

ORIGINAL ARTICLE

Factors affecting the survival of transplants from donors after prehospital cardiac death

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Objective. To evaluate factors that influence the survival of transplanted organs from donors after prehospital cardiac death.

Methods. Retrospective observational study of data collected from the records of a hospital emergency service.

Results. Two hundred cases from 2008 through 2011 were studied. Sixty-nine potential donors (34.5%) were rejected. Three hundred organs were extracted from the remaining 131 donor cases, to yield a mean (SD) of 2.32 (0.83) organs/donor or 1.52 (1.29) organs/potential donor. Seventy-six percent (152) donors were treated with mechanical cardiopumps during transport. We detected no significant differences between cases transported with manual chest compressions and cases treated with cardiopumps regarding age (40.13 vs 43.52 years, $P=0.06$), responder arrival times (13 min 54 s vs 12 min 54 s, $P=0.45$), or transport times (1 h 27 min vs 1 h 32 min). Cases transported with manual chest compressions yielded significantly more kidneys (mean, 1.96/potential donor) than those transported with cardiopump compressions (mean, 1.38/potential donor) ($P=0.008$). Eleven of the 229 kidneys harvested (4%) were not transplanted. The median (interquartile range) serum creatinine concentrations after kidney transplants at 6 and 12 months, respectively, were 1.37 (1.10–1.58) mg/dL and 1.43 (1.11–1.80) mg/dL.

Conclusions. We did not identify predictors of the survival or failure of kidney, liver, or lung transplants in the recipient. However, our findings suggest that the use of a cardiopump affects the remission of donors. Long-term creatinine levels are similar after transplantation of kidneys from donors transported with cardiopump or manual compressions.

Keywords: Organ donation after cardiac death. Emergency health services. Transplants.

Factores que influyen en la evolución de los injertos de donantes tras muerte cardiaca extrahospitalaria

Objetivo. Valorar los factores extrahospitalarios que pueden influir en la viabilidad de los injertos en los receptores.

Método. Estudio observacional retrospectivo que recoge datos de los registros del sistema de emergencias y del hospital de aquellos pacientes con muerte cardiaca extrahospitalaria que fueron trasladados al hospital para valorar.

Resultados. Se recogen 200 casos entre los años 2008 y 2011, de los que 69 (34,5%) no fueron donantes. De los 131 donantes utilizados se extrajeron 300 órganos [media de 2,32 (DE 0,83) órganos/donante utilizado y 1,52 (DE 1,29) órganos/donante potencial]. De los 200 pacientes, 152 fueron trasladados bajo cardiocompresión mecánica (76%). No hay diferencia significativa en edad (40,1 frente a 43,5 años, $p = 0,06$) y tiempo de llegada (13'54" frente a 12'54", $p = 0,45$) y tiempo de transferencia (1 h y 27' frente a 1 h y 32') entre el grupo de pacientes trasladados con cardiocompresión manual y con cardiocompresión mecánica, pero sí en la media de órganos por donante potencial en favor de la cardiocompresión manual (1,96 frente a 1,38, $p = 0,008$). De los 229 riñones extraídos, no se transplantaron 11 (4%). La mediana de la creatinina a los 6 meses de los riñones fue de 1,37 mg/dl (RIC: 1,10-1,58) y a los 12 meses de 1,43 mg/dl (RIC: 1,11-1,80), sin diferencias entre ambos grupos.

Conclusiones. Nuestros datos sugieren que el uso de compresores mecánicos disminuye el reclutamiento de donantes. A largo plazo la concentración de creatinina en los riñones trasplantados es similar independientemente del tipo de compresión usada durante el traslado y ninguna variable extrahospitalaria predice la evolución de los injertos.

Palabras clave: Donación tras muerte cardiaca. Servicios de emergencias. Trasplante.

Introduction

The donation after type II cardiac death is the one that is generated after the death of a patient due to sudden death and an unsuccessful resuscitation in the emergency field. The factors that influence the subse-

quent evolution of grafts from these donors are very varied and are well studied in the hospital setting^{1,2}, but not in the outpatient setting.

