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Research Article

Adherence to guidelines for the management of donors after brain death

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ABSTRACT

Purpose: Guideline adherence for the management of a donor after brain death (DBD) is largely unknown. This study aimed to perform an importance-performance analysis of prioritized key interventions (KIs) by linking guideline adherence rates to expert consensus ratings for the management of a DBD.
Materials and methods: This observational, cross-sectional multicenter study was performed in 21 Belgian ICUs. A retrospective review of patient records of adult utilized DBDs between 2013 and 2016 used 67 KIs to describe adherence to guidelines.
Results: A total of 296 patients were included. Thirty-five of 67 KIs had a high level of adherence congruent to a high expert panel rating of importance. Nineteen of 67 KIs had a low level of adherence in spite of a high level of importance according to expert consensus. However, inadequate documentation proved an important issue, hampering true guideline adherence assessment. Adherence ranged between 3 and 100% for single KI items and on average, patients received 72% of the integrated expert panel recommended care set.
Conclusions: Guideline adherence to an expert panel predefined care set in DBD donor management proved moderate leaving substantial room for improvement. An importance-performance analysis can be used to improve implementation and documentation of guidelines.

1. Introduction

For the management of a potential donor after brain death (DBD), consensus-based guidelines, such as the recommendations of the Society of Critical Care Medicine, provide evidence-based advice aiming at improving quality of care [1]. Guidelines however are not necessarily implemented in practice [2,3]. A recent systematic review on sustainability of adherence to guidelines by medical professionals identified a limited number of studies and lack of methodological quality, hampering conclusions [4].

Compliance to guidelines for potential DBD is largely unknown and most studies have focused on brain death diagnosis. Adherence to the American Academy of Neurology (AAN) guidelines for determination of brain death, updated in 2010, proved variable [5,6]. A study in 91 countries revealed differences in perceptions and practices of brain death diagnosis worldwide. In comparison to AAN criteria, significant between-hospital variability was documented in examinations, apnea testing, necessity and type of ancillary testing, time to brain death declaration, as well as the number and minimal qualifications of physicians required for declaration [7].

Besides brain death determination, management of a potential DBD should focus through adherence to guidelines, on different other issues, including maintenance of adequate perfusion to all organ systems, early referral to the organ procurement organizations, and family support [8].

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To improve potential DBD management, key interventions (KIs) should be prioritized in order to guarantee high quality care, and impact significantly on patient, donor family, recipient or graft outcomes. However, targeting the right areas for improvement remains difficult. Focusing on all the KIs as a whole can prove burdensome and complex. An importance-performance analysis, originally a marketing research technique, can be an alternative method of prioritizing KIs by linking KI expert panel ratings of importance to the performance indicator of guideline adherence rates [9].

Hence, the aim of this study is to perform such an importance-performance analysis of predefined KIs for the management of a potential DBD by linking guideline adherence rates to expert panel ratings of importance.

2. Material and methods

2.1. Variables

Selection of KIs was based on existing guidelines [10-19], review articles [1,20-26] and process flow diagrams [27-35]. This selection of KIs was evaluated in a RAND modified three-round Delphi study, aiming at expert consensus on the importance of a KI for the management of a potential DBD. Eighteen experts within Belgium rated all the selected KIs on a 9-point Likert rating scale (score 1 indicating "strongly disagree"; score 9 "strongly agree") on the extent of contribution to quality of care. A KI was considered important with a median score of 7 or more with 75% or more of the ratings within the highest tertile (Likert score: 7–9). Out of a total of 80 KIs assessed throughout the Delphi process, 54 KIs with consensus and 14 KIs without consensus on importance after the third Delphi round were included in the importance-performance analysis. Two KIs without consensus were combined, achieving a final tally of 67 KIs. The KIs were classified into 4 core processes: (I) detection inside the ICU and notification to a transplant center (10 KIs); (II) donor evaluation and characterization (15 KIs); (III) donor management, bundled as: general care (7 KIs), monitoring (14 KIs), cardiovascular management (5 KIs), respiratory management (4 KIs), renal and electrolyte management (6 KIs), hormone substitution (4 KIs); and (IV) post procurement (3 KIs). Twelve KIs were excluded because of impossibility of objective measurement in patient records or restriction of implementation to clinical indication [36].

2.2. Study population

This observational, cross-sectional multicenter study was part of the Care Pathway for Donation after Brain Death (CP4DBD) quality improvement research project, set up by the Belgian federal government to evaluate and improve the care process and quality of care for potential DBDs (or for the donor family, recipient or graft). All 84 Belgian acute hospitals with a recognized donor coordination function were invited in June 2016 to participate through an information letter from the Director General, Department of Healthcare, Federal Public Service Health, Food Chain Safety and Environment. A local study coordinator was appointed in each participating hospital.

Patient inclusion criteria for the study consisted of (1) utilized DBD (actual donor from whom at least one organ was transplanted), (2) adults (≥18 years of age), and (3) admitted to an intensive care unit (ICU) between January 1, 2013 and December 31, 2016.

Hospital and ICU characteristics were collected at the start of the study. Patient characteristics, admission data and adherence to guidelines were recorded by retrospective review of in-hospital patient records, using a standardized data extraction form. Registration of the variable (KIs) within the patient record was assessed as "performed", "not performed" or "not measurable" (and in some cases with not applicable or not possible). Variables were reported as not performed when the patient record explicitly stated the absence of the intervention. KIs were reported as not measurable whenever information on (non-) execution of the KI was missing or ambiguous. This allowed discrimination between non-executed and non-documented variables.

