



# Attitudes of healthcare providers towards cardiac donation after circulatory determination of death: a Canadian nation-wide survey

## Les attitudes des fournisseurs de soins de santé concernant le don cardiaque après un décès cardiocirculatoire : un sondage pancanadien

Kimia Honarmand, MD, MSc · Jeanna Parsons Leigh, PhD · John Basmaji, MD · Claudio M. Martin, MSc, MD · Robert Sibbald, MSc · Dave Nagpal, MD, MSc · Vince Lau, MD · Fran Priestap, MSc · Sabe De, MD · Andrew Healey, MD · Sonny Dhanani, MD · Matthew J. Weiss, MD · Sam Shemie, MD · Ian M. Ball, MD, MSc

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### Abstract

**Purpose** *The number of patients on cardiac transplant waitlists exceeds the number of available donor organs. Cardiac donation is currently limited to those declared dead by neurologic criteria in all but three countries. Cardiac donation after circulatory determination of death (cardiac DCDD) can be conducted using direct procurement and perfusion (DPP) or normothermic*

*regional perfusion (NRP). Implementation of cardiac DCDD in many countries has been slowed by ethical debates within the donation and transplantation community. We conducted a national survey to determine the perceptions of healthcare providers regarding cardiac DCDD.*

**Methods** *We conducted an electronic survey of 398 healthcare providers who are involved in the management of heart donors and/or heart transplant recipients in Canada (226 nurses, 82 critical care physicians, 31 donation specialists, and 59 transplant specialists). Our primary outcomes were their attitudes towards and concerns regarding cardiac DCDD protocols*

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K. Honarmand, MD, MSc (✉) · J. Basmaji, MD · C. M. Martin, MSc, MD · D. Nagpal, MD, MSc · V. Lau, MD · F. Priestap, MSc  
Department of Medicine, Western University, London Health Sciences Centre, London, ON, Canada  
e-mail: kimia.honarmand@medportal.ca

J. Parsons Leigh, PhD  
Department of Epidemiology and Biostatistics, Western University, London, ON, Canada

R. Sibbald, MSc  
Department of Family Medicine, Western University, London, ON, Canada

S. De, MD  
Division of Cardiology, Western University, London, ON, Canada

A. Healey, MD  
Trillium Gift of Life Network, Toronto, ON, Canada

Division of Emergency Medicine, Department of Medicine, McMaster University, Hamilton, ON, Canada

S. Dhanani, MD  
Department of Pediatrics, University of Ottawa and Children's Hospital of Eastern Ontario, Ottawa, ON, Canada

Division of Pediatric Critical Care, Children's Hospital of Eastern Ontario, Ottawa, ON, Canada

M. J. Weiss, MD  
Division of Pediatric Intensive Care, Centre-Mère Enfant Soleil du CHU de Québec, Québec City, QC, Canada

and their implementation in Canada. We distributed the survey electronically through several Canadian donation and transplantation organizations.

**Results** We identified that 361 of 391 respondents (92.3%; 95% confidence interval [CI], 89.6 to 95.1) believed that DPP is acceptable, and 329 of 377 respondents (87.3%; 95% CI, 83.9 to 90.7) supported its implementation in Canada. We found that 301 of 384 respondents (78.4%; 95% CI, 74.2 to 82.6) believed that NRP is acceptable and 266 of 377 respondents (70.6%; 95% CI, 66.0 to 75.2) supported its implementation in Canada.

**Conclusion** This is the first survey describing the attitudes of healthcare providers towards cardiac DCDD. We identified widespread support for cardiac DCDD and its implementation in Canada among Canadian healthcare providers within the organ donation and transplantation community in Canada.

## Résumé

**Objectif** Le nombre de patients sur les listes d'attente de greffe cardiaque excède le nombre d'organes disponibles. À l'exception de trois pays, le don cardiaque se limite actuellement aux donneurs dont le décès a été déclaré à l'aide de critères neurologiques. Le don cardiaque après un décès cardiocirculatoire (DDC cardiaque) peut être réalisé par obtention directe et perfusion (ODP) ou par circulation régionale normothermique (CRN). Dans de nombreux pays, l'implantation du DDC cardiaque a été freinée par des débats déontologiques au sein de la communauté des dons et greffes. Nous avons effectué un sondage national afin d'étudier les perceptions des fournisseurs de soins de santé en ce qui touche au DDC cardiaque.

**Méthode** Nous avons réalisé un sondage électronique auprès de 398 fournisseurs de soins de santé impliqués dans la prise en charge des donneurs cardiaques et/ou des récipiendaires de greffe cardiaque au Canada (226 infirmières, 82 médecins intensivistes, 31 spécialistes du don d'organes et 59 spécialistes de la greffe). Nos critères d'évaluation principaux étaient leurs attitudes envers et leurs inquiétudes en ce qui a trait aux protocoles de DDC cardiaque et à leur mise en œuvre au Canada. Nous avons

distribué le sondage par voie électronique via plusieurs organismes canadiens de dons et de greffes.

**Résultats** Nous avons trouvé que 361 des 391 répondants (92,3 %; intervalle de confiance [IC] 95 %, 89,6 à 95,1) estimaient que l'obtention directe et perfusion (ODP) serait acceptable, et 329 sur 377 répondants (87,3 %; IC 95 %, 83,9 à 90,7) appuyaient sa mise en œuvre au Canada. Nous avons constaté que 301 de 384 répondants (78,4 %; IC 95 % 74,2 à 82,6) étaient d'avis que la CRN était acceptable, et 266 de 377 répondants (70,6 %; IC 95 %, 66,0 à 75,2) appuyaient sa mise en œuvre au Canada.

**Conclusion** Il s'agit du premier sondage décrivant les attitudes des fournisseurs de soins de santé en ce qui touche au DDC cardiaque. Nous avons déterminé que les fournisseurs de soins de santé de la communauté canadienne de dons d'organe et de greffes étaient en général en faveur d'un DDC cardiaque et de sa mise en œuvre au Canada.

The number of patients on the heart transplant waitlist exceeds the number of available donor hearts.<sup>1-4</sup> Cardiac donation is currently limited to those who are declared dead based on neurologic criteria in all but three countries (UK, Australia, and Belgium). Incorporating cardiac donation after circulatory determination of death (cardiac DCDD) may increase the number of organs available for life-saving cardiac transplantation.

