mainly caused by availability and evolution of procedure.

Subsequently, we proceeded to apply the LSTL measures decided in clinical session with consensus of medical and nursing staff, giving a relevant role to the physician responsible for the patient in ICU. The Clinical Record included the medical agreement and the information passed on to the family. Each case was carried out according to criteria by the respective ICU doctors. In the first donor, the process included lowering the fraction of intake oxygen, discontinuing inotropic drugs and increasing opioid as comfort analgesia. The second and third cases needed extubation and administration of opioids in the sites the catheter was inserted.

Once CA happened, the ICU doctor determined the absence of pulse or blood pressure during a time of no less than five minutes, to confirm death by cardiorespiratory criteria.

From that moment, the work of the ICU doctors ends and the Transplant Coordination professionals begin their procedures. They start with an infusion of 3mg of sodium heparin per kg of weight, inflation of both arterial catheter balloons for the total occlusion of arterial light and beginning of infusion, first with 3 litres of saline solution at 4ºC followed by cold organ preservation liquids (Celsior® or ViaSpan®, depending on availability). On donor number 1, we used a high-flow pump for cold solutions perfusion. On donors 2 and 3, perfusion was done only by gravity with high flow lines. A tabulated sheet was created to document each process and their duration.

Critical ischaemia times have been defined according to the Asystole Donation Document of Spain: Current situation and recommendations,[8] where true or functional hot ischaemia counts from the moment of significant hypoperfusion determined by blood pressure lower than 60mmHg and ends when the perfusion with preservation liquids is finished. Hot ischaemia of circulatory arrest is counted since CA or absence of pulse until the start of cold perfusion, and it includes the regulative five minutes of asystole confirmation.

The urologist surgeons that had been previously selected got ready for surgery immediately after the end of infusion. The technique used was one known as "fast extraction". The kidneys extracted in bocks were re-perfused individually once placed in the auxiliary table.

Table 1. Characteristics of type III Maastricht donors and their conditions until extraction

Donor	Age	Neurological Lesion	Days in ICU	CR / /eGFR	Time start LSTL until CA (min)	Hypotension time <60mmHg (min)	Time of circulatory arrest (min)	Time since start of preservation (min)	Time from end of preservation until extraction (min)	RB score RK/LK
1	46	Haemorrhagic CVA	3	0.9/119	40	6	11	43	20	3 / 3
						Hot functional ischaemia: 60 min				
2	58	Anoxia	4	0.98/88	20	4	5	50	30	2 / 2
						Hot functional ischaemia: 59 min				
3	47	Haemorrhagic CVA	8	0.5/199	15	10	5	35	25	0 / 0
						Hot functional ischaemia: 50 min				

CVA: cardiovascular accident; RB: Renal biopsy, CR: creatinine pre-extraction (mg/dl); eGFR: estimated glomerular filtration rate by Cockcroft-Gault (ml/min/1,73m^2); LSTL: life support treatments limitations; CA: cardiac arrest, RK: right kidney; LK: left kidney; ICU: Intensive care unit.

The assessment of viability of kidney grafts was based on the computation of the total ischaemia times, macroscopic appearance and the results of a renal biopsy of each graft at the time of organ extraction of approximately 10x5x5mm, from a representative portion of the parenchyma with the intention to study a minimum of 25 superficial and deep glomeruli and two interlobar and/or arcuate arteries. Histological examination was performed using cryostat sections by haematoxylin and eosin staining. The evaluation screened for four types of lesions: sclerosed glomeruli, myointimal elastosis, tubular atrophy and interstitial fibrosis. Each lesion type was given a score between 0 and 3 points.[9] Apart from the 6 kidneys, 6 corneas were removed and osteotendinous tissue was extracted only from donor number 3. Graft biopsies were indicated depending on clinical evolution.

Six patients not previously hyperimmunised were the renal graft recipients, receiving immunosuppression with steroids, thymoglobulin (1mg/kg/day) for seven days, tacrolimus (0.1mg/kg/day) which was introduced on the fifth day after transplantation and mycophenolate mofetil (1-2g/day).

RESULTS

Table 1 shows the characteristics of donors and the most critical times that followed LSTL. For donor number 1, the time from LSTL to CA was 40 minutes, with 6 minutes of hypotensive phase lower than 60mmHG before CA. For donor number 2, CA came after an interval of 20 minutes and, in donor number 3, after 15 minutes.

