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Clinical paper

Potential kidney donors among patients with out-of-hospital cardiac arrest and a termination of resuscitation rule

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Abstract

Importance: Uncontrolled donation after circulatory determination of death (uDCD) has been developed and can serve as a source of kidneys for transplantation, especially when considering patients that meet extended criteria donation (ECD).

Objective: This study assessed the theorical size and characteristics of the potential pool of kidney transplants from uDCD with standard criteria donation (SCD) and ECD among patients who meet Termination of Resuscitation (TOR) criteria following Out of Hospital Cardiac Arrest (OHCA).

Methods and participants: This study focused on adult patients experiencing unexpected OHCA, who were prospectively enrolled in the Parisian registry from May 16th, 2011, to December 31st, 2020.

Results: During the study period, EMS attempted resuscitation for 19,976 OHCA patients, of which 64.5% (12,890) had no return of spontaneous circulation. Among them, 47.4% (9,461) had TOR criteria, representing no chance of survival, and from them, 8.8% (1,764) met SCD criteria and could be potential organ donors and 33.6% (6,720) met ECD for kidney donors. The mean potential number per year of uDCD candidates with SCD and ECD remain stable respectively around 98 (±10.8) and 672 (±103.8) cases per year. Elderly patients (≥65 y.o.) represented 61.2% (n = 5,763/9,461) of patients who met TOR and 100% (5763/5763) of patients who could have matched both ECD criteria and TOR.

Conclusion and relevance: Implementing uDCD program including SCD and ECD for kidney transplantation among OHCA cases quickly identified by the TOR, holds significant potential to substantially broaden the pool of organ donors. These programs could offer a viable solution to address the pressing burden of kidney shortage, particularly benefiting elderly recipients who may otherwise face prolonged waiting times and limited access to suitable organs.

Keywords: Out of Hospital Cardiac Arrest, Organ donation, Termination of Resuscitation rules, Extended criteria donors, Uncontrolled donation after cardiac death

Introduction

Each year thousands of patients die or endure poor quality of life while waiting for a kidney suitable for transplantation.[1] As a response to the shortage of available grafts, donation after circulatory determination of death (DCD) has been developed including two categories defined by the historical Maastricht classification.[2] The first option is controlled DCD (cDCD) which currently serves as the main source of organ donation. In this category, cardiac arrest is expected and associated with a withdrawal of life-sustaining therapies. Another option is uncontrolled DCD (uDCD) which concerns patients who have suffered a witnessed out-of-hospital cardiac arrest (OHCA) followed by an unsuccessful cardiopulmonary resuscitation.[3] However, rapid referral for uDCD under mechanical ventilation and continuous automated external cardiac massage should only be considered for patients with no chances of survival.

To assist Emergency Medical Services (EMS) in making evidence-based decisions on the field, termination-of-resuscitation rules (TOR) have been established. These rules reflect medical futility and are applied when the likelihood of survival is low (<1%) in patients experiencing OHCA.[4] Currently different TOR have been

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developed in various countries.[5] Yet, these rules do not consider the potential benefits that may arise from transporting patients regarded as deceased to hospitals for organ donation.

Furthermore, the shortage of standard criteria donors (SCD) has stimulated the development of strategies to identify extended criteria donors (ECD), especially in the context of kidney grafts from elderly patients.[6] The Eurotransplant program, serves as an illustration with the median age of deceased kidney donors increasing steeply from 36 years in 1990 to 56 years in 2022. This shift includes a more than doubled proportion of kidney grafts from ECD donors aged over 70 (6.7 vs. 15.4%).[7] The "old-for-old" allocation policy used for kidney transplantation (KT) has confirmed the survival benefit of being transplanted compared to remaining listed on a dialysis program.[8]

The US and French government have recently taken steps to address this issue through respectively national initiatives with a goal to double the number of available kidney grafts through improved procurement and utilization of deceased donors organs.[9–11] In this circumstance, uDCD can serve as a substantial and sustainable source of kidneys for transplantation, especially when considering patients that meet ECDs. This study aims to retrospectively assess the theorical size and characteristics of the potential pool of kidney transplants from uDCD with SCD and ECD in the Greater Paris area among patients who meet TOR criteria following OHCA.

Material and methods

Population: Paris sudden death expertise center cohort

The Paris Sudden Death Expertise Center (SDEC) registry encompasses Paris and its suburbs, with a population of approximately 6.7 million people. The methods employed by the registry have been previously documented (Supplement available at https://www.annals.org).[12] This study focused on patients included in the registry from May 16th, 2011 to December 31th, 2020. It prospectively included every case of unexpected OHCA in individuals above the age of 18. Patients were excluded if they had a previous terminal condition, had a documented "do-not-resuscitate" directive, did not receive advanced cardiac life support (ACLS) from emergency medical services personnel, or had an obvious non-cardiac cause according to the Utstein templates.[13]

Emergency medical services in Great Paris area

In the Greater Paris area, the current emergency medical system follows a two-tiered approach, with physicians playing a key role. The first tier, known as basic life support (BLS), is provided by firefighters who are trained to utilize automated external defibrillators (AEDs). The second tier, advanced cardiac life support (ACLS), typically consists of a team including an advance nurse, an ambulance driver and an experienced emergency physician who are dispatched to the scene and equipped to perform various life-saving procedures, including endotracheal intubation, establishing intravenous access, administering medications, conducting a 12-lead ECG assessment in line with international guidelines.[14] The ALS team is able to declare the death at the scene.