In previous studies it is observed how the use of mechanical compressors (CCM) or times can influence the obtaining of organs. In 2010, an article was publis-

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hed evaluating the efficacy of mechanical cardiocompressors as a method of preserving organs³. It compared two groups of donors in asystole of 40 cases each; one group was handled with CCM and the other with manual compression. The kidney rate and organ and tissue donor rate were significantly lower in the CCM-donor group. These data suggest whether the use of these devices was correct. Although this study had obvious limitations, since it included few cases and only valued the transplanted organs, without taking into account the evolution of them. In a more detailed way, if only renal grafts are valued, the data offered by a cohort of donors handled with CCM versus manual compression do not have significant differences⁴. But, apart from mechanical compressors, there are other variables that are also worth valuing. The objective of this study is to evaluate the extra-hospital factors that may influence the viability of the grafts in the receptors.

Method

Retrospective observational study based on the collection of data from the records of the emergency system and the Hospital 12 de Octubre de Madrid during the period from 2008 to 2011. This study has been evaluated by the Research Ethics Commission of SUMMA112 and has its approval.

The variables collected were: age, sex, time of the call (when emergency notification is received), time of arrival (time between the call and the unit arrives at the scene), time of transfer (time of arrival at the hospital), time of arrival at the hospital (time gap from the call to the arrival at the hospital), total number of organs donated; type of organ donated, and cause of non-donation (patient refusal, family refusal, pump failure, biological cause and others). The patient's refusal refers to those cases in which he or she has made the decision against the donation of organs while still alive. The pump failure refers to the action of cannulating the patient and submitting it to extracorporeal circulation, the biological cause includes medical causes that excludes them as donors, in the other section includes judicial refusal, technical problems, times outdated or impossibility of the cannulation or the helicopter. Primary failure of right or left renal graft, right and left renal receptor creatinine concentration at 12 months, and liver and lung receptor survival at 12 months were collected.

As for the statistical analysis used this is a retrospective case series study based on the collection of data from clinical records. Statistical analysis was performed using the SPSS v.16.0 statistical software. Quantitative variables are represented as mean, with standard deviation (SD) or median with interquartile range (IQR). The qualitative variables are presented in percentages. For the hypothesis test, the chi square test or the Fisher f test were used if necessary, the Student t test or non-parametric tests.

The univariate analysis of the data distinguishes between two types of factors that may influence whether a potential donor is used or not. Individual factors inclu-

de age, sex, and cause of death. Among the factors of the process we include the stop-arrival times, hospital stop-transfer times and the use of the helicopter in the procedure.

In the multivariate analysis we have included the variables age, sex, arrival and transfer times and use of CCM. In the arrival and transfer times, the variable has been categorized according to inclusion criteria or did not comply. In the case of arrival times, if this had occurred before or after the 15 minutes and in the case of the transfer time if it was greater or less than 120 minutes, as described in the inclusion criteria after cardiac death.

Results

A total of 200 cases were collected between the years 2008 and 2011 both included (Figure 1). The possible cause of death was not recorded in prehospital care in most cases (56.8%), followed by suspicion of cardiologic (30.3%), neurological (4.5%), traumatic (2.5%), respiratory (2.5%) and others (3.5%) (Table 1). The average time of arrival from the alert to the arrival of the assistance team was 13:08 (SD 7:12) minutes. The average time of arrival at the hospital from the alert was 91 (SD 29) minutes.

The number of cases that were not finally donors was 69 patients, which constitutes 34.5% of the total. The cause of the most frequent non-donation was the biological cause or poor state of the organs (10.5%), followed by family negative (6.5%), failure to connect the donor to extracorporeal circulation (2%), negative of the patient expressed in life (1.5%) and judicial negative (0.5%). 2.5% of the reasons for non-donation were due to a variety of causes, including logistical aspects such as overtime, errors in the extra or in-hospital logistics, etc.