2.3. Importance-performance matrix

The relationship between importance and adherence is represented by an importance-performance matrix, as used in similar research [37,38]. The KI importance dimension was defined by the expert-rating described above [36]. The performance dimension was defined by the adherence rate, measured per KI as the number of patients that received the KI (numerator)/the number of patients for whom the KI was indicated (denominator). A cut-off of 75% was defined to represent a high level of performance. Combining the importance and performance dimensions forms a matrix consisting of 4 quadrants [9]. The upper 2 quadrants represent important KIs, with high adherence (upper right) and low adherence rate (upper left). The lower 2 quadrants represent the less important KIs, with high adherence (lower right) and low adherence rate (lower left).

2.4. Statistical analysis

Continuous data are reported as mean and standard deviation (SD) or median and interquartile range (IQR), dichotomous data presented as absolute numbers and percentage. Analyses at hospital and patient level were performed in SPSS version 24.0.

2.5. Ethical approval

The study received ethical approval from the Ethical Committee of the Ghent University Hospital, Belgium (2016/1089, B670201629590) and from the Ethical Committee of each participating hospital.

3. Results

3.1. Hospital and patient characteristics

Twenty-one Belgian hospitals participated in the study, including 4 (19%) university and 17 (81%) non-university hospitals. Their number of hospital beds ranged between 235 and 1995. The number of adult ICU beds which were 24/7 functional for mechanical ventilation ranged between 6 and 94. The average number of patients per hospital included was 14.1 and ranged between 1 and 41.

Over the 4-year study period from January 1, 2013 to December 31, 2016, data from 296 DBDs (mean age 52.4 ± 16.2 years, 155 (53%) male) were retrospectively collected. This sample represented 34% of all DBDs ($n = 881$) in Belgium in the same time period [39]. The mean organs transplanted per donor (OTPD) was 3.7 ± 1.7 and 150 (51%) had ≥4 OTPD. Of the 296 ICU admissions, 195 (66%) were transferred directly from the emergency room of the same hospital and 44 (15%) directly from another hospital. Hospital and patient characteristics are summarized in Table 1.

3.2. Importance-performance analysis

The importance-performance matrix is presented in Fig. 1. Thirty-five of the 54 high level of importance KIs had a level of performance above 75% (upper right quadrant). Nineteen of the 54 high level of importance KIs were performed for <75% of the patients (upper left quadrant) and can thus be classified as high priority interventions to improve the management of a potential DBD. Eleven of these underused KIs do not achieve a threshold performance of 50%. In the lower left quadrant, 10 low priority KIs are shown with both low importance and performance. Three overused KIs were identified (lower right quadrant) with low importance and nevertheless high performance.

Table 1
Hospital and patient characteristics.

Hospital characteristics ($n = 21$)	
	Total
Hospital beds, median (IQR)	542 (451–970)
Adult ICU beds, median (IQR)	22 (13–44)
Type of hospital, n/N (%)	
University	4/21 (19%)
Non-university	17/21 (81%)
Neurosurgical facilities on site, n/N (%)	21/21 (100%)
Interventional neuroradiology facilities on site, n/N (%)	12/21 (57%)
Transplantation facilities on site, n/N (%)	5/21 (24%)
Number of included patients per hospital, n/N (%)	
<5	6/21 (29%)
5–10	4/21 (19%)
11–20	6/21 (29%)
21–30	1/21 (5%)
31–40	3/21 (14%)
41–50	1/21 (5%)

Patient characteristics ($n = 296$)	
	Total
Age (in years), mean ± SD	52.4 ± 16.2
Sex, n/N (%)	
Male	155/295 (53%)
Female	140/295 (47%)
Unknown	1
Admission source, n/N (%)	
Emergency room	195/295 (66%)
Other acute care hospital	44/295 (15%)
Operating room	35/295 (12%)
General ward	19/295 (6%)
Other	2/295 (1%)
Unknown	1
Type of admission, n/N (%)	
Medical	145/296 (49%)
Surgical: emergency	90/296 (30%)
Trauma	51/296 (17%)
Surgical: elective	9/296 (3%)
Burns	1/296 (0.3%)
Cause of death	
Anoxia/strangulation	6/296 (2%)
Cardiovascular	19/296 (6%)
Cerebral Ischemia	16/296 (5%)
Intracranial bleeding	156/296 (53%)
Suicide	7/296 (2%)
Trauma (other)	51/296 (17%)
Trauma (road accident)	18/296 (6%)
Tumor	5/296 (2%)
Other	18/296 (6%)
Organs transplanted per donor, mean ± SD (n/N)	3.7 ± 1.7 (1106/296)
% used organs of utilized donors after brain death, n/N (%)	
Kidney right	235/296 (79%)
Kidney left	234/296 (79%)
Liver	242/296 (82%)
Heart	102/296 (34%)
Lung right	132/296 (45%)
Lung left	133/296 (45%)
Pancreas	25/296 (8%)
Intestine	3/296 (1%)

SD = Standard deviation; IQR = Interquartile range.

3.3. Adherence to guidelines

Table 2 summarizes adherence and expert consensus rates for all KIs. Adherence to individual KIs varied between 100% (blood gas analysis on a regular basis) and 3% (written reporting of detection of serious adverse events). Furthermore, low adherence to high importance guidelines (upper left quadrant in the importance-performance matrix) (<50% and $N > 100$) was found for the following interventions: reviewing, if polyuria, of the medical history, urinary and blood sample to exclude secondary polyuria (14%); interviewing family and/or other relevant sources to obtain the medical and behavioral history (23%); information to the family about brain death diagnosis (28%); installation of lung protective ventilation (41%); oral hygiene every 6 h (42%); written report of the clinical examination of the potential donor (48%); and information to the family about the possibility of organ and tissue donation and the outcome of the National Register consultation (49%). None of the patients received the full care set of 54 KIs. On average, patients received 72% of recommended care. For the donor management care activities, the received recommended care was 86% for general care (4 KIs), 84% for monitoring (11 KIs), 77% for cardiovascular management (3 KIs), 42% for respiratory management (2 KIs), 74% for renal and electrolyte management (5 KIs) and 81% for hormone substitution (1 KI).