Uncontrolled donation after circulatory death

If resuscitative efforts of ALS team fail to achieve return of spontaneous circulation (ROSC), and if the patient is deemed eligible, the uDCD protocol can be activated promptly to prepare for organ procurement.

There is no universal consensus on selection criteria for uDCD, and the identification of a potential donor currently follows regional/national protocols.[15] These generally include: age above 18 year (for adults) and not over 55 or 65 years, a no-flow time (the interval between cardiac arrest and CPR start) within 15–30 min, and a total warm ischemia time (the interval between cardiac arrest and the start of organ preservation) not longer than 150 min. Exclusion criteria generally include trauma, homicide, or suicide as a cause of arrest, and comorbidities such as cancer or sepsis, and according to local program and the targeted organ to transplant, kidney and liver disease.[15,16] Standard uDCD criteria are resumed in supplemental table 1.

Extended criteria for kidney donors

Extended criteria for kidney donors were first described in 2002 and expand the traditional eligibility for organ donation.[17] Since then, the criteria have undergone various modifications, with the primary goal of optimizing organ procurement rates while minimizing discard and rejection rates. These extended criteria allow for the inclusion of older donors (over the age of 60) and of those with certain medical conditions that were previously considered barriers to donation (donor over the age of 50 with two of the following: a history of high blood pressure, a creatinine greater than or equal to 1.5 mg/dL, or death resulting from a stroke) [17](supplemental table 2).

Pre-hospital termination of resuscitation rules

Pre-hospital TOR are guidelines used by EMS providers to determine when to cease resuscitation efforts in the field when the chances of survival are very low. There are several different TOR that have been developed in various countries: Basic Life Support (BLS) TOR,[18] Advanced Life Support (ALS) TOR,[19] Korean Cardiac Arrest Research Consortium (KoCARC) TOR I, II, II,[20,21] GOTO's TOR,[22] NUE TOR,[23] New TOR,[24] Paris TOR[25] (supplemental table 3). In our study, patients with positive TOR, have been defined retrospectively as those who meet at least one of all the above-mentioned TOR criteria. The emergency physicians in France use a comprehensive approach to assess whether to continue or terminate resuscitation efforts at the scene, in line with European guidelines. This approach is not based on strict application of TOR criteria.

Ethical

All aspects of the registry were approved by the appropriate institutional review boards [authorization DR-2012–445].

Outcomes

In our study, we aimed to estimate the potential for organ donation through the uDCD (uncontrolled Donation after Circulatory Death) program. We used three definitions based on the WHO critical pathway: possible, potential, and eligible uDCD donors. They are defined as follows: Possible uDCD donors are patients with OHCA (Out-of-Hospital Cardiac Arrest) where resuscitation was attempted. Potential uDCD donors are patients with OHCA where resuscitation was attempted and who met TOR (Termination of Resuscitation) criteria. Eligible uDCD donors are patients with OHCA where resuscitation was attempted, who met TOR criteria (at least one) and who met uDCD criteria (at least one). To clarify the calculations, we will used a consistent denominator: the number of patients with resuscitation attempts.

To calculate the annual incidence of cases per 100,000 inhabitants, we utilized national data from the *INSEE* (National Institute of Statistics and Economic Studies). This national database provides the annual population for a specific geographical area (Paris and the greater metropolitan area).

Statistical analysis

Sampling was carried out regarding the primary outcome variable, i.e. the annual number of OHCA patients that could qualify as potential organ donors based on SCD or ECD. After identification, the results were further analyzed using descriptive statistics. Categorical variables were expressed as numbers (percentages); continuous variables were expressed as means (standard deviation). P-values were two-tailed and considered significant if below 0.05. All statistical analyses were performed by using R (including R version 3.6.5) for Mac OS version 3.3.3 (https://www.R-project.org).

Results

Number of theorical patients eligible for uDCD with TOR

Between May 11, 2011, and December 31, 2020, there were 37,230 cases of OHCA that occurred in Paris and its inner suburbs. Resuscitation was attempted by EMS for 19,976 (53.5%) patients with 12,890 (64.5%) cases who had no sustained ROSC prior to hospital transport. After selection based on criteria of all previously published TOR, a cumulative total of 9,461 (47.4%) patients had no chance of survival. Among them, 1,764 (8.8%) met one of the SCD and could be identified as potential organ donors and 6720 (33.6%) met the extended criteria for kidney donors (Fig. 1).

Temporal trend and annual incidence of TOR decisions and potential kidney donors

During the study period (10 years), the total number of OHCA cases who had no chance of survival based on the different TOR varied from 652 (3.3%) for the NUE TOR to 8365 (41.8%) for the Paris TOR. The mean annual number of patients who met at least one of the TOR criteria remained stable and varied from 443 (24.3%) in 2012 to 553 (24.6%) in 2017 (Fig. 2**A**). This represents an annual incidence of 8.1–10.0/100,000 inhabitants (Fig. 2**B**).