Donation after circulatory determination of death may occur after a decision is made to withdraw life-sustaining measures in a patient who is unlikely to recover from critical illness. Consent for organ donation may be sought from the patient's family after a decision is made to withdraw life-sustaining measures. Patients with a prior expressed wish to donate organs or whose families consent to organ donation after death may then proceed to the operating room for organ recovery after death by circulatory criteria has been declared.

Two cardiac DCDD protocols have been reported.<sup>5</sup> In direct procurement and perfusion (DPP), after the withdrawal

Department of Pediatrics, Faculté de Médecine, Université Laval, Québec City, QC, Canada

Population Health and Optimal Health Practices Research Unit, Traumatology-Emergency-Critical Care Medicine, Université Laval, CHU de Québec – Université Laval Research Center, Québec City, QC, Canada

S. Shemie, MD  
Deceased Organ Donation, Canadian Blood Services and  
Division of Critical Care Medicine, Montreal Children's  
Hospital and McGill University Health Centre & Research  
Institute, Montreal, QC, Canada

I. M. Ball, MD, MSc  
Department of Medicine, Western University, London Health  
Sciences Centre, London, ON, Canada

Department of Epidemiology and Biostatistics, Western  
University, London, ON, Canada

of life-sustaining measures and death declaration, the donor's sternum is opened, and the heart is recovered and then placed in an *ex situ* perfusion system where its activity is restored. The beating heart is then transported to the location of the recipient for transplantation.

In normothermic regional perfusion (NRP), after withdrawal of life-sustaining measures and death declaration, the donor's sternum is opened, the vessels that branch from the aortic arch are ligated and the central vessels are cannulated to institute cardiopulmonary bypass and thus restore cardiac activity and systemic circulatory flow. The surgical interruption of the cerebral vasculature is undertaken to prevent cerebral blood flow following the reinstitution of systemic circulation to the remaining thoraco-abdominal organs. This protocol allows for *in situ* assessment of cardiac function. After surgical removal of the heart, its activity may be restored in an *ex situ* perfusion system similar to that described in the DPP protocol during transportation to the location of the recipient.

Cardiac DCDD programs have been implemented in the UK,<sup>6,7</sup> Australia,<sup>8,9</sup> and Belgium,<sup>10</sup> with approximately 100 cases of cardiac DCDD conducted to date. Implementation of such programs in other countries, including Canada, has been hindered by practical considerations and ethical debates within the medical community both for and against DCDD heart programs.<sup>11-14</sup> We conducted a national survey to determine the attitudes and opinions of Canadian healthcare providers towards cardiac DCDD and perceived barriers to its implementation.

## Methods

### Ethics

Western University research ethics board approved this study (reference number: 2018-110472-10501; May 10, 2018). All respondents provided informed consent electronically prior to completing the survey.

### Survey development

We used established survey development methodology<sup>15</sup> to design a survey targeted towards healthcare providers who are involved in the management of deceased organ donors or transplant recipients. We developed a series of educational content and associated Likert scale questions informed by a review of published literature and discussions at national meetings.

We conducted pre-testing and clinical sensibility testing in which all investigators and a convenience sample of additional healthcare providers reviewed the survey for accuracy, relevance, and likelihood of yielding pertinent information.<sup>15</sup>

Pre-testers included seven critical care physicians (including three donation physicians), two cardiac transplant surgeons, two transplant cardiologists, one non-cardiac transplant surgeon, two organ donation organization coordinators, a critical care nurse, a social worker, a perfusionist, a bioethicist, and a qualitative methodology expert. We modified the survey based on the feedback obtained.

The final survey (eAppendix 1, available as Electronic Supplementary Material [ESM]) consisted of four sections: attitudes towards non-cardiac DCDD, DPP, and NRP; concerns regarding cardiac DCDD; support for the implementation of cardiac DCDD in Canada; and perceived barriers to cardiac DCDD implementation (Fig. 1).

### Survey administration

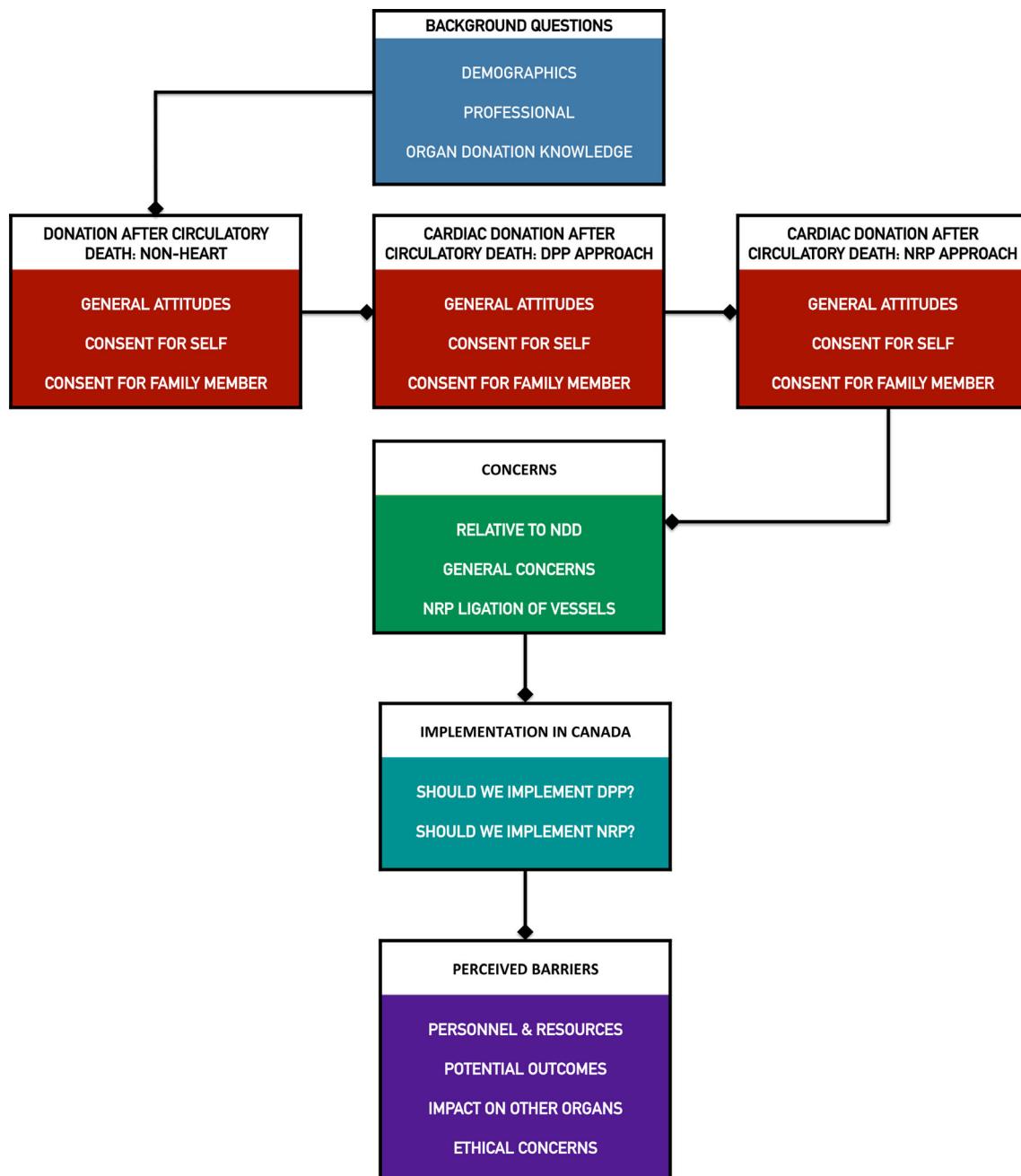
Our sample of interest included nurses, critical care physicians, organ donation physicians and personnel, as well as transplant physicians and surgeons who are likely to be involved in the management of cardiac donors and/or cardiac transplant recipients.