4. Discussion

The present study shows the baseline level of guideline adherence to a broad set of 67 KIs in 21 Belgian hospitals and demonstrates significant variability between individual KIs. On average, patients received 72% of the recommended care set. For the 54 KIs that were rated by experts as highly important, 35 KIs were performed for >75% of the patients. These results have no direct benchmark but seem to score better than adherence to recommended care in general, as reported by McGlynn et al. [3], in which patients received on average 55% of recommended care.

Importance-performance analysis can prove useful to hospitals to select focused, preferably high level of importance/low level of performance, care interventions to improve guideline adherence and documentation of recommended care, as an alternative to the more burdensome indiscriminate approach of implementing the whole set of recommendations. Based on the importance-performance analysis in the present study, 19 such priority KIs could be identified. For some KIs the low performance rate is likely related to under documentation. Apart from the impact of under documentation on determining true guideline adherence, documentation shortages as such may represent a quality problem in daily practice for any complex care process, in terms of coordination and continuity of care. When an intervention is not mentioned in the patient record, other healthcare providers are not aware of its performance, possibly leading to duplication of interventions.

Notification of the local donor coordinator at the time a potential DBD is detected based on defined clinical triggers is a high level of importance KI but had a performance of only 50%. However, due to inadequate documentation in up to 50% of patients, true guideline adherence is unknown. Nowadays, in many European Union member states including Belgium, donor coordinators have been appointed in hospitals with an intensive care unit, where organ retrieval from deceased donors can be considered. Donor coordinators have clearly defined responsibilities in establishing, managing and reviewing the deceased donation processes in their hospital [40]. A recent Spanish audit of the donation pathway of 1970 patients with devastating brain injury, showed that there was less family objection to organ donation when the donor coordinator participated in the interview [41]. Three consensus KIs related to the approach of the donor families, e.g., (a) bad news conversation and support, (b) information about the diagnosis of brain death, and (c) information about the possibility of organ and tissue donation and the outcome of the National Register consultation had a performance of, respectively, 58%, 28% and 49%. However, due to inadequate documentation of these three KIs in the patient records, respectively, 41%, 72%, 51%, true guideline adherence again could not be certified. Further efforts should also focus on implementation strategies in donor hospitals to improve quality of KI documentation. These specific KIs should be priorities as it is well recognized that the approach and skills of health professionals discussing organ donation are key influences on decisions made by families regarding organ donation [42].

To obtain an accurate, reliable and objective medical and behavioral history, health care professionals should perform an interview with the relatives and/or other relevant sources. In our study, the performance