Times of hot ischaemia from CA to the beginning of perfusion were 11 minutes for the first donor, motivated by technical problems in the infusion pump connectors. On the second and third donor, this time was five minutes. Time of ischaemia from the beginning until the end of cold solution perfusion varied between 35 minutes for donor number 3 and 50 minutes for donor number 2. Finally, the preservation time between the end of the cold perfusion until clamping and perfusion by the extracting surgeon was between 20 and 30 minutes. True or functional hot ischaemia times were 60 minutes, 59 minutes, and 50 minutes, respectively, for each of the three donors.

Surgery was performed with fast extraction technique and gross examination confirmed that all three donors had kidneys of normal aspect. Kidney samples showed: in donor number 1 a biopsy score of 3 for each kidney, in donor number 2 the score was 2 for each kidney, and it was 0 for each kidney from donor number 3.

Table 2 shows the main characteristics of the 6 transplanted patients and their renal function evolution. Both kidneys transplanted from donor number 1 had higher oliguria and longer delayed graft function, needing about a month of hospitalisation with 9 and 10 haemodialysis sessions, respectively. Radiological studies with ultrasound and doppler initially showed patterns of high resistance to blood flow. The first biopsy performed on the first two recipients showed glomeruli with no significant changes, tubules diffusely affected by tubular epithelial necrosis with formation of cylinder with intense intraluminal regenerative cell changes. C4d staining test was negative. Two successive biopsies performed a week apart, showed the same type of changes but less severe, coinciding with diuresis recovery. The three following recipients never had a biopsy given that although they presented delays in graft function, diuresis was recovered soon and they needed a reduced number of haemodialysis sessions. None of the recipients presented clinical or histological criteria of acute rejection.

Transplant recipient number 6 presented haemorrhagic shock right after surgery which needed surgical re-intervention.

Table 2. Characteristics and evolution of transplant patients

Donor	Trasplant	Sex	Age	Baseline disease	Cold Ischaemia (hours)	DGF	HD (n)	Hospitalisation day (n)	Cr decrease (day)	Cr 1 m (mg/dl)	Cr 3 m (mg/dl)	Cr 6 m (mg/dl)	GFR (ml/min)
1	1	M	62	Unexplained	13	Yes	10	34	28°	5.2	4.4	2.2	33.6
	2	F	52	PKD	16	Yes	9	29	26°	5.5	3.7	2.7	23.0
2	3	F	68	DM	18	Yes	2	13	13°	2.4	2.3	1.7	37.3
	4	M	73	Unexplained	20	Yes	4	11	7°	2.3	2.2	2.3	28.5
3	5	M	49	Type 1 MPGN	12	Yes	2	10	10°	1.3	0.9	0.9	106.0
	6	M	56	Nephroang.	9	-	-	6	-	-	-	-	NA

CR: serum creatinine; DM: diabetes mellitus, GFR: last value of estimated glomerular filtration rate by Cockcroft-Gault (ml/min/1,73m^2); MPGN: membranoproliferative glomerulonephritis type 1; HD: haemodialysis sessions; F: female; NF: non-functioning; PKD: polycystic kidney disease; DGF: delayed graft function; M: male. CR decrease: day when creatinine starts decreasing

Diffuse bleeding and venous thrombosis were found, leading to transplantectomy. This kidney was transplanted partially decapsulated, and when removing perirenal fat, it was very dense and much attached.

DISCUSSION

LSTL is a common practice in ICU when the applied treatments are considered unresponsive (or useless) since they cannot offer the patient reasonable possibilities of recovery. Under these circumstances, there are sufficient arguments to use consensus protocols about end of life, considering that the applied treatments do not add benefits. LSTL is currently considered a part of a good clinical practice.[10]

The numbers vary from centre to centre, but it is believed that between 10% and 50% of deaths occurring in ICUs in Spain are a consequence of the removal of therapeutic measures in situations with no possibility of recovery.[11] In this scenario, the choice of donation may be offered once end of life has been certified. The tendency towards a higher number of donors deceased by CA is compensating in some countries the decrease of donors deceased by BD. It is assessed as an opportunity to maintain an adequate number of transplants in an environment of lower BD which in the United States constitutes 10% to 11% of all deceased donors.[12] Nevertheless, we must take into account that CA donors should be an addition to BD donors. Along these lines, it is important not to promote controlled type III donation in potential donors who may evolve to BD with time, where the optimisation of extracted organs is higher.[13]

