Organ utilization among deceased donors in Canada, 1993–2002

[L'utilisation d'organes de donneurs décédés au Canada de 1993 à 2002]

Kim Badovinac MA MBA,* Paul D. Greig MD FRCS(C),† Heather Ross MD MHSC FRCPC,‡
Christopher J. Doig MD MSC FRCPC,§ Sam D. Shemie MD¶

Background: Optimizing organ utilization from consented donors is a critical need, given a static organ donation rate. We report changes in the characteristics of donors and organ utilization patterns in Canada over a ten-year period.

Methods: For the decade spanning the years 1993–2002, data were extracted from the Canadian Organ Replacement Register (CORR), the national transplant registry. A donor was defined as a deceased person from whom at least one vital organ was retrieved and transplanted.

Results: The donor pool is aging (median age of donors increased eight years over the decade), with proportionately fewer donors dying from head trauma (motor vehicle collisions) and proportionately more from cerebrovascular accidents. At least four organs were utilized from approximately half the donors. These donors were significantly younger every year over the sampling period when compared with donors where $\leq$ three organs were utilized. In 2002, utilization rates were: 87.0% (kidneys), 85.0% (livers), 42.2% (hearts), 30.6% (pancreata), 28.3% (lungs), and $\leq$ 1% (intestines). There was increased utilization of donor pancreata, lungs and liver over the decade, but a flat utilization pattern for hearts, and a small decline in kidney utilization. Utilization rates vary from province to province.

Conclusions: Trends in the Canadian organ donor pool are characterized by an increasing age and a shift towards cerebrovascular diseases as primary causes of death. In order to improve organ utilization and understand regional variability, the scope of data provided to the national registry requires enhanced detail to address the factors that lead to non-utilization. Addressing the low utilization rates for hearts and lungs is especially critical, given the need for thoracic transplantation in Canada.

Contexte : Optimiser l'utilisation d'organes de donneurs consentants est une véritable nécessité, étant donné la stabilité actuelle du taux de don d'organes. Nous présentons les caractéristiques des donneurs et de l'utilisation des organes au Canada au cours d'une décennie.

Méthode : Pour la décennie 1993-2002, les données ont été extraites du Registre canadien des insuffisances et des transplantations d'organes (RCITO). Un donneur était défini comme une personne décédée chez qui un organe au moins était prélevé et transplanté.

Résultats : Le pool de donneurs est âgé (l'âge moyen a augmenté de huit ans pendant la décennie) et il y a proportionnellement moins de décès causés par un trauma à la tête (collision de véhicules automobiles) et plus par des accidents cérébrovasculaires. Quatre organes au moins ont été utilisés chez environ la moitié des donneurs. Ces donneurs étaient significativement plus jeunes que les donneurs chez qui $\leq$ trois organes ont été prélevés pendant la période étudiée. En 2002, les taux d'utilisation ont été de : 87,0 % (reins), 85,0 % (foie), 42,2 % (cœur), 30,6 % (pancréas), 28,3 % (poumons) et $\leq$ 1 % (intestins). Il y a eu une utilisation grandissante de pancréas, de poumons et de foie, mais une utilisation stable du cœur et une faible baisse pour les reins. Les taux d'utilisation varient d'une province à l'autre.

Conclusion : L'évolution du pool de donneurs d'organes canadien est caractérisée par une hausse de l'âge et, comme principale cause de décès, des maladies cérébrovasculaires. Pour améliorer l'utilisation des organes et comprendre la variabilité régionale, le champ des données fournies par le registre national doit comporter plus de détails pour que les facteurs qui mènent à la non-utilisation des organes soient corrigés. La correction de la faible utilisation du cœur et des poumons est particulièrement critique, étant donné les besoins en transplantation thoracique au Canada.

From the Canadian Institute for Health Information,* the GI Transplant Program,† and Cardiac Transplant Program,‡ Toronto General Hospital – University Health Network, Toronto, Ontario; the Department of Critical Care Medicine,§ The University of Calgary, Calgary, Alberta; and the Division of Pediatric Critical Care,¶ Montreal Children's Hospital, McGill University Health Centre, Montreal, Quebec, Canada.