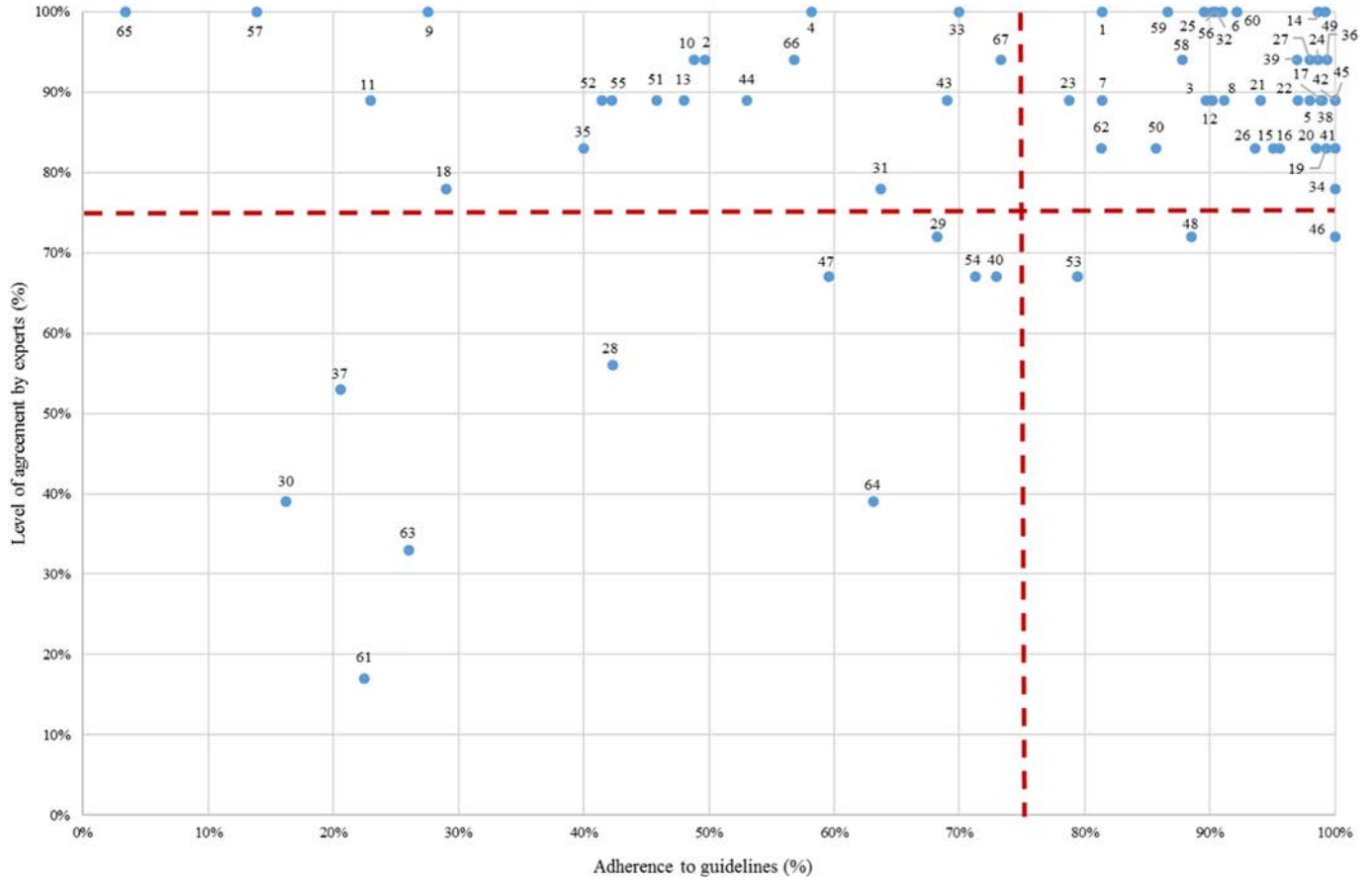

Fig. 1. Importance-performance analysis. The numbers in Fig. 1 correspond with the key interventions mentioned in Table 2. The horizontal line shows the high or low level of importance (75%), whilst the vertical line shows the high or low level of performance (75%). Upper right quadrant: good performance of high priority key interventions; upper left quadrant: bad performance of high priority key interventions; lower left quadrant: good performance of low priority key interventions; lower right quadrant: bad performance of low priority key interventions.

rate of this consensus KI was only 23%. This interview is however crucial to donor evaluation to minimize any risks associated with the transmission of diseases, together with a detailed review of the medical records, assessment of the medical and behavioral history, full clinical examination, findings of post-mortem autopsy, if performed, and laboratory tests [40]. However, due to inadequate documentation in up to 75% of patients, true guideline adherence is unknown. Another priority in donor evaluation should be the performance of the documentation of a clinical examination of the potential donor, as only 48% of the patients received this consensus KI. In our study, the performance rate of a bronchoscopy in the assessment of lung explantation was 42%, to collect samples for microbiological tests 31%, and to perform a bilateral bronchoalveolar lavage to clear mucous plugs or blood clots that may contribute to impaired oxygenation 14%. Transplant centers should primarily focus on these KIs, related to bronchoscopy, because these KIs are only performed on their request prior to referral.

Traditionally, normothermic body temperature, which may require active warming, is aimed for in DBDs. In our study two KIs, monitoring of central ("core") body temperature and using of warming mattress, blankets or warmed intravenous if hypothermia (temperature < 35 °C) had a performance of 70% and 64%, respectively. However, mild hypothermia (34 to 35 °C) after declaration of death according to neurologic criteria may lead to better allograft outcomes. In a comparison of two targeted temperature ranges (34 to 35 °C and 36.5 to 37.5 °C), hypothermia reduced the frequency of delayed graft function in kidney transplantation, defined as a requirement for dialysis during the first week after transplantation [43]. Further research is needed to determine the utility of hypothermia in this setting. Other monitoring priorities include a new 12 lead ECG for a potential heart donor in response to changes in monitored complexes (performance rate: 40%), bronchial secretion sample for microscopy and culture if secretions are present (performance rate: 69%), and hourly monitoring of urine output, for early detection of diabetes insipidus (performance rate: 53%).

In the absence of literature specific to DBD, recent guidelines have recommended to follow established advanced cardiopulmonary life support guidelines to manage arrhythmias. In particular, changes in adrenergic responses in the course of brain death predispose the potential DBD to a myriad of transient and sustained arrhythmias requiring medical management [1]. In our study, 28% of the DBDs had a tachycardia, but only 45% of these patients received treatment.

As a priority, respiratory management consists of the implementation of ventilator strategies utilizing low stretch protocols and measures to recruit atelectatic lung to enhance lung recovery [1,23,44]. The mean performance rate of a lung protective ventilation strategy in our study was 41%, with a performance rate of 36% for a minimum FiO_2 to obtain a PaO_2 between 80 and 100 mmHg, 45% for a tidal volume between 6 and 8 mL/kg, 67% for a plateau pressure < 30 cm H_2O, and 17% for a positive end expiratory pressure between 8 and 10 cm H_2O. Besides, Hua et al. recently concluded in a systematic review that oral hygiene care reduces the risk of developing ventilator-associated pneumonia from 25% to about 19%. In our study, the performance rate for oral hygiene care every 6 h was 42%, demonstrating once again room for improvement [45].

In our study, 43% of the patients had diabetes insipidus. The performance rate to review the medical history, urinary and blood sample to exclude secondary polyuria (osmotic, induced or adapted) was respectively 14%, undoubtedly an underestimation of true guideline adherence in view of inadequate documentation in up to 85% of cases.

Table 2
Adherence to the key interventions for the management of a potential donor after brain death.