This type of donor, currently grouped within CA controlled donors, should provide organs in better conditions than non-controlled donors, that is, those in which CA happens outside of the hospital and who undergo cardiac massage and are taken to a hospital with a CA donation programme (type II).[14] In addition, type III Maastricht donors have a less complex logistic which allows programmed extraction that can be performed in smaller hospitals. In the past, our hospital kept an organ donation programme for 11 years. It consisted of organs from inpatient CA donors, preserved with renal cooling and it reached 20 effective donors.[15]

The three donors herein presented may be considered as middle aged, none of them had hypertension, diabetes, vascular disease or were smokers. Renal pre-extraction function was normal. This aspect is certainly noticeable since lesions from the agonal phase and hot ischaemia will be less when organs have optimal anatomical and functional conditions. In theory, this can provide a greater possibility of regeneration from, the almost certain to happen, acute tubular necrosis. However, pre-implantation biopsies from donor number 1 were the ones with higher scores (3 per kidney), though still within the range of kidneys that are optimal for transplant, could have influenced the functional delay of the graft.

True or functional hot ischaemia includes the most critical times that can condition the functionality of the graft since it can produce lesions. Opposite to other CA non-controlled donors, these cannot have cardiac massage to lessen ischaemia beside the risk of auto-resuscitation, then the times should be a bit more than the five-minute minimum established by legislation in RD 2070/1999.[16] The current norm contemplates, besides diagnosis of CA death, the protocols aimed at obtaining the pertinent judicial permits in the case of non-natural death. Thus, controlled as well as non-controlled donors have, currently, complete legal support.

In the three donors, we requested and obtained family consent to place arterial and venous catheter that will allow renal preservation. Having this advantage is essential to shorten ischaemia times after circulatory arrest. In the first donor, the catheter was placed by vascular surgeons in their ICU bed. This procedure, through venotomy and arteriotomy was very difficult. Thus it was modified in the following donors to be performed in an operating room or similar environment with an operating table and more appropriate lights. With catheters properly inserted and heparinised, hot ischaemia times during circulatory arrest until the beginning of preservation should not be greater than the five minutes necessary to confirm death by CA. In this manner, ischaemic lesions are reduced while kidneys are kept at body temperature without blood flow or oxygen support. On donor number 1, this time lasted 11 minutes. It was our first type III donor; LSTL was performed in the ICU and there was an unforeseen problem with the fast infusion pump connectors that had been prepared in the operating room. Following this complication, we rejected the use of the infusion pump in the following donors and chose to keep cold perfusion by gravity through high flow lines and placing solutions to the maximum height possible.

Afterwards, another period of organic damage includes the ischaemia times during the perfusion of cold solutions, in which kidney temperature will begin to descend progressively and therefore will have gradually less metabolic needs. In our experience, this time never exceeded 50 minutes. Finally, the third ischaemia period, probably less harmful, includes from the end of cold perfusion until surgical extraction. Its duration will depend on the abilities and experience of the operating team and it tends to be around 30 minutes.

In regards to recipients, we chose non hyper-immunised patients. This fact and the induction in the six patients with thymoglobulin can facilitate the delayed introduction of

tacrolimus from the fifth day and avoid early graft immune dysfunction.

After transplant, the first two recipients followed a similar path with very severe oliguria. In fact, three serial renal biopsies showed great tubular damage. However, they recovered diuresis within a week and after the first renal biopsy we found cells in mitosis at the tubular level, which was considered a precocious sign of functional anatomic recovery of the graft. After almost a month of hospitalisation, patients were sent home without dialysis although creatinine levels higher than 5mg/dl descended progressively during subsequent evolution (Table 2). These kidneys came from donor number 1, who presented greater times from the beginning of LSTL to CA, more time from circulatory arrest until the beginning of perfusion and pre-implantation biopsy with greater score.

In recipients number 3 and 4 from the second donor, we saw a much faster functional recovery. They needed two and four haemodialysis sessions respectively and were sent home 11 and 13 days after intervention. These two kidneys did not have biopsies performed.