The potential number per year of uDCD candidates among the different TOR, ranged from 20 (1.9%) to 205 (21.9%) with a mean number of 98 (±10.8) per year (Fig. 2**C**), corresponding to an annual incidence of 0.4–4.1/100,000 inhabitants (Fig. 2**D**). The “San Carlos” (Spain) and the “Maastricht worst case” (Netherlands) criteria identified respectively the smallest and the largest proportion of uDCD candidates among patients with TOR criteria (Table 1).

When considering ECD criteria, numbers of eligible candidates are ranging from 558 (67.8%) to 777 (71.9%) with a mean number of 672 (±103.8) cases per year. This corresponds to an annual occurrence of 12.9–15.0 cases per 100,000 population (Fig. 3) and has remained constant over the years.

Patients’ characteristics according to TOR, SCD and ECD criteria

Coherently, we observed differences between OHCA patients’ characteristics who might fulfill the SCD criteria and those of patients who might meet ECD criteria. Patients who theoretically met SCD were younger (53.6 y.o. (±9.7) vs 76.5 y.o. (±9.5)) and presented with a lower prevalence of various medical comorbidities including: diabetes, chronic kidney disease, cancer or HIV infection (629 (35.5%) vs 3069 (45.7%)), compared to those who theoretically met ECD. Key aspects surrounding OHCA circumstances such as interval to initiate CPR, duration of resuscitation efforts or location of cardiac arrest, were similar between patients meeting the SCD or ECD criteria (Table 2). Elderly patients (≥65 y.o.) represented 53.7% (n = 10,708/19976) of all OHCA for whom resuscitation was attempted by EMS, 61.2% (n = 5763/9461) of patients who met TOR and 100% (5763/5763) of patients who could have matched both ECD criteria and TOR (Table 2).

Discussion

We showed that uDCD including SCD and ECD programs for kidney transplantation could significantly expand the organ donor pool and address the burden of organ shortage. In fact, during our study period among OHCA patients identified by TOR to have no chances of survival, the potential number of OHCA donors ranged between 1.9% and 21.9%. It represented a mean number of 98 potential donors every year, depending on which uDCD criteria were used. ECD criteria identified a stable number of 33.6% potential kidney donors each year among all OHCA patients who met TOR criteria and 100% potential donors among the sub-population of elderly patients.

The implementation of uDCD or ECD programs involves to considering several factors that can contribute to its effectiveness and success. In the pre-hospital setting, the first step is the identification of potential donors (i.e., patients with no chance to survive). Their identification is a race against time and should occur at a very early stage, following a standardized, ethical and reproducible approach. The TOR are capable to address these two challenges in a timely and appropriate manner. However, it is important to note that these TOR are not always reliable in predicting the outcome of a patient. They identify cases with a survival rate less than 1%[4] that reflects medical futility and justifies stopping CPR. A significant number of studies report external validation of TOR providing an indication of the optimal performance of the TOR that may over-estimate its performance in clinical practice. Only one study[26] reported a validation of a BLS rules in clinical practice and concluded to 100% of accuracy. That is why TOR should not be enough to take the decision but only the foundation step to consider the patient for organ donation. Based on the different TOR, eligibility evaluation is short and can last at worst 15 minutes.[5] In fact, the criteria that compose TOR are objective and simple limiting subjective decision that can be very challenging in this situation (supplemental table 3). The use of TOR to initiate the consideration for organ donation, seemed to be an ethical evidence-based decision-making by managing of potential conflicts between the interests of the donor (i.e., early evaluation of his survival rate) and recipient. TOR can be divided into 3 groups that explain the significant variability (from 3.3% to 41.8%) in the identification rates. TOR with highest numbers of identified patients (BLS and Paris TOR) because of the witness criteria (only EMT), TOR with the lowest number (NUE TOR) because it only includes patients over 80 years old and the majority of TOR (ALS, GOTO, New, KoCARC I, II, and III) identified a similar number of patients. Moreover, according to Morrison et al., TOR are easy to use and seemed to be acceptable by the EMS providers and physicians (79% of compliance). In this sudden and emotional situation, by implementing TOR, EMS physicians could gain valuable time to