Number	Intervention	Performance rate n/N (%)	Not documented n/N (%)	Expert consensus rate (%) [36]
	Detection inside the ICU and notification to a transplant center			
1	Detection of the potential donor after brain death based on defined clinical triggers.	241/296 (81%)	52/296 (18%)	100%
2	Notification to the local donor coordinator at the time these criteria are met.	147/296 (50%)	148/296 (50%)	94%
3	Assessment of the prerequisites prior to the clinical evaluation of brain death.	1871/2087 (90%) [a]	20/2087 (1%) [a]	89%
	a) Coma, irreversible, and cause known.	261/261 (100%)	0/261 (0%)	
	b) Neuroimaging compatible with coma.	258/261 (99%)	0/261 (0%)	
	c) Central nervous system depressant drug effect absent (if indicated, toxicology screen; if barbiturates given, serum level < 10 μg/mL).	249/261 (95%)	4/261 (2%)	
	d) No evidence of residual paralytics or neuromuscular blocking agents (electrical stimulation if paralytics used).	257/261 (98%)	3/261 (1%)	
	e) Absence of severe acid-base, electrolyte, and endocrine abnormality.	217/261 (83%)	1/261 (0.4%)	
	f) Normothermia or mild hypothermia (core temperature > 36 °C).	155/261 (59%)	1/261 (0.4%)	
	g) Systolic blood pressure > 100 mmHg. Vasopressors may be required.	224/261 (86%)	1/261 (0.4%)	
	h) No spontaneous respiration.	250/260 (96%)	10/260 (4%)	
4	Family approach (bad news conversation and support).	341/586 (58%) [b]	243/586 (41%) [b]	100%
	a) Delivering bad news about the hopeless, medical situation.	198/293 (68%)	95/293 (32%)	
	b) Support of the family (physician, nurse, social assistant, psychologist, pastoral service…).	143/293 (49%)	148/293 (51%)	
5	Notification of the potential donor after brain death by an ICU physician to a transplant center.	290/296 (98%)	6/296 (2%)	89%
6	Determination of brain death	808/888 (91%) [c]	75/888 (8%) [c]	100%
	a) According to the latest medical knowledge concerning the subject.	260/296 (88%)	32/296 (11%)	
	b) By three physicians.	274/296 (93%)	21/296 (7%)	
	c) Excluding those who are treating the receptor or will perform the procurement or transplantation.	274/296 (93%)	22/296 (7%)	
7	Legal declaration of death.	241/296 (81%)	31/296 (10%)	89%
8	Notification to the legal authorities if the cause of death was unknown or suspicious.	72/79 (91%)	7/79 (9%)	89%
9	Information to the family about the diagnosis of brain death.	81/294 (28%)	213/294 (72%)	100%
10	Information to the family about the possibility of organ and tissue donation and the outcome of the National Register.	286/586 (49%) [d]	298/586 (51%) [d]	94%
	a) Information to the family about the possibility of organ and tissue donation.	271/294 (92%)	23/294 (8%)	
	b) Information to the family about the outcome of the National Register.	15/292 (5%)	275/292 (94%)	
	c) Preferably in a separated conversation after family understand the diagnosis of brain death.	34/294 (12%)	258/294 (88%)	
	d) Preferably in a separated conversation after family accept the diagnosis of brain death.	33/294 (11%)	259/294 (88%)	
	Donor evaluation and characterization			
11	Interviewing family and/or other relevant sources to obtain the medical and behavioral history.	68/296 (23%)	223/296 (75%)	89%
12	Reviewing medical charts to obtain the medical and behavioral history.	267/296 (90%)	27/296 (9%)	89%
13	Clinical examination of the potential donor: written report.	142/296 (48%)	23/296 (8%)	89%
14	Blood sample.	292/296 (99%)	4/296 (1%)	100%
15	ABO and rhesus blood group or additional laboratory tests.	563/592 (95%) [e]	3/592 (1%) [e]	83%
	a) ABO and rhesus blood group.	273/296 (92%)	3/296 (1%)	
	b) Additional laboratory tests.	290/296 (98%)	0/296 (0%)	
16	Urine sample: measurement of sediment, protein & glucose.	283/296 (96%)	4/296 (1%)	83%
17	Chest X-ray: mandatory for each potential donor and to allow evaluation of a potential lung and/or heart donor.	293/296 (99%)	0/296 (0%)	89%
18	Bronchoscopy (on request of the transplant center, all the following interventions are not always necessary)	114/393 (29%) [f]	23/393 (6%) [f]	78%
	a) To allow evaluation of a potential lung donor.	57/135 (42%)	7/135 (5%)	
	b) To collect samples for microbiological tests.	39/127 (31%)	6/127 (5%)	
	c) To perform a bilateral bronchoalveolar lavage (BAL) to clear mucous plugs or blood clots that may contribute to impaired oxygenation.	18/131 (14%)	10/131 (8%)	
19	Arterial blood gas: to allow evaluation of a potential (lung) donor.	134/135 (99%)	1/135 (1%)	83%
20	Arterial blood gas after 10 min ventilation with FiO_2 100% & 5 cm H_2O PEEP: to allow evaluation of a potential lung donor.	133/135 (99%)	0/135 (0%)	83%
21	12 lead ECG: to allow (partial/initial) evaluation of a potential heart donor.	95/101 (94%)	1/101 (1%)	89%
22	Cardiac ultrasound: to allow evaluation of a potential heart donor.	99/102 (97%)	0/102 (0%)	89%
23	Coronary angiography: if cardiac ultrasound is acceptable but other comorbidities are present.	26/33 (79%)	1/33 (3%)	89%
24	Abdominal ultrasound (or CT scan): to allow evaluation of a potential liver, pancreas and/or kidney donor.	287/291 (99%)	1/291 (0%)	94%
25	Collection of the minimum data on a donor information form as requested by the transplant center for the characterization of organs and donor.	265/296 (90%)	26/296 (9%)	100%
	Donor management: general care			
26	Presence of an arterial and central venous line.	277/296 (94%)	1/296 (0.3%)	83%
27	Continuation of appropriate antibiotic therapy and other life supporting pharmacotherapy.	290/296 (98%)	0/296 (0%)	94%
28	Continuation of enteral feeding (until otherwise instructed by the transplant	11/26 (42%)	0/26 (0%)	56%

Table 2 (*continued*)