In regards to recipients 5 and 6 from donor number 3, the first one presented functional graft delays and needed two haemodialysis sessions. This recipient maintained an excellent glomerular filtration rate, much higher than levels reached by recipients of standard BD donors. Recipient number 6 presented primary graft failure due to haemorrhagic complications in the first 24 hours, which led to hypotension and thrombosis. This complication was not related to the preservation procedure. We considered the de-capsulation produced in the auxiliary table of the operating room after extraction, during the removal procedure of dense and abundant perirenal fat may have been a contributing factor since the other kidney, which did not need decapsulation, functioned magnificently.

As a conclusion from this initial experience, type III Maastricht donors offer an opportunity to obtain kidneys usable for transplant although in this study ischaemic damage accumulated in some of the kidneys was significant. This tells us that three out of five recipients keep their serum creatinine levels around 2mg/dl (1.7-2.3mg/dl), greater that the levels expected with other types of donors. We believe this to be a consequence of total hot ischaemic damage produced in each of the critical phases (LSTL, hypotension, hypoxia, circulatory arrest, death diagnosis, preservation and extraction). This argument represents the most plausible explanation, besides the related difficulties with a new procedure that requires learning. Similar experiences confirm greater incidence of graft renal function delay and higher primary graft failure with the use of kidneys from CA donors. Though, patients who survive the initial phase had the same chance of long-term survival,[17,18] or better[19] than transplants from BD donors. Therefore, improving the quality of renal transplant results performed with type III Maastricht donors happens to shorten true or functional hot ischaemia times.

What times could be reduced? In the hypotensive agonal phase previous to cardiac arrest, there is not much to be done. Under 60mmHg there is renal hypoperfusion especially when O_2 saturation is also reduced. These measures were not taken in our three donors. We cannot, ethically or legally, administer drugs that would accelerate CA although it is necessary to know other allowed actions, such as heparin administration and comfort analgesics.[20] After circulatory arrest, we need to adjust the start of cold perfusion immediately after the 5 regulatory minutes, as it was done in our three donors. In perfusion ischaemia, our experience from the last two donors with gravity infusion through high flow lines and using maximum possible height for preservation liquids seems a sufficient alternative. In preservation ischaemia surgical techniques that enable rapid extraction in the shortest possible time should be applied.[21] In regards to cold ischaemia times, it also applies that the shorter the time the better. In order to avoid delays, we can disregard patient selection based on HLA compatibility and in donors younger than 60 years with normal renal function without proteinuria and no history of metabolic or hypertensive disease. Pre-implantation kidney biopsy may also be omitted for cold ischaemia not much higher than 12 hours.[17]

Finally, we must evaluate whether in type III Maastricht donors techniques such as ECMO (extracorporeal membrane oxygenation) can be used to minimise or revert ischaemic lesions, as well as to evaluate the possibility of using the donors' liver once the perfusion-oxygenation of the body has been adjusted in normothermia.[22] Pulsatile perfusion machines that monitor flow, resistance, pressure and temperature seem to be useful in validating or even improving the viability of transplants with kidneys extracted after CA.[23]

Conflicts of interest

The authors declare that they have no potential conflicts of interest related to the contents of this article.