Address correspondence to: Dr. Sam D. Shemie, Montreal Children's Hospital - McGill University Health Centre, 2300 Tupper Street, Montreal, Quebec H3H 1P3, Canada. E-mail: sam.shemie@muhc.mcgill.ca

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FOR nearly two decades, organ transplantation has been the mainstay lifesaving treatment for patients with end-stage organ failure. Meeting the organ demand for transplantation, however, is a daily challenge faced by transplant programs across Canada. The rate of deceased donors has remained static over the past decade, ranging from a high of 15.3 donors per million population in 2000 to a low of 13.0 in 2002, averaging 14.1 per million population. For patients awaiting transplantation, most significantly for those awaiting extra-renal transplants, this trend has dire consequences. From 1993 to 2002, 1,660 Canadians died while awaiting organ transplantation. This number likely underestimates the total number of deaths associated with the lack of organ donors, as it excludes patients withdrawn from the transplant waiting list because they had become too sick to be transplanted. Since 1999, there has been increased reliance on imported donor organs from the United States. Over the period 1999–2002, 99 transplants, most of which were heart and lung transplants (82.8%), were performed in Canada with organs from American donors. This relationship is not reciprocal, as Canada receives more organs than it sends to the United States, with infant hearts representing a large proportion of these organs. Canada's lower donation rate relative to that of the United States, and declining infant death rates in particular, would seem to play a role in this trend.

As a result of the challenges in procuring an adequate organ donor pool, it is essential to document organ utilization patterns among deceased donors. We therefore undertook a descriptive analysis of changes in the characteristics of organ donors and organ utilization patterns in Canada over a ten-year time frame, using national registry data as the data source.

Methods

Data were extracted from the Canadian Organ Replacement Register (CORR) for the decade 1993–2002. The CORR, which is managed by the Canadian Institute for Health Information (CIHI) is a national information system that collects, records, analyses and reports the level of activity and outcomes of vital organ transplantation and renal dialysis. Donor data within CORR are provided by organ procurement organizations across Canada. These data are subject to internal checks within CIHI, but have not been validated with external sources. For the decade 1993–2002, missing values for the primary data elements used in this report were noted as follows: age (0.3%); sex (0.1%); and causes of death (2.1%).

A donor was defined as a deceased person for whom at least one vital organ was retrieved and trans-

planted. Year of donation was based on the 'cross clamp' date. There were 4,222 donors included in the analysis for the decade spanning the period 1993–2002. Organ utilization was defined as all organs from donors (defined above) that were retrieved for the purpose of transplantation, whether or not these organs were transplanted. For example, if the pancreas was retrieved but used for islet transplantation, it was counted as a utilized pancreas even though technically, islet transplantation is considered a tissue rather than an organ transplant. Similar inclusion rules were used for heart valves for donors where at least one non-cardiac organ was used for transplantation. Organ counts were based on the number of organs retrieved to a maximum of eight (two kidneys, two lungs, heart, liver, pancreas, bowel). If both kidneys and both lungs were retrieved from a single donor, the organ count would be four.

The presented results reflect primarily national data. Province, in the context of this report, refers to the province where the organs were procured, and not where the donor resided. Hence, not all provinces and territories are represented. Provincial variation in terms of organ donation is notable and varies from year to year, particularly in those provinces with a population of less than two million. Except where noted, the results are based on averages for the years 2000–2002. Data may vary from previously published reports based upon differences in analytical conventions and definitions.^{1–3}

Data are presented as mean, median, standard deviation, and ranges. While much of the analysis is descriptive, statistical interpretation was undertaken, where appropriate, using the SAS® Enterprise Guide®, Version 2.05 (SAS Institute Inc., Cary, NC, USA). Chi-square and pooled two-tailed Student's *t* tests were applied, with statistical significance assumed when $P < 0.05$.

Results

Donor characteristics

GENDER

During the decade of study, 55.1% of donors were male (range: 59.1% in 1998 to 51.9% in 1999). Male donors predominated amongst donors < 40 yr of age (1,224/1,969), while a slightly greater proportion of females were represented amongst donors > 40 yr of age (1,144/2,237). Provincial variations in sex distribution were observed amongst deceased donors. For example, for the period 2000–2002, 71.8% of donors from New Brunswick (28/39) were male, in contrast to 37.8% from Newfoundland and Labrador (17/45).