We distributed the web-based survey through REDcap<sup>16</sup> (hosted at London Health Sciences Centre), and through Canadian donation and transplantation organizations whose members are likely to be healthcare providers (nurses, physicians, and other healthcare providers) who are involved in the management of heart donors and/or heart transplant recipients and are therefore likely to be representative of the population of interest.

Given that the size of the population of interest was not known and our goal was to reach the majority of the population of interest, we did not conduct a sample size calculation. We aimed to obtain a response rate of 30% using email contacts as the denominator, consistent with the findings of previous studies on response rates in national, non-incentivized, web-based surveys of healthcare providers.<sup>17-21</sup>

### Statistical analysis

We used descriptive statistics to summarize respondent characteristics and responses to Likert questions. We decided *a priori* to include responses from those who completed only part of the survey in the analysis. We categorized respondents based on their professional roles: 1) nurses, 2) critical care physicians, 3) organ donation physicians and coordinators, and 4) transplant physicians and surgeons. We then conducted Jonckheere's trend test, a non-parametric test for ordered medians, to compare the responses of each of these professional roles and between provinces. We conducted all quantitative analyses using Statistical Package for Social Sciences Version 25.0 (IBM Corp, 2017; Armonk, NY, USA). The significance level was set at 5%.



**Fig. 1** Overview of the survey of healthcare providers regarding cardiac donation after circulatory determination of death (cardiac DCDD). DPP = direct procurement and perfusion; NDD = donation after neurological determination of death; NRP = normothermic regional perfusion

To provide context for responses to the Likert scale questions, two investigators (K.H. and J.B.) conducted thematic content analysis of all open-ended responses.<sup>22</sup> First, they independently reviewed all open-ended responses. They then met to discuss the themes and subthemes that emerged from the open-ended responses and produced a comprehensive list of themes and subthemes regarding the three donation protocols (non-cardiac DCDD, DPP, and NRP). A third investigator (J.P.L.) was available to resolve disagreements.

## Results

### Sample

The following organizations distributed the electronic survey to their members via two or three emails over a six-week period: Canadian Association of Critical Care Nurses (CACCN), Canadian Donation and Transplant Research Program (CDTRP), Canadian Society of Transplantation (CST), Canadian Critical Care society

(CCCS), and Canadian Cardiac Transplant Network (CCTN). Table 2 shows the organizations that distributed the survey, the number of members on their distribution lists, and the number of respondents reporting membership to each organization. To protect anonymity, the authors did not have direct access to the email lists.

The overall response rate was 21.2% (451 of 2,126). The estimated response rate for each organization ranged from 16% (CACCN) to 41% (CCCS/SCSI). Not reflected in these estimates is the likely overlap in membership across the organizations, respondents who reported affiliation with more than one organization, or the fact that 41 respondents reported no affiliation with any professional organization (Table 2).

The survey was accessed by 515 respondents. Among these, 55 were excluded from participating in the survey because they reported that they were not currently practicing as a healthcare provider in Canada, seven were excluded because they reported occupations in which they do not manage organ donors or transplant recipients, and 55 were excluded because their surveys were incomplete and contained only demographic and occupational information.

We thus included 398 surveys (including 24 completed in French, and 33 only partially completed) in the final analysis. Responses from those who completed only part of the survey were included in the analysis, leading to slight variations in the denominators for various responses. Our sample consisted of 229 nurses, 148 physicians, and 21 surgeons. When grouped according to professional roles, there were 226 nurses (critical care, emergency, or transplant), 82 intensive care unit (ICU) physicians (including nine anesthesiologists), 31 donation physicians or personnel/coordinators (donation specialists), and 59 transplant physicians and surgeons (transplant specialists). Among the 398 respondents, 42 (10.6%) reported “never” managing deceased organ donors or transplant recipients. Respondent characteristics are presented in Table 1.

