Trends in brain-dead organ donor characteristics: a 13-year analysis

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Background: Driven by disease trends, such as obesity and metabolic syndrome, that are increasingly prevalent in the general population, we aimed to evaluate the comorbidities and attributes of the brain-dead organ donor population over time in a longitudinal study.

Methods: We compared overall health and baseline attributes of organ donors between 2000–2005 and 2006–2012 using our prospective transplant database. Descriptive and comparative analyses of the 2 historical cohorts were performed.

Results: A total of 1040 brain-dead organ donors were included in our analysis: 496 from the 2000–2005 period and 544 from the 2006–2012 period. Our analysis revealed that donors from the recent (2006–2012) period were more likely to have increased body mass index (26.4 ± 6.0 v. 25.0 ± 4.8, \( p = 0.003 \)), smoking history (57.0% v. 27.2%, \( p < 0.001 \)), coronary artery disease (14.3% v. 3.2%, \( p = 0.015 \)) and dyslipidemia (19.1% v. 4.2%, \( p < 0.001 \)), but less likely to have concurrent infection (1.1% v. 7.9%, \( p < 0.001 \)) than those from the earlier period.

Conclusion: Our data suggest that the characteristics and comorbidities of brain-dead organ donors have somewhat deteriorated over the last decade. Further studies are needed to evaluate the impact of these health attributes on donated organ utilization and outcomes.

Despite the efforts of the transplant community to address the urgent need for donor organs, the disparity between the number of patients on the waiting list and available donor organs remains substantial.\(^1\) It is now well recognized that solid organ transplantation is the most definitive and effective treatment for end-stage liver disease and kidney failure. Innovative measures, such as the use of split livers\(^2\)–\(^4\) and living-related donation,\(^5,6\) have been
developed to try to reduce the gap between transplantable organ supply and demand. In fact, in 2001 in the United States, the use of living-related donor organs increased considerably to surpass the number of deceased organ donor procurements (52% v. 48%). Evidently the donation patterns of transplant centres are influenced by many factors, such as death and donation rates, allocation policy, listing regulations and usage of expanded criteria donors (ECD). Recently, Redelmeier and colleagues reported on the organ donation trends in Ontario, Canada. This population-based cohort study reported a small donation rate, yet noted a significant increase in deceased donors over a 16-year period.

On the other hand, population-based epidemiological studies from North American data suggest a persistent growth in the prevalence of certain disease states, such as metabolic syndrome. For instance, metabolic syndrome is defined by the presence of several risk factors, such as obesity, hyperlipidemia, diabetes and hypertension, all of which have their own negative impact on morbidity and mortality. Moreover, metabolic syndrome has been associated with fatty liver disease, steatosis and liver fibrosis as well as chronic kidney disease. Since deceased donors consist of a portion of the general population, such epidemiological changes and disease trends could potentially be reflected into the organ donor pool. Multiple clinical, biochemical, technical and ethical factors already play a role in organ donation discussions, but worse comorbidities and unfavourable metabolic profiles may potentially further challenge the decision to consider organ donation. Although multiple national reports on organ donation trends exist, data on specific characteristics and comorbidities of deceased donors are scarce.

We postulated that as some disease trends, such as metabolic syndrome, are increasingly prevalent in the general population, demographic characteristics of brain-dead organ donors might also be affected. We thus aimed to evaluate the changes in brain-dead organ donor characteristics in a longitudinal study over a period of 13 years, using the registry of deceased donors procured by our institution.

**METHODS**

**Organ donor population**

This study was approved by the McGill University Health Center (MUHC) and the Transplant Quebec Research Ethics Boards (REBs). All eligible brain-dead organ donors identified between January 2000 and December 2012 who donated 1 or more organs to a patient from the MUHC were included in the study. The donor inclusion criteria included only brain-dead donors who were 18 years of age or older. For the purpose of this study, living-related donors and donation after cardiac death (DCD) were excluded from the analysis. The extracted data from our prospective transplant database were limited to organ donor characteristics, such as donor age; sex; race; cause of death; ABO group; body mass index (BMI); glomerular filtration rate (GFR) before procurement; history of smoking, coronary artery disease, hypertension, diabetes or dyslipidemia; history of malignancy or drug abuse; and presence of an active infection.

Brain death was declared as standard and defined as complete loss of motor or respiratory drive, absence of brainstem reflexes in the context of an irreversible injury and absence of metabolic or contributing reversible injuries. The donor GFR was calculated using the 4 variables in the Modification of Diet in Renal Disease (MDRD) Study: serum creatinine, age, race and sex. For the causes of brain death, anoxic brain injury included brain death after events like respiratory or cardiac arrest, poisoning (e.g., carbon monoxide), drug overdose or drowning. Traumas causing brain death included motor vehicle accidents as well as penetrating and blunt traumatic head injuries. Although florid septicemia and severe infections were a contraindication to organ donation, presence of an infectious source (bacteremia, fungemia) did not preclude organ donation candidacy. Expanded criteria donors are defined as those aged 60 years or older, or older than 50 years with at least 2 of the following conditions: hypertension history, serum creatinine > 1.5 mg/dL, or death due to stroke, which are the criteria used by the United Organ Sharing Network (UNOS).