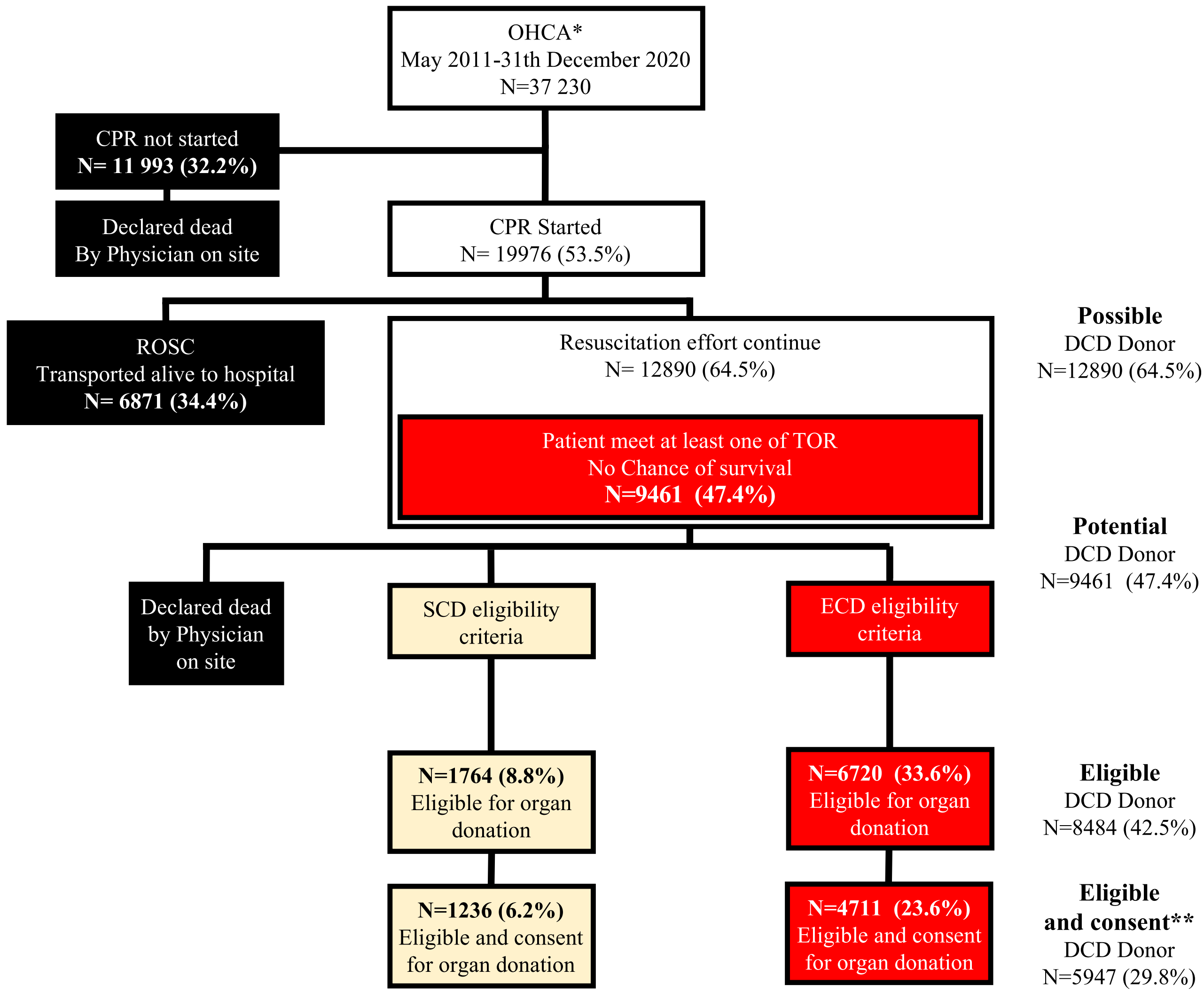

Fig. 1 – Description of the population analyzed in the study. EMS = Emergency Medical Services; OHCA = Out of Hospital Cardiac Arrest; ROSC = Return Of Spontaneous Circulation TOR = Termination of Resuscitation Rules; SCD = Standard Criteria Donation. *Patients with obvious non cardiac etiology were excluded from the analysis (N = 5304); **After application of opposition rate (30.0%).

initiate discussions with the family regarding the status of resuscitation efforts and organ donation. The TOR could also provide guidance to EMS personnel about when to involve families in the decision-making process and how to communicate with them about the status of resuscitation efforts in this sudden, difficult and emotional situation. The additional time gained allows for sensitive and thorough communication, ensuring that the family is well-informed about the option of organ donation, its benefits, and the implications of their decision.[27]

The application of TOR protocols may differ in the absence of an ECPR (Extracorporeal Cardiopulmonary Resuscitation) program compared to when ECPR is available, as they share common criteria such as the presence of a witness and the initial rhythm. However, the main difference between TOR and ECPR lies in their purpose: ECPR aims to extend life and improve outcomes in patients with potentially reversible causes of cardiac arrest, while TOR focuses on recognizing futility in resuscitation efforts and ethically terminating treatment. By clarifying these differences, healthcare providers can better determine the appropriate course of action for patients experiencing cardiac arrest, either by escalating to ECPR for eligible candidates or by applying TOR criteria to recognize when further efforts may be futile, thus making organ donation a possible consideration.

Organ transplantation is by far the most effective treatment for patients on the waiting list.[28] It considerably improves their life expectancy and quality of life compared to dialysis.[29] Kidney transplantation both reduces medical spending on ESRD treatment and is associated with better long-term outcomes for the recipient. According to the United States renal data system (USRDS), the life expectancy for ESRD patients who receive transplant is more than double the life expectancy on dialysis across all age groups.[30]

As waiting lists for organs continue to grow due to the shortage of available donors, governments of several countries make steps to address this burden by maximizing the utilization of every organ from elderly deceased donors which led in recent decades, to interest to explore the benefit of KT among elderly patients. In our study we highlighted that 100% of OHCA elderly patients, aged over 65 y.o.