#### Attitudes towards non-cardiac DCDD

We found that 375 of 397 respondents (94.4%; 95% confidence interval [CI], 92.0 to 96.8) agreed or strongly agreed that DCDD is acceptable with no differences between professional roles ( $P = 0.07$ ). Similarly, 360 of 398 respondents (90.4%; 95% CI, 87.4 to 93.4) agreed or strongly agreed that they would consent to donating their organs in this manner after death, with a higher proportion of transplant clinicians agreeing or strongly agreeing than nurses and ICU physicians (nurses, 87.6%; ICU, 91.5%; donation, 96.8%; transplant, 98.3%;  $P = 0.03$  and  $P = 0.01$ , respectively). Finally, 370 of 398 respondents (93%; 95% CI, 90.4 to 95.6) agreed or strongly agreed that they would

consent to the same on behalf of a family member (Fig. 2a), with a higher proportion of transplant clinicians agreeing or strongly agreeing than nurses and ICU physicians (nurses, 92.0%; ICU, 90.2%; donation, 96.8%; transplant, 98.3%;  $P = 0.02$  and  $P = 0.01$ , respectively). There were no differences in response patterns between the provinces.

#### Attitudes towards cardiac DCDD

We identified that 361 of 391 respondents (92.3%; 95% CI, 89.6 to 95.1) agreed or strongly agreed that the DPP approach to cardiac DCDD is acceptable, 352 of 391 respondents (90.0%; 95% CI, 86.9 to 93.1) agreed or strongly agreed that they would consent to donating their hearts in this manner after death, and 355 of 391 respondents (90.8%; 95% CI, 87.8 to 93.8) agreed or strongly agreed that they would consent to the same on behalf of a family member (Fig. 2b). There were no differences in response patterns between professional roles or provinces.

We identified that 301 of 384 respondents (78.4%; 95% CI, 74.2 to 82.6) of respondents agreed or strongly agreed that the NRP approach to cardiac DCDD is acceptable, 286 of 384 respondents (74.5%; 95% CI, 70.1 to 78.9) agreed or strongly agreed that they would consent to donating their hearts in this manner after death, and 284 of 384 respondents (74%; 95% CI, 69.6 to 78.4) agreed or strongly agreed that they would consent to the same on behalf of a family member (Fig. 2c). There were no differences in response patterns between professional roles or provinces.

Of 377 respondents, 329 (87.3%; 95% CI, 83.9 to 90.7) agreed or strongly agreed that they would support the implementation of DPP in Canada whereas 266 of 377 respondents (70.6%; 95% CI, 66.0 to 75.2) agreed or strongly agreed that they would support the implementation of NRP in Canada. There were no differences between professional roles or provinces (Fig. 3).

Among 12 respondents who did not find the DPP approach to be acceptable, seven (58.3%) also did not find non-cardiac DCDD, as is currently conducted in Canada and many other countries, to be acceptable. Among 29 respondents who did not find the NRP approach to be acceptable, seven (24.1%) also did not find non-cardiac DCDD to be acceptable.

#### Views about public acceptability of non-cardiac and cardiac DCDD protocols

We found that 304 of 398 respondents (76.4%; 95% CI, 72.1 to 80.7) agreed or strongly agreed that the Canadian

**Table 1** Sample characteristics

Characteristic	Overall sample <i>n</i> = 398	Nurses <i>n</i> = 226	ICU <sup>1</sup> <i>n</i> = 82	Donation <sup>2</sup> <i>n</i> = 31	Transplant <sup>3</sup> <i>n</i> = 59
<b>Age, Median [IQR]</b>	45 [36–55]	41.5 [32–54]	42 [35–56.3]	46 [38–57]	48 [43–55]
<b>Gender, <i>n</i> (%)</b>					
Female	271 (68.1)	208 (92.0)	26 (31.7)	15 (48.4)	22 (37.3)
Male	123 (30.9)	17 (7.5)	55 (67.1)	15 (48.4)	36 (61.0)
Other	1 (0.3)	0 (0)	1 (1.2)	0 (0)	0 (0)
Prefer not to answer	3 (0.8)	1 (0.4)	0 (0)	1 (3.2)	1 (1.7)
<b>Province, <i>n</i> (%)</b>					
Nova Scotia	35 (8.8)	23 (10.2)	4 (4.9)	5 (16.1)	3 (5.1)
New Brunswick	3 (0.8)	3 (1.3)	0 (0)	0 (0)	0 (0)
Prince Edouard Island	5 (1.3)	5 (2.2)	0 (0)	0 (0)	0 (0)
Newfoundland	5 (1.3)	3 (1.3)	1 (1.2)	1 (3.2)	0 (0)
Quebec	61 (15.3)	22 (9.7)	15 (18.3)	8 (25.8)	16 (27.1)
Ontario	160 (40.2)	84 (37.2)	48 (58.5)	10 (32.3)	18 (30.5)
Manitoba	23 (5.8)	17 (7.5)	2 (2.4)	1 (3.2)	3 (5.1)
Saskatchewan	5 (1.3)	3 (1.3)	0 (0)	1 (3.2)	1 (1.7)
Alberta	56 (14.1)	36 (15.9)	6 (7.3)	1 (3.2)	13 (22.0)
British Columbia	45 (11.3)	30 (13.3)	6 (7.3)	4 (12.9)	5 (8.5)
<b>Practice setting*, <i>n</i> (%)</b>					
Academic	308 (77.4)	149 (65.9)	75 (91.5)	25 (80.6)	59 (100.0)
Urban community	57 (14.3)	46 (20.4)	9 (11.0)	2 (6.5)	0 (0)
Suburban community	18 (4.5)	14 (6.2)	4 (4.9)	0 (0)	0 (0)
Rural community	29 (7.3)	26 (11.5)	3 (3.7)	0 (0)	0 (0)
<b>Organ donation organization</b>	14 (3.5)	4 (1.8)	1 (1.2)	9 (29.0)	0 (0)
<b>Patient population, <i>n</i> (%)</b>					
Adult	278 (69.8)	166 (73.5)	58 (70.7)	17 (54.8)	37 (62.7)
Pediatric	41 (10.3)	14 (6.2)	14 (17.1)	3 (9.7)	10 (16.9)
Both	66 (16.6)	41 (18.1)	6 (7.3)	8 (25.8)	11 (18.6)
Not applicable	13 (3.3)	5 (2.2)	4 (4.9)	3 (9.7)	1 (1.7)
<b>Organ donor management experience, <i>n</i> (%)</b>					
Never	83 (20.9)	41 (18.1)	3 (3.7)	4 (12.9)	35 (59.3)
1–5 patients per year	162 (40.7)	122 (54.0)	30 (36.6)	4 (12.9)	6 (10.2)
6–10 patients per year	65 (16.3)	31 (13.7)	27 (32.9)	5 (16.1)	2 (3.4)
10–20 patients per year	34 (8.5)	14 (6.2)	11 (13.4)	6 (19.4)	3 (5.1)
20+ patients per year	54 (13.6)	18 (8.0)	11 (13.4)	12 (38.7)	13 (22.0)
<b>Transplant recipient management experience, <i>n</i> (%)</b>					
Never	221 (55.5)	157 (69.5)	39 (47.6)	21 (67.7)	4 (6.8)
1–5 patients per year	51 (12.8)	31 (13.7)	14 (17.1)	2 (6.5)	4 (6.8)
6–10 patients per year	23 (5.8)	8 (3.5)	11 (13.4)	2 (6.5)	2 (3.4)
10–20 patients per year	29 (7.3)	8 (3.5)	7 (8.5)	0 (0)	14 (23.7)
20+ patients per year	74 (18.6)	22 (9.7)	11 (13.4)	6 (19.4)	35 (59.3)