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REFERENCES

1. Saidi RF, Bradley J, Greer D, Luskin R, O'Connor K, Delmonico F, et al. Changing patterns of organ donation at a single center. Are potential brain donors being lost to donation after cardiac death? Am J Transplant 2010;10:2536-40.
2. Saralegui I, Poveda Y, Martín A, Balciscueta G, Martínez S, Pérez C. et al. Life-sustaining-treatment limitation in ICU, a well established and improved practice with critical patients. Intensive Care Med 2009;35 Suppl 1:S262.
3. Koostra G, Daemen JHC, Oomen APA. Categories of non-heart-beating donors. Transplant Proc 1995;27:2893-4.
4. Corral E, Maynar J, Saralegui I, Manzano A. Donantes a corazón parado tipo III de Maastricht: una opción real. Med Intensiva 2011;35:59-60.
5. Domínguez-Gil B, Haase-Kromwijk B, Van Leiden H, Neuberger J, Coene L, Morel P, et al. Current situation of donation after circulatory death in European countries. Transpl Int 2011;24:676-86.
6. Moers C, Leuvenink HGD, Ploeg RJ. Donation after cardiac death: evaluation of revisiting an important donor source. Nephrol Dial Transplant 2010;25:666-73.
7. Reich DJ, Mulligan DC, Abt PL, Pruett TL, Abecassis MMI, D'Alessandro A, et al. ASTS recommended practice guidelines for controlled donation after cardiac death. Am J Transplant 2009;9:2004-11.
8. Documento de consenso de la ONT sobre donación en asistolia. Available at: http://www.ont.es/infesp/DocumentosDeConsenso/DONACIÓN EN ASISTOLIA EN ESPAÑA. SITUACIÓN ACTUAL Y RECOMENDACIONES.pdf. [Accessed: May 14, 2012].
9. Serón D, Anaya F, Marcén R, García del Moral R, Vazquez-Martul E, Alarcón A, et al. Recomendaciones para la indicación, obtención, procesamiento y evaluación de biopsias en el trasplante renal. Nefrologia 2008;28:385-96.
10. Monzón Marín JL, Saralegui Reta I, Abizanda i Campos R, Cabré Pericas L, Iribarren Diarasarri S, Martín Delgado MC, et al.; Grupo de Bioética de la SEMICYUC. Recomendaciones de tratamiento al final de la vida del paciente crítico. Med Intensiva 2008;32:121-33.
11. Saralegui I, Martin JC, Oses I. Limitación de tratamientos de soporte vital en Medicina Intensiva: Estudio multicéntrico español. Comunicación en el Congreso SEMIU. Málaga 2010.
12. Klein AS, Messersmith EE, Ratner LE, Kochik R, Baliga PK, Ojo AO. Organ donation and utilization in the United States, 1999-2008. Am J Transplant 2010;(4 Pt 2):973-86.
13. Skaro AI, Jay CL, Ladner D, Abecassis MM. Trends in donation after cardiac death and donation after brain death - Reading between the lines. Am J Transplant 2010;10:2390-1.
14. Nuñez JR, Del Rio F, Lopez E, Moreno MA, Soria A, Parra D. Non-heart beating donors: an excellent choice to increase the donor pool. Transplant Proc 2005;37:3651-4.
15. Frutos MA, Ruiz P, Requena MV. Extracción de riñones de donantes a corazón parado mediante enfriamiento corporal total. Nefrologia 1996;16:65-72.
16. Real Decreto 2070/1999 de 30 de diciembre. Boletín Oficial del Estado 3; martes, 4 de enero de 2000.
17. Summers DM, Johnson RJ, Allen J, Fuggle SV, Collet D, Watson CJ, et al. Analysis of factors that affect outcome after transplantation of kidneys donated after cardiac death in the UK: a cohort study. Lancet 2010;376:1303-11.
18. Hoogland ERP, Snoeijs MGJ, van Heurn LWE. DCD kidney transplantation: results and measured to improve outcome. Curr Opin Organ Transplant 2010;15:177-82.
19. Sánchez-Fructuoso A, Prats D, Torrente J, Pérez-Contín MJ, Fernández C, Álvarez J, et al. Renal transplantation from non-heart beating donors: a promising alternative to enlarge the donor pool. J Am Soc Nephrol 2000;11:350-8.
20. Phua J, Lim KT, Zygun DA, Doig CJ. Pro/Con debate: in patients who are potential candidates for organ donation after cardiac death, starting medications and/or interventions for the sole purpose of making the organs more viable is an acceptable practice. Crit Care 2007;11:211-4.
21. Snoeijs MG, Dekkers AJ, Buurman WA, Van der Akker K, Welten RS, Schurink GW, et al. In situ preservation of kidneys from donors after cardiac death: results and complications. Ann Surg 2007;246:844-52.
22. Trotter JF. Controversies in Liver Transplantation. In: Schiff ER, Maddrey WC, Sorrell MF (eds.). Schiff's Diseases of the Liver, 11th Edition. Oxford: Wiley-Blackwell; 2011.
23. Moers C, Smits JM, Maathuis MHJ, Treckmann J, van Gelder F, Napieralski BP, et al. Machine perfusion or cold storage in deceased-donor kidney transplantation. N Engl J Med 2009;360:7-19.

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