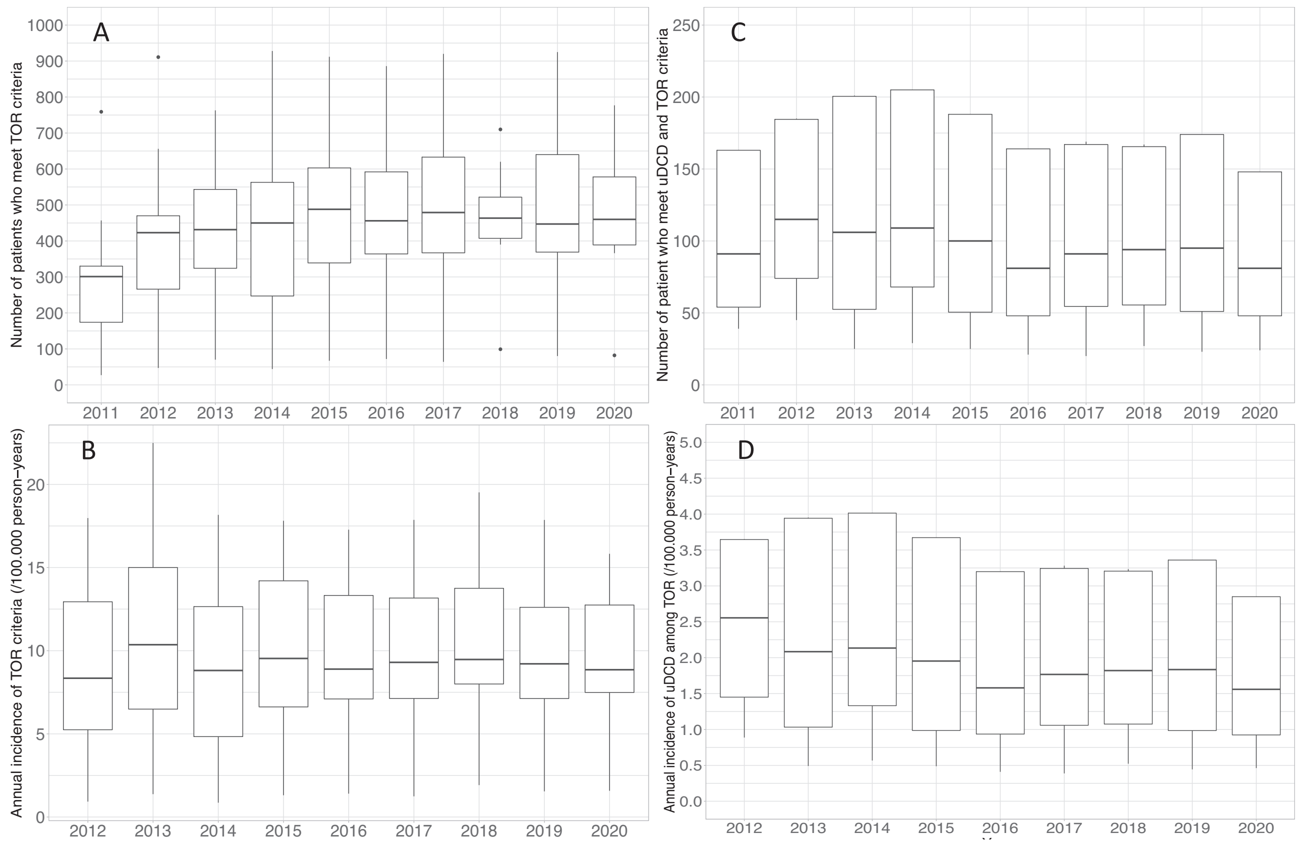

Fig. 2 – Average annual number (A) and incidence* (B) of patients who meet criteria of TORR, and among them the average annual number (C) and incidence* (D) of patients who meet uDCD criteria. *The annual incidence is given per 100,000 inhabitants. §For 2011, since the cohort started the 11st of May 2011, the annual number is lower and we did not provide the annual incidence. TOR Termination Of Resuscitation rules; uDCD = uncontrolled Donation after Cardiac death.

for whom resuscitation is attempted by ALS and who meet TOR, could become a potential kidney donor based on ECD. Additionally, the opposition rate for organ donation varies by age group, with the highest opposition among young people and the lowest opposition (or highest consent) among the elderly[2]. The concept of ECD, specifically designed for kidney grafts from older patients, complements the "old-for-old" allocation policy used in KT make it more feasible and widely accepted, particularly among the elderly. Recently, Molnar et a. observed that elderly adults, undergoing home hemodialysis had a risk of mortality that was almost five times as high as that of Kidney transplant recipients.[31] In fact, The recent and continuous advances in kidney transplantation improve graft survival among elderly.[32] The benefits of kidney transplantation for a 65-year-old recipient, concern not only the overall survival but also their health-related quality of life (HRQoL). Tsarpali et al., demonstrated that individuals aged 65 or above who undergo kidney transplantation experience a significant enhancement in HRQoL one year after the procedure, compared to their condition after spending one year on the transplantation waiting list and this benefit persists three years after transplantation.[33,34] Moreover, patients who remain on dialysis demonstrate a steady and continuous decline in HRQoL.[35]

The survival benefit is observed for standard uDCD and ECD for kidney transplantation.[36] In recent study, Rouhi et al. demonstrate that although initial allograft outcomes are inferior following uDCD, the long-term durability of kidney allografts from uDCD is comparable to that of cDCD transplantation.[37] Others studies observed similar long-term outcomes for uDCD kidneys than cDCD and have potential for excellent function and can constitute a valuable extension of the donor pool. However, further efforts are necessary to address the high rate of primary nonfunction.[38] In fact, on a pathophysiologic view and strictly concerning to organ transplantation, the ischemia/reperfusion injury is the main factor able to affect organ function in the uDCD donor due to at least 2 no-flow periods (that of the CA and that of the no-touch period) and to prolonged periods of low-flow.[16] Based on this underlying mechanism, a recent systematic review and *meta*-analysis provide evidence that dynamic preservation strategies can minimize the effect of the ischemia/reperfusion injury on outcomes following kidney transplantation.[39]

KT is also associated with better cost outcomes compared to dialysis. In France, hemodialysis represents 70% of the total budget for managing ESRD, while transplantation accounts for only 6%. Per patient and per year of treatment, kidney transplantation costs 4 times less than hemodialysis.[40] Most of the costs of KT are concentrated in the year of the transplantation and consist of the cost of procuring an organ, transplant surgery and post-operative care.