Number	Intervention	Performance rate n/N (%)	Not documented n/N (%)	Expert consensus rate (%) [36]
	center).			
29	Continuation of deep venous thrombosis prophylaxis if there were no contraindications.	73/107 (68%)	1/107 (1%)	72%
30	Prescription of low-dose dopamine with a dose of (and not exceeding) 4 μg/kg/min until the aortic clamping.	48/296 (16%)	1/296 (0.3%)	39%
	Halving the dosage or ending the infusion when circulatory adverse effects occurred in association with the dopamine infusion, such as tachycardia or a marked increase in blood pressure.	15/32 (47%)	0/32 (0%)	
31	Prevention of hypothermia.	93/146 (64%)	28/146 (19%)	78%
32	Reduction of the vasopressor dose to the minimal level to maintain hemodynamic stability.	238/263 (90%)	1/263 (0.4%)	100%
	Donor management: monitoring			
33	Monitoring of the core body temperature.	207/296 (70%)	58/296 (20%)	100%
34	ECG monitoring of heart rate.	296/296 (100%)	0/296 (0%)	78%
35	New 12 lead ECG for a potential heart donor if there are subsequent changes in monitored complexes.	6/15 (40%)	1/15 (7%)	83%
36	Invasive arterial pressure monitoring.	294/296 (99%)	1/296 (0.3%)	94%
37	Measurement of additional parameters with extended monitoring (e.g. PICCO, pulmonary artery catheter…) in case of a patient with hemodynamic instability.	14/68 (21%)	0/68 (0%)	53% [g]
38	Availability of a recent chest X-ray for a potential lung and/or heart donor.	174/176 (99%)	0/176 (0%)	89%
39	Monitoring of ventilator parameters.	287/296 (97%)	6/296 (2%)	94%
40	Assessment of cuff pressure, periodically, to check if there is no cuff leak and cuff pressure is 20–30 cm H_2O to avoid aspiration.	216/296 (73%)	35/296 (12%)	67%
41	Peripheral oxygen saturation monitoring.	296/296 (100%)	0/296 (0%)	83%
42	Blood gas analysis on a regular basis.	296/296 (100%)	0/296 (0%)	89%
43	Bronchial secretion sample for microscopy and culture if secretions are present.	167/242 (69%)	25/242 (10%)	89%
44	Monitoring of urine output (hourly).	157/296 (53%)	1/296 (0%)	89%
45	Measurement of blood electrolytes on a regular basis.	296/296 (100%)	0/296 (0%)	89%
46	Monitoring of glycemic status.	296/296 (100%)	0/296 (0%)	72%
	Donor management: cardiovascular management			
47	Treatment of hypertension related to "adrenergic storm" of severe degree (MAP >120 mmHg) and prolonged (> 30 to 60 min) with calcium entry blockers or short-acting cardioselective beta-blockers.	53/89 (60%)	0/89 (0%)	67%
48	No prescription of hydroxyethyl starch (HES) for intravascular volume replacement.	247/279 (89%)	1/279 (0.4%)	72%
49	Prescription of vasoactive drugs when correction of the volume deficit fails to achieve the threshold hemodynamic goals.	263/265 (99%)	0/265 (0%)	100%
50	Treatment of bradycardia causing hemodynamic instability with a short acting β-adrenergic agonist (epinephrine/dopamine/dobutamine/isoprenaline) or occasionally transvenous pacing.	6/7 (86%)	0/7 (0%)	83%
51	Treatment of tachycardia.	38/83 (46%)	0/83 (0%)	89%
	Donor management: respiratory management			
52	Installation of a lung protective ventilation.	491/1184 (41%) [h]	148/1184 (13%) [h]	89%
	a) Minimum FiO_2 to obtain a PaO_2 between 80 and 100 mmHg.	107/296 (36%)	1/296 (0.3%)	
	b) Tidal volume (Vt): 6–8 mL/kg (ideal body weight).	134/296 (45%)	45/296 (15%)	
	c) Plateau pressure: < 30 cm H_2O.	199/296 (67%)	93/296 (31%)	
	d) PEEP (Positive End Expiratory Pressure): 8–10 cm H_2O.	51/296 (17%)	9/296 (3%)	
53	Intermittent nasopharyngeal suction.	235/296 (79%)	42/296 (14%)	67%
54	Intermittent tracheal suction.	211/296 (71%)	44/296 (15%)	67%
55	Oral hygiene every 6 h.	125/296 (42%)	29/296 (10%)	89%
	Donor management: renal and electrolyte management			
56	If oliguria, no prescription of diuretic after treating of hypovolemia, hypotension and cardiac dysfunction.	83/92 (90%)	1/295 (0.3%)	100%
57	If diabetes insipidus, reviewing of the medical history, urinary and blood sample to exclude secondary polyuria.	18/130 (14%)	111/130 (85%)	100%
58	If diabetes insipidus, adequate diagnose of diabetes insipidus.	115/131 (88%)	1/131 (1%)	94%
59	If diabetes insipidus, treatment of diabetes insipidus with sufficient fluid volume replacement to compensate polyuria and anti-diuretic hormone replacement.	110/127 (87%)	0/127 (0%)	100%
60	Treatment of electrolyte disturbances.	176/191 (92%)	1/191 (1%)	100%
	Donor management: hormone substitution			
61	Prescription of hydrocortisone to reduce the cumulative dose and administration duration of vasopressors.	60/267 (22%)	1/267 (0.4%)	17%
62	Appropriate prescription of insulin if treating hyperglycemia to achieve a target glucose level of 180 mg/dL or less.	187/230 (81%)	0/230 (0%)	83%
63	Prescription of methylprednisolone (250 mg bolus +100 mg/h until recovery of organs) for a potential liver donor.	63/242 (26%)	0/242 (0%)	33%
64	Thyroid replacement therapy for hemodynamically unstable donors or for potential hearts donors with abnormal (<45%) left ventricular ejection fraction.	12/19 (63%)	2/19 (11%)	39%