Of the 131 donors used, 300 organs were extracted, constituting an average of 2.32 (SD 0.83) or-

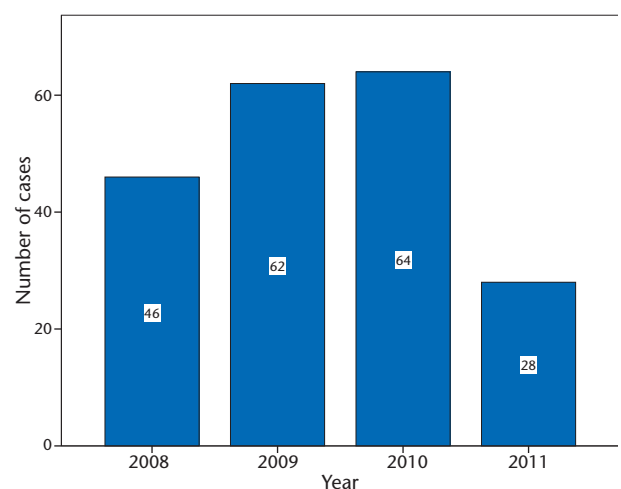


Figure 1. Number of donors per year.

Table 1. General population data

	Men N = 172 n (%)	Women N = 28 n (%)	Total N = 200 n (%)
Age in years [average (SD)]	43.1 (10.2)	39.9 (12.2)	42.0 (11.3)
Cause of death			
Unknown/Unregistered	97 (56.4)	16 (57.1)	113 (56.5)
Cardiac	57 (33.1)	3 (10.7)	60 (30.0)
Neurological	8 (4.7)	1 (3.6)	9 (4.5)
Traumatic	5 (2.9)	0	5 (2.5)
Respiratory	2 (1.2)	3 (10.7)	5 (2.5)
Other	5 (2.9)	2 (7.1)	7 (3.5)
Use of cardio-compressors	134 (77.9)	18 (64.3)	152 (76.0)
Donors used	114 (66.3)	17 (60.7)	131 (65.5)
Transplanted kidneys	200 (116.3)	29 (103)	229 (114.5)
Creatinine at 12 months (mg/dl) [median (IQR)]	1.43 (1.18-1.87)	1.48 (1.15-1.96)	1.43 (1.11-1.80)
Transplanted livers	35 (20.3)	6 (21.4)	41 (20.5)
Transplanted lungs	26 (15.1)	4 (14.3)	30 (15.0)
Total organs	261 (151.7)	39 (139.3)	300 (150)

SD: standard deviation; IQR: interquartile range.

gans/donor used and 1.52 (SD 1.29) organs/potential donor. 229 kidneys, 41 livers and 30 lungs were extracted. The helicopter was used 24 times for the transfer of potential donors. The average time of arrival on stage was 15:55 (SD 4:46) minutes and the mean time of arrival at the hospital was 92:32 (SD 23: 6) minutes. In 7 cases the donation could not be made, 5 for medical reasons and 2 for family refusal. Of the 17 remaining donors, 45 organs were extracted: 33 kidneys, 9 livers and 3 lungs, which is 1.8 potential donor organs and 2.6 donor organs used when the helicopter was transferred.

Of the cases collected, 152 (76%) were transferred under mechanical cardio compression, 110 cases were transferred with LUCAS®, 30 with Autopulse® and 12 under cardio compressor, but the type was not known. There was no significant difference in age (40.1 vs 43.5 years, $p = 0.05$) and time of arrival (13'54 " versus 12'54 ", $p = 0.45$) and time transference (1 h 27 'versus 1 h 32', $p = 0.39$) among the manual and mechanical cardio compression patients.

Of the potential donors transferred under mechanical cardiomyopathy, 158 kidneys, 27 livers and 24 lungs were extracted for transplantation. This constitutes an average of 1.38 (SD 1.31) organs per potential donor. There is a statistically significant difference with the mean per potential donor in manual cardio compression (1.96 vs 1.38, $p = 0.008$).