Based on our findings, we strongly advocate that organ donation should always be considered for each patient experiencing OHCA in

Table 1 – Annual number of patients who met at least one of TOR criteria according to different Standard Uncontrolled Donation after Circulatory Death criteria and ECD criteria.

	Years									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Number of patients who met at least one of TOR criteria	626	823	991	934	988	977	1020	1052	1081	969
Standard uDCD criteria										
Madrid[1]	91 (15.0)	115 (14.4)	106 (11.0)	109 (12.3)	100 (10.4)	81 (8.6)	91 (9.1)	94 (9.1)	95 (9.0)	81 (8.7)
San Carlos[2]	39 (6.4)	45 (5.6)	25 (2.6)	29 (3.3)	25 (2.6)	21 (2.2)	20 (2.0)	27 (2.6)	23 (2.2)	24 (2.6)
Maastricht worst-case[3]	163 (26.8)	184 (23.1)	200 (20.8)	205 (23.1)	188 (19.6)	164 (17.4)	165 (16.4)	164 (15.8)	174 (16.6)	148 (16.0)
Maastricht best-case	163 (26.9)	185 (23.2)	201 (20.9)	205 (23.2)	188 (19.6)	164 (17.4)	169 (16.8)	167 (16.1)	174 (16.6)	148 (16.0)
Paris best case[4]	55 (9.0)	75 (9.4)	53 (5.5)	68 (7.7)	52 (5.4)	48 (5.1)	56 (5.6)	57 (5.5)	51 (4.9)	48 (5.2)
Paris worst case	53 (8.7)	73 (9.2)	52 (5.4)	68 (7.7)	49 (5.1)	48 (5.1)	53 (5.3)	54 (5.2)	51 (4.9)	48 (5.2)
Extended criteria (ECD)[5]	435 (69.5)	558 (67.8)	722 (72.9)	663 (71.0)	700 (70.9)	675 (69.1)	751 (73.6)	756 (71.9)	777 (71.9)	683 (70.5)

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the event of unsuccessful resuscitation efforts. From our analysis (as presented in Table 2), it is evident that certain subgroups of patients, particularly the elderly, should not be overlooked as potential organ donors. We suggest that EMS clinicians adopt a proactive approach in considering systematically the possibility of organ donation for these patients who met TOR. The criteria for ECD allow for the inclusion of older donors and those with certain medical conditions, thereby expanding the donor pool and providing a vital source of kidneys for transplantation.

We acknowledge that the potential for uDCD is significant, yet the number of actual uDCD donors remains very low, currently at 232 donors over 10 years for Paris and its suburbs. uDCD donation requires significant logistical coordination between the EMS system, dispatcher, and hospital system including ICU and surgical team. The race against time in uDCD scenarios makes it challenging to apply the protocols effectively. The need for rapid decision-making and action can sometimes conflict with the careful process (such as bypass connections, ICU bed availability, access to the operating room, and surgeon availability) required for organ donation. Additionally, high refusal rates and the challenges emergency physicians face in adhering to protocols—stemming from inexperience, discomfort, or ethical conflicts—further complicate and hinder the feasibility of implementing the uDCD procedure. We believe that addressing these organizational and logistical factors provides a more comprehensive understanding of the gap between potential and actual uDCD donors. However, our primary objective was to highlight the potential increase in organ donors if these measures were implemented consistently.

Limitations

The present study had some limitations worth mentioning. The projected number of uDCD donors considered in our investigation represents an ideal scenario and is very likely to be lower in reality due to various factors. Firstly, there is a possibility that potential cases could be missed or that the emergency physicians on the EMS team might be hesitant in seeking consent, leading to challenges in meeting critical time frames. Secondly, because our study was retrospective in nature, ethical issues related to consent for donation were not accounted for. It is important to note that consent rates vary widely across countries, ranging from a low of 58% to a high of 91%,[41] and are influenced by multiple factors beyond the control of the EMS team. Indeed, estimating the impact of the consent rate by applying the French national rate that is around 30% for the specific context of uDCD Maastricht II, is a valuable consideration (Fig. 1).