(*continued on next page*)

Table 2 (*continued*)

Number	Intervention	Performance rate n/N (%)	Not documented n/N (%)	Expert consensus rate (%) [36]
	Post procurement			
65	Written report that detection of serious adverse events was performed.	10/296 (3%)	19/296 (6%)	100%
	If a serious adverse event was detected, registration and reporting to the transplant center.	5/6 (83%)	1/6 (17%)	
66	Debriefing about the results of the transplantation.	663/1167 (57%) [i]	361/1167 (31%) [i]	94%
	a) The relatives	182/283 (64%)	96/283 (34%)	
	b) The health care professionals	178/296 (60%)	96/296 (32%)	
	c) The primary care physician	98/296 (70%)	82/296 (28%)	
67	Exclusion of any medical, pharmaceutical or hospital costs after the determination of brain death and legal declaration of death on the hospitalization invoice.	217/296 (73%)	27//296 (9%)	94%

[a] 3 = 3a + 3b + 3c + 3d + 3e + 3f + 3 g + 3 h.
[b] 4 = 4a + 4b.
[c] 6 = 6a + 6b + 6c.
[d] 10 = 10a + 10b.
[e] 15 = 15a + 15b.
[f] 18 = 18a + 18b + 18c.
[g] Mean results of 2 key interventions.
[h] 52 = 52a + 52b + 52c + 52d.
[i] 66 = 66a + 66b + 66c.

To conclude, three post procurement KIs should be prioritized based on our importance-performance analysis. These interventions are expected to fall under the responsibility of a well-trained donor coordinator on the ICU. The performance rate of a written report on detection of serious adverse events was only 3%, debriefing about the results of the transplantation to the relatives, health care professionals and primary care physician 57%, and ensuring that the hospitalization invoice of the patient is excluded of any medical, pharmaceutical or hospital costs after the determination of brain death and legal declaration of death 73%.

A first limitation of the study consists of possible selection bias, as only the utilized DBDs are included. Hospitals without utilized but with potential DBDs could not participate in the study. Besides, potential DBDs lost along the organ donation pathway were not included in the dataset, but could also provide useful information. Resource and time constraints excluded a detailed chart review of all deceased ICU patients in participating hospitals. Second, an inclusion criterion on hospital level to participate in the study was the willingness to develop and implement a care pathway for donation after brain death after the study. This may bias selection of participating hospitals towards those with already present intrinsic motivation towards standardizing care and management of potential DBD. A final and major limitation consists of the frequent underestimation of the true guideline adherence as analysis was restricted to information available in the patient records with obvious suboptimal clinical documentation. This however can be considered as a major finding in itself.

To our knowledge, this is the first audit evaluating clinical practice in the entire donation pathway. The main novelty resides in the use of an importance-performance analysis as an approach for prioritizing interventions in improving quality of care for potential DBDs. The participating hospitals in this CP4DBD quality improvement research project received a detailed report with the guidelines upon which these KIs were based, together with feedback on actual organization of the care process. In addition, all participating hospitals received training on care pathway development and implementation. An evidence-based care pathway and this benchmarking approach in donor hospitals can be used as a method to reduce clinical variability and improve both documentation as well as adherence [46-48]. Documentation, monitoring, and evaluation of variances and outcomes are one of the essential components of a care pathway [49]. The introduction of a checklist can be a useful tool to support this and to address the proven documentation need in the donation pathway. Growing evidence in several areas of healthcare has supported the introduction of such tools in clinical practice [50-52].

In conclusion, guideline adherence to an expert panel predefined care set in DBD donor management proved moderate with substantial room for improvement. These findings underscore the need for a strategy to improve implementation and documentation of evidence-based guidelines, for which an importance-performance analysis may prove useful.

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Conflicts of interest

None of the authors have any conflicts of interest to declare.

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References

[1] Kotloff RM, Blosser S, Fulda GJ, Malinoski D, Ahya VN, Angel L, et al. Management of the potential organ donor in the ICU: Society of Critical Care Medicine/American