Of the 152 potential donors transferred under mechanical cardiomyopathy, 93 donors were used (61%). If we analyse only the population of donors used, the mean increases to 2.27 (SD 0.89) organs per donor and, in this case, there is no significant difference with manual cardio compression (2.49 vs 2.27, $p = 0.18$).

Of the 229 kidneys extracted, 11 (4%) were not transplanted. The median creatinine of the right kidney at 6 months was 1.30 mg/dl (IQR: 1.10-1.58) and at 12 months of 1.41 mg/dl (IQR: 1.11-1.80). The median creatinine in the left kidney at 6 months was 1.51 mg/dl (IQR: 1.31-1.80) and at 12 months of 1.47

Table 2. General data by thoracic compression method

	Manual N = 48 Average (SD)	Mechanic N = 152 Average (SD)	p
Age (in years)	43 (11)	40 (11)	0.05
Average arrival time (in minutes)	12:54 (6:01)	13:54 (8:40)	0.45
Transfer time (in minutes)	92 (27)	87 (29)	0.39
Donor used [n (%)]	38 (78.7)	93 (61.2)	0.02
Right kidney [median (IQR)]			
Creatinine 6 months (mg/dl)	1.21 (1.11-1.27)	1.31 (1.09-1.64)	0.07
Creatinine 12 months (mg/dl)	1.38 (1.23-1.87)	1.44 (1.13-1.87)	0.60
Left kidney [median (IQR)]			
Creatinine 6 months (mg/dl)	1.37 (1.30-1.73)	1.53 (1.25-1.88)	0.60
Creatinine 12 months (mg/dl)	1.46 (1.20-2.17)	1.47 (1.24-1.90)	0.70

SD: standard deviation; IQR: interquartile range.

mg/dl (IQR: 1.20-1 , 92). Of the 41 livers extracted, all were transplanted. Survival at one year was 71.8%. The year-to-year survival of the pulmonary grafts was 88.9% (Table 2).

In relation to the univariate analysis, in our series there is no significant relationship between care times and the validity or not of the donor (Figure 2).

Of the 200 cases studied, 172 were males (86%) and 28 were females (14%). Of the males, 114 donors were used (66.3%) versus 58 unused donors (33.7%). Among women, 17 were used (60.7%) and 11 (39.3%) were not used donors. Although there is a greater number of males, there are no significant differences between men and women for organ donation with OR 0.87 (95% CI: 0.35-2.15, $p = 0.76$).

The mean age of the donors used was 43.1 (SD 10.2) years whereas the mean age of the unused donors was 39.9 (SD 12.2) years ($p = 0.22$).

In most cases the cause of death was not recorded. Of these, 61.9% of the patients were used donors, compared to 69.8% of the remaining reasons for death ($p = 0.25$). Patients who died due to suspected cardiac causes donated some of their organs in 68.3%, compared to 64% of the other reasons for death ($p = 0.55$). The reason for death due to neurological pathology was found in only 9 patients, of whom 66.6% donated an organ compared to 65.3% of the other potential donors ($p = 0.93$). All patients in whom respiratory cause was suspected donated some organ, but it was a low number, only 5, with no statistical significance. For the traumatological origin of death, despite registering a low number of patients, it differs in its behaviour. Of the 5 patients of traumatic origin, only 1 donated their organs (20%) compared to 66.5% of donors used that were found in all other causes ($p = 0.05$).

From the total number of donors, 61.2% of CCM donors were used donors versus 78.7% of donors with a manual compressor (CCMa) [OR: 0.42 (95% CI: 0.19-0.92, $p = 0.02$)] (Figure 3). CCMs have been used in larger donors than manual cardio compression [43.5 (SD 10.3) years versus 40.1 (SD 10.1) years, $p = 0.05$].