<sup>1</sup> ICU: physicians who work in critical care (ICU = intensive care unit)<sup>2</sup> Donation: donation physicians and coordinators<sup>3</sup> Transplant: transplant physicians and surgeons

\*Percentages do not add up to 100.0% as some respondents reported practicing in more than one setting

IQR = interquartile range

**Table 2** Estimated response rates by organization or society

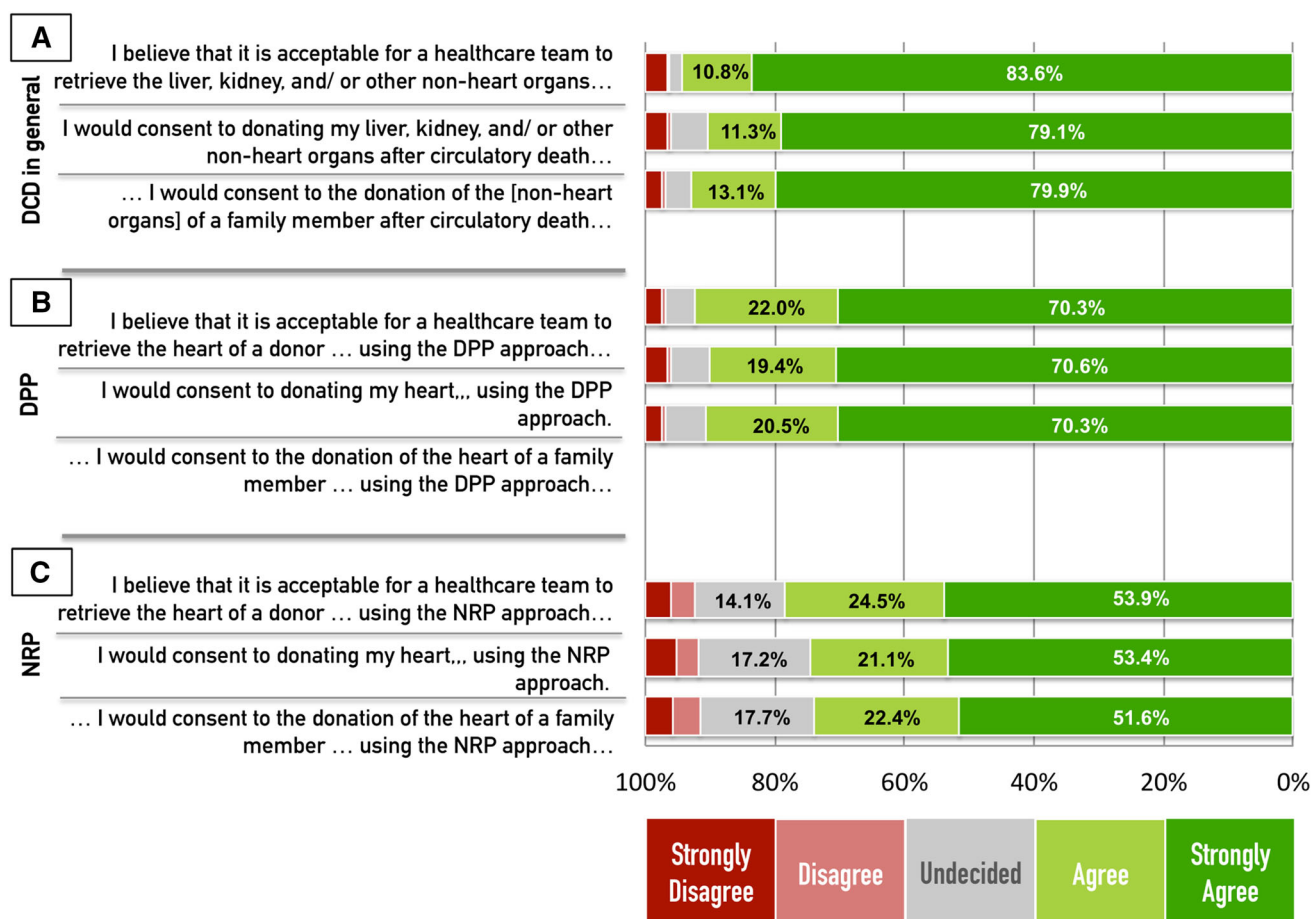
Organization or Society*	Number of emails on distribution list	Total number of respondents	Estimated response rate <sup>§</sup>
Canadian Association of Critical Care Nurses (CACCN) <sup>†</sup>	1,283	200	15.6%
Canadian Donation and Transplant Research Program (CDTRP)	160	43	27%
Canadian Society of Transplant (CST)	327	60	18.3%
Canadian Critical Care Society/ Société Canadienne de Soins Intensifs (CCCS/ SCSI)	259	107	41.3%
Canadian Cardiac Transplant Network(CCTN) <sup>‡</sup>	97	N/A	N/A
No organization or society membership	N/A	41	N/A

\*Each organization distributed the survey link to their email distribution list two to three times over a six-week period. Additional individualized emails were sent to various critical care specialists and cardiac transplant surgeons and transplant cardiologists