TABLE Sex and age characteristics of deceased organ donors, Canada, 1993–2002

<i>Year</i>	<i>n</i>	<i>% Male</i>	<i>% 50+ yr</i>	<i>Median age (yr)</i>	<i>Average number of organs procured per donor</i>	<i>% 4+ Organs procured</i>
1993	409	52.8	21.8	37	3.3	44.5
1994	404	57.2	26.9	38	3.4	48.5
1995	426	54.7	28.3	37	3.7	57.8
1996	419	53.9	30.5	39	3.5	51.6
1997	429	54.3	30.2	39	3.6	56.9
1998	416	59.1	37.6	44	3.4	47.1
1999	420	51.9	36.8	43	3.6	51.9
2000	471	56.9	34.2	42	3.4	46.7
2001	420	53.6	35.2	44	3.5	46.2
2002	408	56.7	38.0	45	3.6	52.5

FIGURE 1 Distribution of cause of death among donors by sex and age group, Canada 2000–2002.

AGE

A summary of sex and age characteristics of donors is provided in the Table. The median age of donors increased from 37 yr in 1993, to 45 yr in 2002. In 1993, 21.8% of donors (89/409) were > 50 yr of age compared to 38.0% (155/408) in 2002. Mean

ages for female donors were higher ($P < 0.05$) than male donors for the years 1994–2000, inclusive. Provincial differences in donor age were also observed. From 2000–2002, median donor age was highest in Newfoundland and Labrador at 44.5 yr, and lowest in Saskatchewan at 33 yr.

FIGURE 2 Organ-specific utilization rates for deceased donors, Canada 1993–2002.

CAUSES OF DEATH

Causes of death for donors varied over the decade, with proportionately fewer donors dying from head trauma associated with motor vehicle collisions (25.8% in 1993 compared to 13.3% in 2002) and proportionately more progressing to neurological death as a result of a cerebrovascular accident (CVA) or stroke (47.4% in 1993 compared to 54.5% in 2002).

Causes of death were related to donor age and sex (Figure 1). Female donors aged 20–49 yr were more likely to die as a result of CVA/stroke deaths (they represented 41.8% of donors, but 57.0% of the CVA/stroke deaths occurred within this group) whereas male donors within the 30–49 yr age range were more likely to die as a result of motor vehicle collisions.

For the years 2000–2002, the proportion of deaths resulting from motor vehicle collisions was similar in New Brunswick (11/39 = 28.2%) and Alberta (11/39 = 28.2%). The proportion of donor deaths attributable to CVA/strokes was greatest in Nova Scotia (27/39 = 69.2%), followed by Newfoundland and Labrador (28/44 = 63.6%).

ORGAN UTILIZATION

Over the decade spanning the years 1993–2002, 14,571 organs were utilized from 4,222 donors, averaging 3.5 organs per donor. Donors from whom at least four organs were procured numbered 2,126 (50.4% of the donor pool). On an annualized basis, the “multi-organ” donors became progressively younger over the sampling time frame, when compared with donors from whom three or fewer organs were procured. The gap between the mean ages of the two groups increased over time. The mean age for these organ donors was 36.6 ± 15.7 yr, compared to 48.1 ± 18.3 yr for donors from whom fewer than four organs were procured ($P < 0.0001$). The gender distribution was similar in the two groups. Proportionately fewer donors in the four+ organs group died from CVA/stroke in 2002 when compared with donors from whom fewer than four organs were procured (49.1% *vs* 60.6%, respectively). This observation was consistent for every year in the decade. Over the years 2000–2002, Alberta and Saskatchewan had the highest percentage of donors in the four+ organs group, at 72.4% and 69.1%, respectively. In contrast, Quebec and Ontario had the lowest percentage of multi-organ donors, at 39.1% and 42.8%, respectively.

ORGAN-SPECIFIC UTILIZATION

From 1993–2002, utilization rates averaged 88.0% for kidneys, 83.4% for livers, 47.7% for hearts, 21.0% for pancreata, 20.2% for lungs, and 0.8% for intestines.