Out of the 24 potential donors who were transfe-

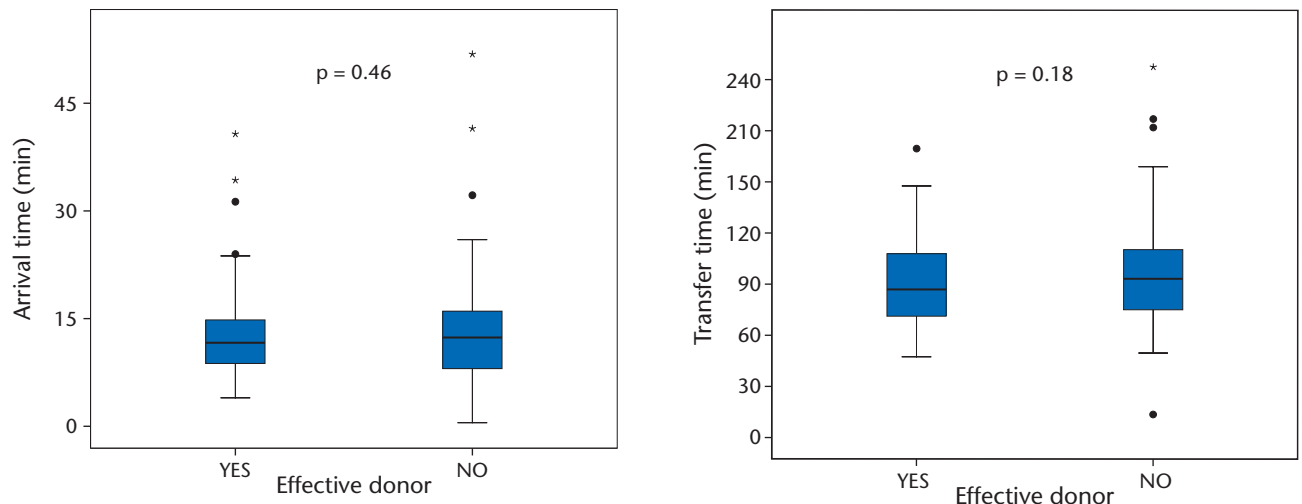


Figure 2. Analysis of the time of arrival (left) and transfer (right) of the emergency team.

red by helicopter 70% donated some of their organs, the same percentage as the group of patients transferred by land vehicle ($p = 0.93$).

In the multivariate analysis, only the use of CCM was associated with a lower number of used donors. The remaining variables did not obtain any relation (Table 3).

Discussion

The first thing that stands out from the descriptive results of our series is that the proportion of women is significantly lower than that of men. These data are in line with the series of all cardiorespiratory arrest (CRP)⁵ and donation in asystole⁶. The majority of patients un-

dergoing CRP under 65 years are males. In addition, there are studies that suggest a greater survival of the female sex in the case of cardiac arrest⁷.

The times of arrival to the scene and of transference to the hospital are adequate to our means. The need to shorten the times in cases of cardiac arrest is well demonstrated⁸. The mean time of arrival at the place of attendance was 13 minutes, which is above the times recommended in the clinical guidelines⁹ for response in a cardiac arrest, but is within the inclusion criteria for the donor after cardiac death, which is estimated in 15 minutes. However, there are studies that affirm the low relation between the response time and the subsequent evolution of the graft¹⁰.

The total number of effective donors in our study reaches 65%. Over the last few years this percentage has increased as more and better donors have been detected. In most of the series, 70% of donors are used, among the cases assessed for donation. Among the 35% of potential donors who did not donate the causes are multiple, the most prominent is to detect any infection that would rule out the donation, such as HIV infection, unknown tumours, etc. Although in our series the family negative reaches 20%, this is not corroborated in other previous studies in which the family negative does not exceed 7%, well below the negative in cases of donation after brain death¹¹. Other reasons for exclusion from the protocol are less frequent, such as pump failure or technical impossibility to cannulate the patient in the femoral artery and vein or to maintain a