<sup>†</sup> CACCN also advertised the survey on their social media accounts. The CACCN email list may include those are no longer practicing in critical care

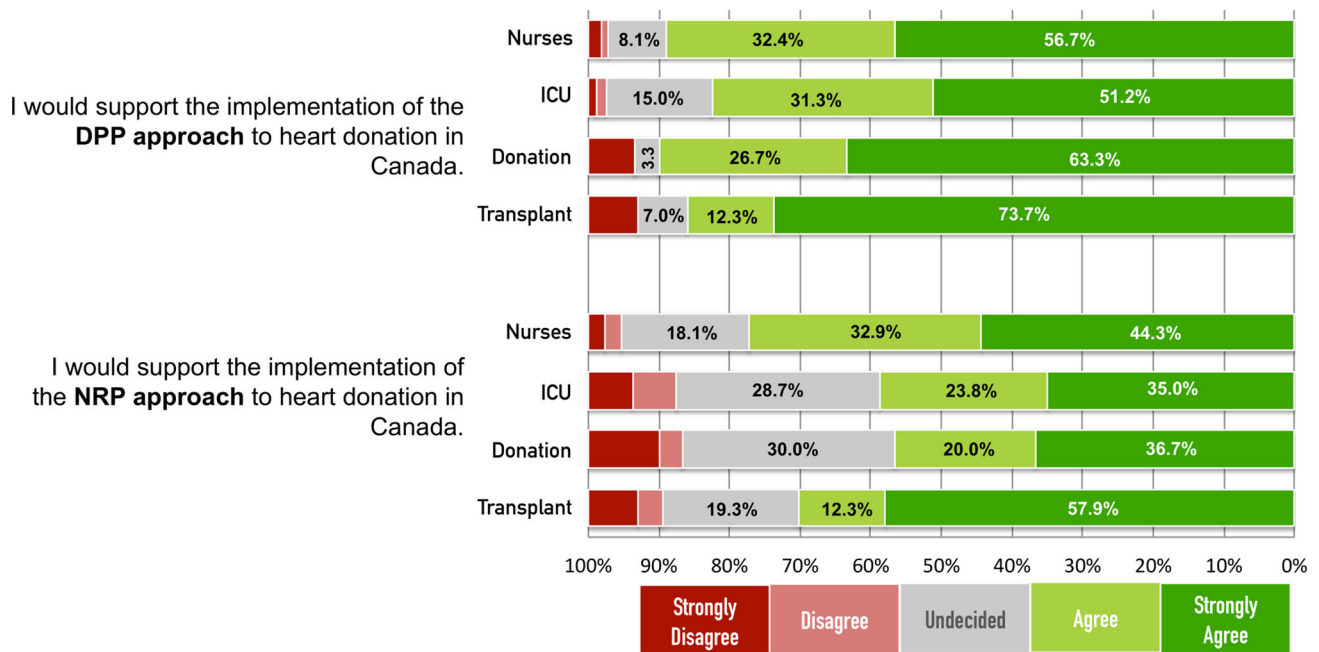
<sup>‡</sup> CCTN was not included in the list of organizations/societies on the survey. Number of respondents for CCTN is based on the number that indicated membership in this group as an open-ended response

<sup>§</sup> These estimated response rates reflect all respondents who accessed the survey and the number of emails/members to which the survey was sent by each. These estimates do not reflect the likely overlap in the distribution lists across the organizations/societies, the respondents who reported more than one affiliation in the list, or the respondents who reported no affiliation to any of the listed organizations or societies



**Fig. 2** Respondents' attitudes towards A) non-cardiac donation after circulatory determination of death (DCDD), B) cardiac DCDD using the direct procurement and perfusion (DPP) protocol, C) cardiac

DCDD using the normothermic regional perfusion (NRP) protocol. Based on A) 397 responses for part 1 and 398 responses for parts 2 and 3; B) 391 responses; C) 384 responses



**Fig. 3** Respondents' support for the implementation of direct procurement and perfusion (DPP) and normothermic regional perfusion (NRP) protocols in Canada. Based on 377 complete responses

public would find non-cardiac DCDD to be acceptable (nurses, 69.9%; ICU, 79.3%; donation, 96.8%; transplant, 86.4%).

Regarding cardiac DCDD protocols, 237 of 390 respondents (60.8%; 95% CI, 55.9 to 65.7) agreed or strongly agreed that the Canadian public would find the DPP approach to be acceptable (nurses, 53.4%; ICU, 70.4%; donation, 71.0%; transplant, 70.2%). Conversely, 143 of 384 respondents (37.2%; 95% CI, 32.3 to 42.1) agreed or strongly agreed that the Canadian public would find the NRP approach to be acceptable (nurses, 34.4%; ICU, 38.3%; donation, 45.2%; transplant, 42.1%).