In our study, and in the context of uDCD the exploration of organ viability and graft outcomes from donors meeting the ECDs classification remains unclear. While we acknowledge the importance of aligning with the practices of EMS in Paris and its suburbs, we believe that considering various criteria offers a broader perspective and allows for a more robust analysis of potential outcomes in vari-

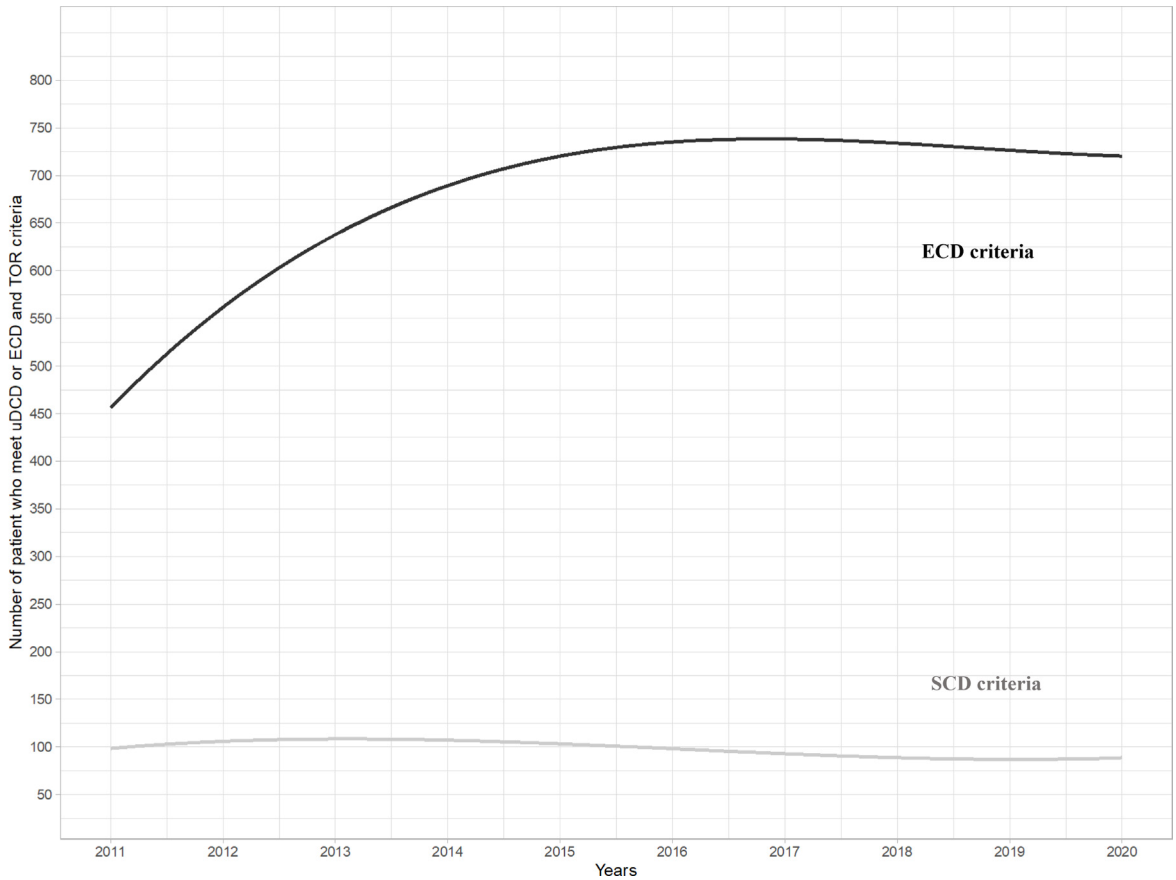

Fig. 3 – Annual number of patients who meet ECD (black line) or SCD for uDCD (grey line) criteria and TOR. ECD = Extended Criteria Donation; TOR = Termination Of Resuscitation rules; uDCD = uncontrolled Donation after Cardiac death.

ous countries. There is need for investigation assessing the potential viability and transplant outcomes of these specific grafts.

Conclusion

Implementing uDCD and ECD programs for kidney transplantation among OHCA cases quickly identified by the TOR to have no chances of survival, holds significant potential to substantially broaden the pool of organ donors. These programs could offer a viable solution to address the pressing burden of kidney shortage, particularly benefiting elderly recipients who may otherwise face prolonged waiting times and limited access to suitable organs. By embracing these innovative approaches, we can enhance the quality of life for patients in need of life-saving kidney transplants.

Data sharing statement

The data that support the findings of this study are available on request from the corresponding author, RC (richard.chocron@gmail.com).

Statement

During the preparation of this work the author(s) used Gemini in order to improve readability and language. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

CRediT authorship contribution statement

Richard Chocron: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Thomas Laurenceau:** Writing – review & editing, Writing – original draft, Methodology. **Tal Soumagnac:** Writing – review & editing, Writing – original draft. **Frankie Beganton:** Writing – review & editing, Project administration, Data curation. **Patricia Jabre:** Writing – review & editing, Writing – original draft, Conceptualization. **Xavier Jouven:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Investigation.

Table 2 – Characteristics of OHCA patients according to TOR, SCD and ECD criteria.