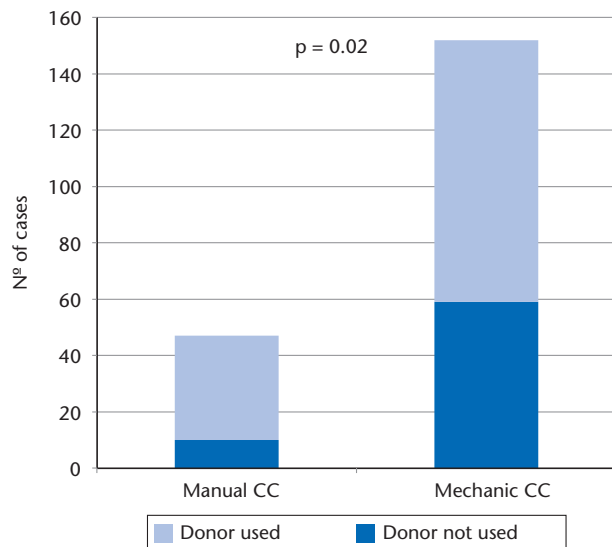


Figure 3. Analysis by thoracic compression method. CC: cardio compression.

Table 3. Multivariate analysis of the variables

	p	OR	CI (95%)
Age	0.119	1	0.88-1.30
Sex	0.995	0.99	0.28-3.45
Arrival time	0.760	1.1	0.92-1
Transfer time	0.816	0.86	0.25-2.94
Use of mechanical cardiocompression	0.026	0.27	0.08-0.86

OR: odds ratio; CI: confidence interval.

correct extracorporeal circulation due to a rupture of large vessels produced at death. In some cases, the protocol has been excluded by detecting a clear manifestation of the patient's lifetime against the donation and this is the clearest and legally confirmed cause of protocol detention. Finally, judicial denials are anecdotal and have always been based on understandable arguments such as ignorance of the patient's identity or inability to contact the family. These data are superimposable to other donation series after cardiac death¹².

The use of the helicopter has made it possible to activate the donation protocol in asystole more often. The air environment has shown that it is perfectly qualified for the transfer of this type of donors¹³.

The variables that influence the evolution of the grafts in the donor cases after cardiac death are so numerous that one cannot attribute to one in particular the survival of such graft. In this evolution they influence from the initial state of the organ in the donor to the measures that are put in place to recover the spontaneous circulation that can at any moment damage one of these organs, but that is the main objective before a patient in cardiac arrest.

But the fact is that, according to our data, the use of mechanical devices decreases the rate of extracted and transplanted organs. We have also observed that the group of patients submitted to mechanical cardio compression is older than the group to which manual cardio compression was performed. Although this age difference is minimal, it exists and should be taken into account for future studies, so that age does not constitute an independent factor in the evolution of the graft. In the scientific literature, age is related to the satisfactory evolution of the renal graft, but these are older than our series, above 70 years¹⁴.

On the other hand, the evolution of the kidneys after a year, comparing them in both groups, mechanical devices and manual cardio compression group, is satisfactory and, in most cases, a normal creatinine is verified before the year is over.

In the case of the liver, the most significant improvement in hepatic graft survival in the CCM donor group. The high survival rate with these devices makes one suspect that the correct perfusion of a labile organ such as the liver is of vital importance to it. It is advisable to endorse these data with larger samples of patients and longer evolution.

Our study has several limitations. It has a low number of cases collected from both hepatic and pulmonary transplants. These two transplant procedures have suffered several incidents in their history, sometimes the procedure has been suspended for various reasons. In addition, at the beginning of the data collection were beginning to perform the procedure so that the learning curve of the whole team can alter our survival data. This learning curve should be checked against more recent data.

In conclusion, it is possible to say that no variable has been found that is a predictive factor in the evolution of the renal, hepatic or pulmonary graft. However,

our data suggest that mechanical compressor applications decrease donor recruitment. In the long term, creatinine concentrations are similar using manual or mechanical cardio compression.

Conflicting interests

The authors declare no conflict of interest related to this article.

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Ethical Responsibilities

This study was approved by the Clinical Research Ethics Committee of the Medical Emergency Service of the Community of Madrid (SUM-MA112).

All authors have confirmed the maintenance of confidentiality and respect for patients' rights in the author's responsibilities document, publication agreement and assignment of rights to EMERGENCIAS.

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