#### Concerns and perceived barriers regarding cardiac DCDD

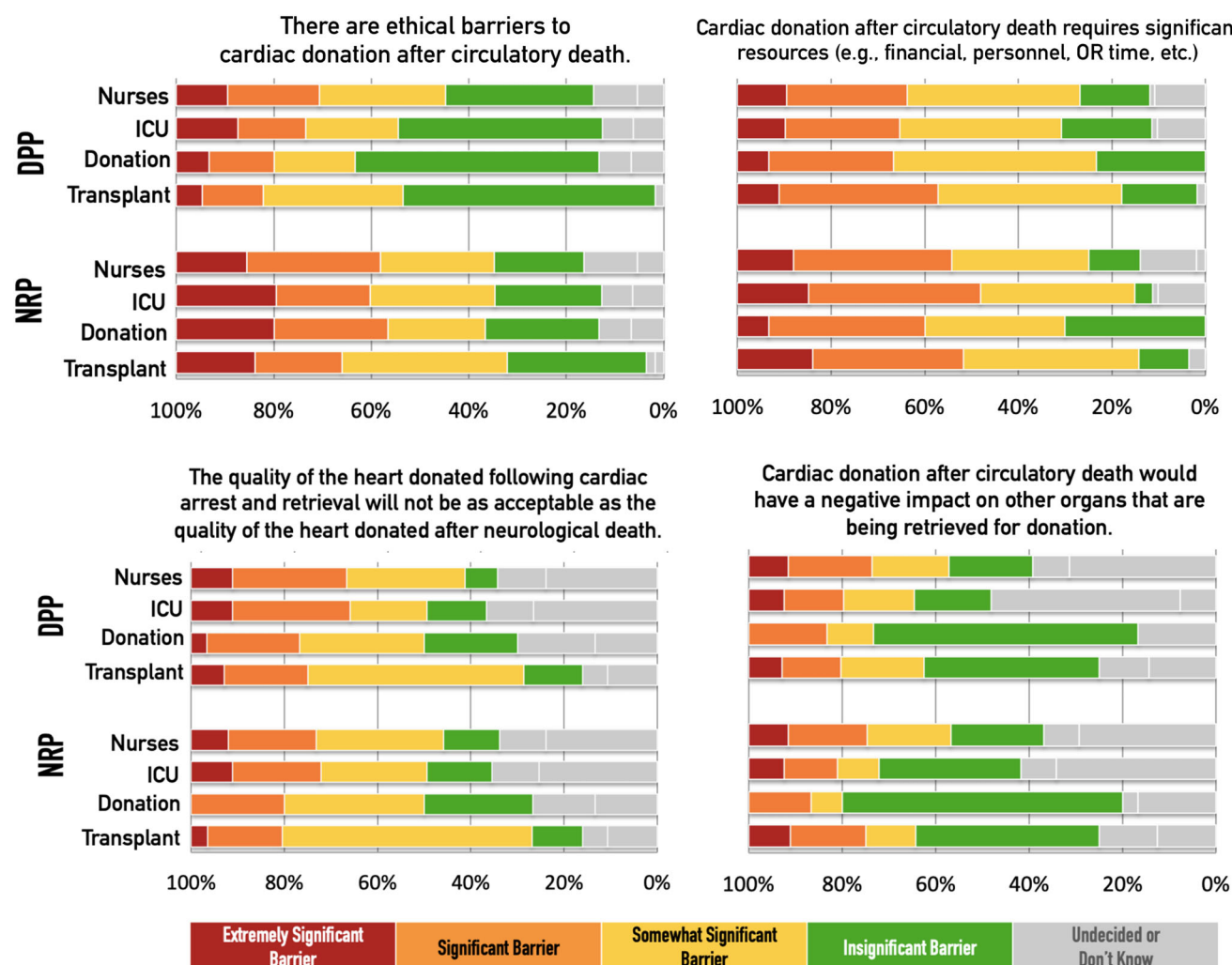
We identified that 109 of 378 respondents (28.8%; 95% CI, 24.2 to 33.4) selected cardiac DCDD as “more concerning” than cardiac donation in NDD, 215 (56.9%; 95% CI, 51.9 to 61.9) had the “same level of concern”, and 22 (5.8%; 95% CI, 3.4 to 8.2) found it “less concerning” (32 respondents or 8.5% were undecided). There were no differences in response patterns between professional roles ( $P = 0.36$ ).

When asked about the DPP approach, 50 of 378 respondents (13.2%; 95% CI, 9.8 to 16.7) indicated that they have concerns about this approach, 288 (76.2%; 95% CI, 71.9 to 80.5) did not report concerns about DPP, and 40 (10.6%; 95% CI, 7.5 to 13.8) were undecided. When asked

about the NRP approach, 112 of 378 respondents (29.6%; 95% CI, 25.0 to 34.2) reported that they have concerns about this approach, 206 (54.5%; 95% CI, 49.5 to 59.5) did not report concerns, and 60 respondents (15.9%; 95% CI, 12.5 to 20.0) were undecided. We identified that 84 of 377 respondents (22.3%; 95% CI, 18.1 to 26.5) reported concerns about the practice of interrupting cerebrovascular flow in NRP specifically, 230 (61.0%; 95% CI, 56.1 to 65.9) did not report concerns, and 63 (16.7%; 95% CI, 12.9 to 20.5) were undecided.

We asked respondents to rate the extent to which various factors pose barriers to the implementation of cardiac DCDD (Fig. 4). There were no differences between professional roles in their perceptions of resource requirements as barriers to DPP and NRP implementation. Relative to nurses, transplant clinicians identified ethical issues to be “insignificant barriers” to DPP ( $P = 0.001$ ) and NRP ( $P = 0.02$ ), with the former group reporting lack of information and uncertainty in this regard.

Relative to nurses and ICU physicians, transplant clinicians reported the quality of the donated heart using DPP and NRP to be a “somewhat significant barrier” (all  $P < 0.05$ ). More transplant clinicians and donation clinicians identified potential effects of DPP on other organs as an “insignificant barrier” than nurses and ICU physicians, with more nurses reporting lack of adequate information and ICU physicians reporting more uncertainty (all  $P < 0.05$ ). Relative to nurses and donation clinicians, a higher



**Fig. 4** Perceived barriers to direct procurement and perfusion (DPP) and normothermic regional perfusion (NRP) protocols. Based on responses from 201 nurses, 79 critical care physicians, 30 donation

specialists, and 56 transplant specialists. DCDD = donation after circulatory determination of death

proportion of transplant surgeons and donation clinicians rated adverse effects of NRP on other organs as an “insignificant barrier” (all  $P < 0.05$ ).

### Open-ended responses

Analysis of open-ended responses provides additional context for responses to Likert scale questions (eAppendix 2, available as ESM). Respondents expressed support for cardiac DCDD and viewed it as an extension of non-cardiac DCDD as is currently conducted in Canada and many other countries. Speculations regarding public acceptance of cardiac DCDD were mixed, with some expressing the belief that the Canadian public would accept cardiac DCDD and others expressing concerns that the public will not understand or accept cardiac DCDD. Regarding both DPP and NRP, respondents expressed

concerns regarding the definition and certainty of death, implications of re-starting cardiac activity after death declaration, the viability of the donated heart, and resource requirements associated with cardiac DCDD protocols. Regarding NRP, concerns were expressed regarding the invasiveness of the protocol, the potential for re-perfusion of the brain after restoration of cardiac activity, and the effect on other transplantable organs.