Each donor organ had a distinctive utilization trend (Figure 2). Liver utilization rates increased 15.5% over the decade, reaching nearly the same rate as for kidneys. Heart utilization rates peaked at 58.3% in 1997 and then fell below 40% in 2000 and 2001. Pancreata utilization rates nearly doubled over the decade, with 30.6% of pancreata being utilized in 2002. Similarly, lung utilization nearly doubled over the decade, reaching, 28.3% in 2002. Intestinal utilization remained very small over the entire period.

Donors, where hearts were utilized, emerged as a very distinct group in terms of the donor age, sex and cause of death. Of all donors during the period 2000–2002, the mean age of heart donors was significantly lower than for non-heart donors (33.5 ± 15.5 *vs* $45.5, \pm 18.6$, $P < 0.0001$) and 17.5% of heart donors compared to 47.1% of non-heart donors were over the age of 50. Proportionately more heart donors were male compared to non-heart donors (64.5% *vs* 50.3% respectively; $P < 0.0001$) and fewer heart donors died from CVA/strokes (43.6% *vs* 59.5%; $P < 0.0001$). The province with the highest proportion of donors where the heart was utilized was Saskatchewan (64.3%), while the provinces ranking lowest were Quebec and Ontario (29.6% and 32.8%, respectively).

Discussion

This descriptive study summarizes trends in organ utilization from deceased donors in relation to demographic factors. The findings reveal an aging donor pool (median age of donors increased eight years over the decade). Causes of death for donors changed, with proportionately fewer donors dying from head trauma caused by motor vehicle collisions, and proportionately more progressing to neurological death as a result of a CVA or stroke. Donors from whom at least four organs were utilized formed approximately half of all donors during the period. These donors were significantly younger every year in the decade, when compared with donors where three or fewer organs were utilized.

The small decline in kidney utilization may be related to increasing donor age and the concomitant decline in renal function. The increased liver utilization rates over the decade are largely the result of liberalization of the age criteria for liver donation and increased utilization of liver transplantation, given improved outcomes associated with surgery. Pancreata utilization rates nearly doubled over the decade, in parallel with the establishment and maturation of pancreas and islet cell transplant programs. Similarly, the growth of lung transplant programs, spurred by significant improvements in organ preservation, donor

management and surgical techniques, is evidenced by the dramatic increase in lung utilization rates.⁴ The low intestinal utilization rate is an anticipated finding, given that intestinal and multivisceral transplant activity in Canada has been limited. The flat utilization pattern for hearts suggests that the aging donor pool has reduced the availability of hearts medically suitable for transplantation.

The utilization rates reported in this study are comparable to those reported for the United States.⁵ The definition of donors used in Canada is more conservative than that used in the United States. That is, consented donors where organs may be retrieved, but not transplanted, are included as donors in data from the United States^A and Spain^B whereas in Canada, a donor is only registered in CORR if at least one organ was retrieved and used for transplantation. Thus, caution should be used when comparing donor data across jurisdictions.

Detailed reasons for non-utilization such as the impact of donor-related organ function, donation/transplant logistics and decision-making processes, and recipient-related factors are not captured in CORR.⁶ Currently, there is no detailed national information source on the extent to which potential organ donors become actual donors and the reasons why donor organs are not utilized more fully. A review of centre-specific utilization rates for hearts and lungs suggest that consent to individual organs, offering of organs, and decisions on transplantability are remedial factors that may enhance utilization.⁷

In conclusion, trends in the Canadian organ donor pool are characterized by an increasing age and a shift towards cerebrovascular diseases as primary causes of death. In order to improve organ utilization and understand regional variability, the scope of data provided to the national registry requires enhanced detail to address the factors that lead to non-utilization. Addressing the low utilization rates for hearts and lungs is especially critical, given the need for thoracic transplantation in Canada. Further research efforts are needed to obtain a more complete national and regional picture on the underlying reasons for, and ramifications of the observed trends.

A 2003 OPTN/SRTR Annual Report 1993-2002. HHS/HRSA/OSP/DOT; UNOS; URREA.

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