	OHCA with resuscitation attempt by EMS	OHCA patients who met at least one of TOR	OHCA patients with TOR and SCD criteria	OHCA patients with TOR and ECD criteria
n	19,976	9461	1764	6720
Age, years old (mean (SD))	65.85 (16.22)	68.47 (15.89)	53.56 (9.73)	76.52 (9.45)
[18–50 y.o.)	3319 (16.7)	1191 (12.6)	481 (27.3)	0 (0.0)
[50–55 y.o.)	1707 (8.6)	672 (7.1)	313 (17.7)	0 (0.0)
[55–60 y.o.)	1998 (10.0)	836 (8.9)	439 (24.9)	0 (0.0)
[60–65 y.o.)	2168 (10.9)	958 (10.2)	531 (30.1)	957 (14.2)
[65–75 y.o.)	4276 (21.4)	2090 (22.2)	0 (0.0)	2090 (31.1)
[≥75 y.o.)	6432 (32.3)	3673 (39.0)	0 (0.0)	3673 (54.7)
Gender, n(%)				
Woman	6435 (32.2)	3343 (35.4)	468 (26.6)	2601 (38.7)
Man	13,524 (67.8)	6112 (64.6)	1294 (73.4)	4116 (61.3)
Any cardiomyopathy, n(%)	5085 (25.5)	2083 (22.0)	220 (12.5)	1828 (27.2)
Ischemic cardiomyopathy, n (%)	2533 (12.7)	914 (9.7)	103 (5.8)	795 (11.8)
Pacemaker, n(%)	486 (2.4)	194 (2.1)	9 (0.5)	183 (2.7)
implantable cardioverter-defibrillator, n(%)	86 (0.4)	15 (0.2)	1 (0.1)	14 (0.2)
Cancer, n(%)	1754 (8.8)	864 (9.1)	172 (9.8)	669 (10.0)
Thrombo-embolic event, n(%)	372 (1.9)	115 (1.2)	15 (0.9)	89 (1.3)
High blood pressure, n(%)	5771 (28.9)	2264 (23.9)	309 (17.5)	1899 (28.3)
Diabetes, n(%)	3432 (17.2)	1580 (16.7)	246 (13.9)	1273 (18.9)
Kidney failure (KF), n(%)	920 (4.6)	375 (4.0)	48 (2.7)	311 (4.6)
No comorbidities (Diabetes, KF, Cancer)	11,406 (57.1)	5670 (59.9)	1156 (65.5)	3669 (54.6)
Infection, n(%)	329 (1.6)	97 (1.0)	28 (1.6)	31 (0.5)
No comorbidities (Diabetes, KF, Cancer) and no infection	11,218 (56.2)	5604 (59.2)	1138 (64.5)	3651 (54.3)
Human immunodeficiency virus	164 (0.8)	63 (0.7)	22 (1.2)	15 (0.2)
Hepatitis B or C virus infection, n(%)	193 (1.0)	43 (0.5)	9 (0.5)	16 (0.2)
Dyslipidemia	1850 (9.3)	422 (4.5)	59 (3.3)	358 (5.3)
Current smoking, n(%)	2569 (12.8)	406 (4.3)	103 (5.8)	223 (3.3)
Previous smoking, n(%)	898 (4.5)	52 (0.5)	5 (0.3)	44 (0.7)
CA to first CPR, minutes (mean (SD))	8.33 (9.24)	14.51 (11.98)	10.90 (8.95)	14.11 (11.51)
Duration of CPR, minutes (mean (SD))	33.23 (29.48)	35.11 (22.44)	44.33 (29.93)	31.67 (17.75)
Initial shockable rhythm, n(%)	5256 (29.1)	21 (0.2)	5 (0.3)	14 (0.2)
Location, n(%)				
Home	14,552 (73.1)	7907 (83.8)	1319 (75.0)	5850 (87.2)
Public location	5362 (26.9)	1532 (16.2)	439 (25.0)	860 (12.8)
Witnessed, n(%)	14,787 (74.0)	5504 (58.2)	1764 (100.0)	4219 (62.8)
Bystander CPR, n(%)	9913 (49.6)	2820 (29.8)	910 (51.6)	2148 (32.0)
Witnessed and CPR, n(%)				
Not witnessed	5189 (26.0)	3957 (41.8)	0 (0.0)	2501 (37.2)
Witnessed without CPR	4874 (24.4)	2684 (28.4)	854 (48.4)	2071 (30.8)
Witnessed with CPR	9913 (49.6)	2820 (29.8)	910 (51.6)	2148 (32.0)
Type of witness, n(%)				
No Bystander	5307 (26.6)	4041 (42.7)	0 (0.0)	2564 (38.2)
Bystander	11,925 (59.7)	5420 (57.3)	1764 (100)	4156 (61.8)
EMS (BLS or ALS)	2744 (13.7)	0 (0.0)	0 (0.0)	0 (0.0)
AED applied by bystander, n (%)	385 (4.3)	42 (1.9)	14 (2.0)	31 (1.9)
Shock delivered during out of hospital CPR, n(%)	6872 (34.4)	730 (7.7)	244 (13.8)	484 (7.2)

AED = automated external defibrillator; ALS = advanced life support;CA = Cardiac Arrest;CPR = Cardio-Pulmonary Resuscitation;ECD = expanded criteria donors; EMS = Emergency Medical Services; CPR = Cardio-Pulmonary Resuscitation;OHCA = Out of Hospital Cardiac Arrest; HIV = Human Immunodeficiency Virus; TOR = Termination of Resuscitation Rules; uDCD = Uncontrolled Donation after Circulatory Death.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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- **Author Contributions:** Dr. R. Chocron, Pr. X. Jouven and M. F. Beganton had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
- **Concept and design:** Dr. R. Chocron.
- **Acquisition, analysis, or interpretation of data:** All authors.
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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2024.110318.

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