### Discussion

In our survey of Canadian healthcare providers, we identified that more than 90% of respondents rated the DPP approach to cardiac DCDD as acceptable and supported its implementation in Canada. We found no differences in attitudes towards DPP between professional

roles and provinces within Canada. Over half of those who did not find the DPP approach to be acceptable also did not find non-cardiac DCDD to be acceptable. The support for DPP was similar to that of non-cardiac DCDD, which is currently available in Canada and many other countries. Ethical concerns were viewed as “significant barriers” to DPP implementation by approximately 20% of respondents. Analysis of open-ended responses demonstrated that healthcare providers considered the DPP approach as an extension of DCDD that should be implemented.

Although support for NRP was lower than that for DPP, a majority of respondents (80%) described the NRP approach to cardiac DCDD to be acceptable and over two-thirds supported its implementation in Canada with no difference between professional roles or provinces. Among those who did not find NRP to be acceptable, nearly one-third also did not support the current practice of non-cardiac DCDD. The lower support for NRP is likely explained by the finding that 22% of respondents had concerns with respect to the surgical interruption of cerebral vasculature that is conducted in NRP and nearly two-thirds found “ethical concerns” to be “significant barriers” to NRP implementation in Canada.

There is debate in the literature regarding the ethics of cardiac DCDD.<sup>11-14,23-26</sup> Declaration of death by circulatory criteria relies on the assumption of irreversible cessation of systemic circulation, although the definition of irreversibility is the topic of much debate.<sup>11-14,24,25</sup> On this basis, some have expressed concern that restoration of cardiac activity after declaration of death invalidates the declaration of death and thus cardiac DCDD is implausible without violation of the “dead donor rule”, which prohibits recovery of organs before death.<sup>11,13,14</sup> Others have countered that declaration of death by circulatory criteria does not pre-suppose that the heart is not viable but that it is unable to sustain circulation within the donor body,<sup>25</sup> that restoration of cardiac activity after declaration of death does not affect the biological state of the heart at the time that death was declared,<sup>25,26</sup> and that recovery of the heart in the DPP protocol is ethically no different than removal of other organs after circulatory determination of death.<sup>9</sup> Furthermore, death by circulatory criteria meets the criteria of permanent cessation of circulation.<sup>24,25</sup>

The debate regarding the NRP protocol to cardiac DCDD involves other arguments. The variable definition of death explains the legal standing of NRP in various jurisdictions. In the UK, where death is defined based on permanent cessation of brain activity, which occurs in DCDD following the cessation of circulation (and thereby cessation of cerebral blood flow),<sup>24</sup> NRP is permissible and routinely conducted. Conversely, in Australia, where death

is defined based on permanent cessation of circulation only, the restoration of circulation within the donor body that occurs in NRP is not permissible,<sup>24</sup> allowing only the DPP protocol for cardiac DCDD to be conducted. Of note, Canada has not yet developed a policy in this regard. Another concern is the assertion that the restoration of thoraco-abdominal perfusion in NRP may restore cerebral blood flow,<sup>13</sup> a risk that is mitigated by the surgical ligation of vessels that supply the cerebral vasculature in NRP.

Some authors have raised concerns regarding the public acceptability of cardiac DCDD protocols,<sup>11</sup> which have been cited as a barrier to the implementation of cardiac DCDD programs at regional and national meetings and conferences in Canada. Not surprisingly, our findings suggest that most healthcare providers believed that the general public would find DPP acceptable but far fewer believed that NRP would be acceptable to the general public. Analysis of open-ended responses also demonstrated concerns among Canadian healthcare providers about public acceptance of cardiac DCDD (eAppendix 2, available as ESM).

We found that nearly half of all respondents viewed the resource requirements (i.e., financial, personnel, operating room time) as representing “significant” or “extremely significant” barriers to DPP and NRP implementation. The quality of the transplanted DCDD heart was viewed as a “significant” or “extremely significant” barrier to implementation of cardiac DCDD by one quarter of respondents, while one-fifth viewed the effect of cardiac DCDD on other transplanted organs as a “significant” or “extremely significant” barrier. These technical and prognostic concerns have not been exhibited in the experiences of the three countries where cardiac DCDD has been implemented.<sup>7,9,10</sup> Further research is needed to explore the effect of cardiac DCDD on the viability of the donated heart and on other transplantable organs.

This study has several strengths. This is the first survey of healthcare providers to explore attitudes and concerns regarding cardiac DCDD and perceived ethical and practical barriers in any country. Our survey was designed according to established survey development methodology<sup>15</sup> and was rigorously pre-tested to ensure accuracy and comprehensibility. We also provided pre-tested educational content to respondents to ensure that they were informed about the three donation protocols. Finally, our sampling strategy ensured national representation of Canadian healthcare providers by accessing the member lists of key national organizations. Finally, we included healthcare providers with various professional roles in the management of deceased organ donors and transplant recipients, leading to a more inclusive description of healthcare providers’ perceptions of cardiac DCDD.

This study has several limitations. Determining an accurate response rate for a national survey where email lists were utilized is challenging. Our estimated response rates ranged from 16% to 41% but do not reflect the likely overlap in the email lists across the organizations, respondents who reported affiliation with more than one organization, or the 41 respondents who reported no affiliation with professional organizations. Nonetheless, these estimated response rates were consistent with those previously reported for non-incentivized, web-based surveys of healthcare providers.<sup>17-21</sup> The critical care nurses' association had the lowest response rate, consistent with other large-scale surveys of nurses,<sup>27,28</sup> which may reflect the email list consisting of retirees or those with changes in their career paths. Another limitation of this study is that, despite providing respondents with pre-tested educational content, we cannot rule out the possibility that respondents did not comprehend the information provided. In addition, the accuracy of respondents' self-reported professional roles cannot be ascertained. Finally, 10% of respondents in our sample reported "never" managing deceased organ donors or transplant recipients, which points to limited experience with organ donation and transplantation among some respondents.

This study provides the first insights into the attitudes and opinions of healthcare providers and the perceived barriers to implementation of cardiac DCDD in Canada. These findings provide a crucial first step towards implementation of such programs in Canada. Our approach to healthcare provider engagement can offer a model that may be employed by other countries prior to the implementation of practice changes and new innovations in organ donation and transplantation.

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