**Statistical analysis**

Categorical and continuous variables are expressed as summary statistics (number, percentage, median, range, mean, standard deviation); all comparisons between groups were carried out using a 2-sided test. We used the Fisher exact test or the \( \chi^2 \) test (for categorical variables) and the Wilcoxon rank-sum test (for continuous non-normally distributed variables) to assess differences between the groups. To identify variables independently associated with a time period (recent 2006–2012 v. remote 2000–2005), we performed multivariable logistic regression analyses. We considered results to be significant at \( p < 0.05 \). All analyses were performed using JMP statistics software version 11.0 (SAS).

**RESULTS**

**Characteristics of organ donors**

After excluding living-related donations and DCD donors, a total of 1040 brain-dead organ donors were included in this study (Fig. 1). A median of 84 (range 79–87) organ donor procurements were performed yearly during the study period. The median age of donors was 47 (range 31–58) years, and 586 (56.3%) were men. Donor BMI was greater than 30 in 586 (56.3%) of the general population, such as chronic kidney disease.

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followed by trauma (241, 23.2%) and anoxic brain injury (133, 12.8%). The ratio of expanded criteria donors over standard criteria donors significantly increased over time, (Fig. 3).

**Comparison of organ donor characteristics over time**

The cohort was divided into 2 time periods — remote (2000–2005) and recent (2006–2012) — to evaluate changes over time in organ donor demographic profile and comorbidities. Baseline characteristics and comorbidities of the 2 groups are detailed and compared in Table 1. In fact, significant differences were noted between the 2 time periods in terms of donor age, BMI, history of smoking, hypertension, hyperlipidemia, diabetes and coronary artery disease (Table 1). Interestingly, there were fewer donors with documented infection at the time of procurement in the recent period (1.1% v. 7.9%, \( p < 0.001 \)). The causes of death were also significantly different between the 2 time periods: in the recent period, fewer donors died as a result of trauma (19.7% v. 27.0%, \( p < 0.001 \)), and more died from anoxic brain injury (17.3% v. 8.1%, \( p < 0.001 \)), consistent with previously published North American data. Moreover, although the distribution of donors’ average BMI did not demonstrate a steady slope year after year, there was increasing risk of BMI above 30 compared with the baseline period (Fig. 3A) and a significant increase in BMI above 30 over time (Fig. 3B).

**Analysis of significant donor characteristics related to period of procurement**

Since many of the variables analyzed were potentially related and concomitantly present as comorbidities, we wanted to ascertain independent predictors of the recent time period (2006–2012) compared with the remote period (2000–2005). The initial descriptive analysis demonstrated significantly greater associations of BMI, smoking history, coronary artery disease, hyperlipidemia and infection with procurements performed in the recent years. The multivariable logistic regression (Table 2) confirmed that several variables were independently predictive of the recent time period: BMI, smoking history, coronary artery disease, hyperlipidemia (more likely in the recent time period) and presence of infection (less likely in the recent time period). In addition, there were more women and better renal function among donors in the recent time period.

**Discussion**

Organ transplantation is a life-saving treatment for many patients with acute or chronic solid organ failures. As a result of this ultimate and definitive therapy, more patients are considered eligible for organ transplantation, contributing to the persistent discrepancy between potential recipients and
available donated organs. The usage of ECD in kidney transplantation was an attempt to counterbalance the organ shortage crisis, and although initial studies reported lower survival after transplantation from ECD than from standard donors, some recent studies have reported more encouraging results. In parallel to these facts occurring in the transplant community, statistics resulting from public health surveillance institutes are all pointing toward a growing prevalence of chronic diseases, such as obesity, diabetes, hypertension, dyslipidemia and coronary artery disease; all of which contribute to an overall worsening health status among the general population, and hence the deceased standard criteria donor pool as well. Our aim was to characterize the trends in comorbidities and physical health attributes of organ donors over more than a decade. Our results indicate that there is a statistically significant increase in comorbidities, such as increased obesity, hyperlipidemia, smoking history and coronary artery disease, suggestive of an overall poorer health status. It may be argued that some of the significant variables probably reflect an increase in the use of ECD by the transplant centres and especially that the ratio of ECD increased over time. However, the situation in our centre may reflect that the increase in comorbidities among donors is associated with the increase in comorbidities in the general population, and this is evidenced by the stability of organs donated over time. There are 2 liver transplantation centres in the province of Quebec, and ours is the only multorgan site. We share the brain death donors under the management of Transplant Quebec. Our centre receives organs from about 75% of the donors, and our provincial donation rate has been stable over the last decade (around 120–130 donors each year); therefore, our data at least represent the situation of the whole province. We therefore are confident that there was no donor selection bias in our cohort and that the application of ECD worldwide did not affect our donor selections.

Also, because the rate of ECD use has been increasing and the total number of eligible donors increases at a slower rate, this suggests that the proportion of eligible donors with “bad” criteria has been rising at the expense of more healthy donors. Therefore, the worsening donor characteristics are most likely not related to surgeons’ willingness to procure organs from ECD, but rather to a donor pool of gradually poorer quality. Most of the variables we describe in the present study have been previously found to be associated with worse outcomes after transplantation. For instance, obesity has been reported to be associated with inflammation and modified immune responses, potentially impacting allorecognition and alloimmunity. Another argument may be that the difference in BMI between the remote and recent periods in our study was only 1.4 and that we may have overestimated the role

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Fig. 2. Organ donors by period and donor category. 0 = standard criteria donors; 1 = expanded criteria donors.
of BMI. However, although such a difference might not be significant in general population, the higher BMI in the recent period of our study impacted the organ quality of the donors. Increasing obesity in the general population affects the BMI of organ donors, which causes problems for transplantation. Orman and colleagues analyzed BMI over 15 years (1995–2010) and found that BMI increased significantly in the past 15 years in the United States, which is consistent with our results. They also reported that obesity might not only affect the quality of the donated livers, but also of donated pancreas. Declining health characteristics of the donor population may consequently have a negative impact on multiple potential solid organs.

Fig. 3. (A) Risk of body mass index (BMI) > 30 of organ donors procured by time period. (B) Percentage of organ donors by BMI category and time period. CI = confidence interval.
Limitations

We acknowledge that our study has some limitations. First, the data were derived from a single institution’s transplant centre, which poses a limitation in terms of sample size and selection bias. Our centre’s expertise lies in kidney, liver and pancreas transplantation, therefore the organ donation attributes will correspond to the recipients treated at our centre who required those donated organs. Although the number of organ procurements performed

<table>
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<tr>
<th>Table 1. Baseline characteristics and comorbidities of organ donor population by time period (n = 1040)</th>
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<td>Age, median (IQR), yr</td>
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<td>Sex</td>
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<td>Cause of death</td>
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<td>Cerebrovascular/stroke</td>
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<td>Trauma†</td>
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<td>Anoxic brain injury‡</td>
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<td>Tumour</td>
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<td>Other/unknown</td>
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<td>ABO group§</td>
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<td>BMI, mean ± SD</td>
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<td>GFR, median (IQR), mL/min/1.73 m²</td>
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<td>Smoking history</td>
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<td>Hyperlipidemia</td>
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<td>Diabetes mellitus</td>
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<td>CAD history</td>
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<td>History of malignancy</td>
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<td>Presence of infection</td>
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BMI = body mass index; CAD = coronary artery disease; GFR = glomerular filtration rate; IQR = interquartile range; SD = standard deviation.

*Unless indicated otherwise.
†Includes motor vehicle accidents and other penetrating/blunt traumatic injury.
‡Includes drug intoxication and drowning.
§Based on n = 1038 (missing data for 1 donor per group).

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<th>Table 2. Forward stepwise multivariable logistic regression analyses depicting independent donor characteristics predicting their odds in the recent time period compared with the remote time period</th>
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<td>Donor characteristic</td>
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<td>Smoker</td>
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<td>Hyperlipidemia</td>
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<td>Infection</td>
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<td>BMI &gt; 30</td>
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<td>4th quartile (good) renal function</td>
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<td>CAD</td>
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<td>Female</td>
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BMI = body mass index; CAD = coronary artery disease; CI = confidence interval; OR = odds ratio; SE = standard error.
by our centre constitutes 75% of the total provincial donor pool,16 our results can still not be generalized to a national level. Moreover, the impact of the deteriorating quality of deceased donors on the organ recovery and discard rate is still unclear. It has been previously shown that some donor attributes, notably older donor age, higher BMI, diabetes and DCD, are all independently associated with organ nonrecovery. Although these data could be extrapolated to our findings, further research would be required to correlate the physical attributes and comorbidities of deceased donors to organ utilization.

CONCLUSION

The present longitudinal analysis of 1040 brain-dead organ donors demonstrates overall worsening of general health attributes and comorbidities in this population. More research is required to evaluate the impact of these findings on organ utilization patterns and recipient outcomes.

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Competing interests: None declared.

Contributors: P. Metrakos designed the study. M. Hassanain, M. Aljiffry, A. Aloraini and A. Madkhali acquired the data, which E. Simoneau and S. Doi analyzed. M. Hassanain, E. Simoneau, M. Aljiffry, A. Aloraini and A, Madkhali wrote the article, which all authors reviewed and approved for publication.

References