College of Chest Physicians/Association of Organ Procurement Organizations consensus statement. Crit Care Med 2015;43(6):1291–325.
[2] Grimshaw J, Eccles M, Tetroe J. Implementing clinical guidelines: Current evidence and future implications. J Contin Educ Health Prof 2004;24(Suppl. 1):S31–7.
[3] McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, Decristofaro A, et al. The quality of health care delivered to adults in the United States. N Engl J Med 2003;348(26):2635–45.
[4] Ament SM, de Groot JJ, Maessen JM, Dirksen CD, van der Weijden T, Kleijnen J. Sustainability of professionals' adherence to clinical practice guidelines in medical care: a systematic review. BMJ Open 2015;5(12):e008073.
[5] Wang HH, Varelas PN, Henderson GV, Wijdicks EF, Greer DM. Improving uniformity in brain death determination policies over time. Neurology 2017;88(6):562–8.
[6] Shappell CN, Frank JI, Husari K, Sanchez M, Goldenberg F, Ardelt A. Practice variability in brain death determination: A call to action. Neurology 2013;81(23):2009–14.
[7] Wahlster S, Wijdicks EF, Patel PV, Greer DM, Hemphill 3rd JC, Carone M, et al. Brain death declaration: Practices and perceptions worldwide. Neurology 2015;84(18):1870–9.
[8] Ellis M, Sally M, Malinoski D. The development and current status of Intensive Care Unit management of prospective organ donors. Indian J Urol 2016;32(3):178–85.
[9] Martilla JA, James JC. Importance-Performance Analysis. J Market 1977;41(1):77–9.
[10] European Directorate for the Quality of Medicines & Healthcare. Guide to the quality and safety of organs for transplantation. https://www.edqm.eu/en/organ-tissues-cells-transplantation-guides-1607.html; 2013, Accessed date: 12 July 2018.
[11] Eurotransplant. Eurotransplant manual: The donor. http://www.eurotransplant.org/cms/mediaobject.php?file=H9+The+Donor_June+20151.pdf; 2015, Accessed date: 12 July 2018.
[12] Karam G, Kälble T, Alcaraz A, Aki FT, Budde K, Humke U, et al. Guidelines on renal transplantation. http://uroweb.org/guideline/renal-transplantation/#; 2014, Accessed date: 12 July 2018.
[13] National Institute for Health and Clinical Excellence. Organ donation for transplantation: Improving donor identification and consent rates for deceased organ donation, http://guidance.nice.org.uk/CG135; 2011 [accessed 12 July 2018].
[14] National Institute for Health and Clinical Excellence. Organ donation for transplantation: Evidence update January 2014. http://www.nice.org.uk/guidance/cg135/evidence/cg135-organ-donation-evidence-update2; 2014, Accessed date: 12 July 2018.
[15] European Renal Best Practice Transplantation Guideline Development Group. ERBP guideline on the management and evaluation of the kidney donor and recipient. Nephrol Dial Transplant 2013;28(Suppl. 2) (ii1–71).
[16] Kotton CN, Kumar D, Caliendo AM, Asberg A, Chou S, Danziger-Isakov L, et al. Updated international consensus guidelines on the management of cytomegalovirus in solid-organ transplantation. Transplantation 2013;96(4):333–60.
[17] Seem DL, Lee I, Umscheid CA, Kuehnert MJ. PHS guideline for reducing human immunodeficiency virus, hepatitis B virus, and hepatitis C virus transmission through organ transplantation. Public Health Rep 2013;128(4):247–343.
[18] Westphal GA, Caldeira Filho M, Fiorelli A, Vieira KD, Zaclikevis V, Bartz M, et al. Guidelines for maintenance of adult patients with brain death and potential for multiple organ donations. Transplant Proc 2012;44(8):2260–7.
[19] Wijdicks EFM, Varelas PN, Gronseth GS, Greer DM. Evidence-based guideline update: determining brain death in adults. Neurology 2010;74(23):1911–8.
[20] Van Raemdonck D, Neyrinck A, Verleden GM, Dupont L, Coosemans W, Decaluwe H, et al. Lung donor selection and management. Proc Am Thorac Soc 2009;6(1):28–38.
[21] McKeown DW, Ball J. Treating the donor. Curr Opin Organ Transplant 2014;19(2):85–91.
[22] Sally M, Malinoski D. Current research on organ donor management. Anesthesiol Clin 2013;31(4):737–48.
[23] Rech TH, Moraes RB, Crispim D, Czepielewski MA, Leitao CB. Management of the brain-dead organ donor: a systematic review and meta-analysis. Transplantation 2013;95(7):966–74.
[24] Dikdan GS, Mora-Esteves C, Koneru B. Review of randomized clinical trials of donor management and organ preservation in deceased donors: opportunities and issues. Transplantation 2012;94(5):425–41.
[25] Dare AJ, Bartlett AS, Fraser JF. Critical care of the potential organ donor. Curr Neurol Neurosci Rep 2012;12(4):456–65.
[26] Youn TS, Greer DM. Brain death and management of a potential organ donor in the intensive care unit. Crit Care Clin 2014;30(4):813–31.
[27] Map of Medicine. Consent/authorisation for donation after brain-stem death (adult). https://nhsbtmediaservices.blob.core.windows.net/organ-donation-assets/pdfs/Consent_and_Authorisation.pdf; 2010, Accessed date: 12 July 2018.
[28] Map of Medicine. Management of brain-stem dead donor (adult). http://nhsbtmediaservices.blob.core.windows.net/organ-donation-assets/pdfs/Management_of_brain_stem_dead_donor.pdf; 2010, Accessed date: 12 July 2018.
[29] Map of Medicine. Neurological determination of death - testing (adult). https://nhsbtmediaservices.blob.core.windows.net/organ-donation-assets/pdfs/Neurological_Determination_of_Death_Testing.pdf; 2010, Accessed date: 12 July 2018.
[30] Map of Medicine. Assessment for donation after brain-stem death (adult). https://nhsbtmediaservices.blob.core.windows.net/organ-donation-assets/pdfs/Assessment_Donation_After_Brainstem_Death.pdf; 2012, Accessed date: 12 July 2018.
[31] Map of Medicine. Donor identification in emergency medicine. https://nhsbtmediaservices.blob.core.windows.net/organ-donation-assets/pdfs/Donor_Identification_Emergency_Medicine.pdf; 2012, Accessed date: 12 July 2018.
[32] Map of Medicine. Neurological determination of death - assessment and planning (adult). https://nhsbtmediaservices.blob.core.windows.net/organ-donation-assets/pdfs/Neurological_Determination_of_Death_Assessment.pdf; 2010, Accessed date: 12 July 2018.
[33] National Institute for Health and Clinical Excellence. Organ donation for transplantation: Discussions with those close to the patient. http://pathways.nice.org.uk/pathways/organ-donation-for-transplantation/organ-donation-for-transplantation-discussions-with-those-close-to-the-patient.pdf; 2014, Accessed date: 12 July 2018.
[34] National Institute for Health and Clinical Excellence. Organ donation for transplantation: Early identification of potential organ donors. http://pathways.nice.org.uk/pathways/organ-donation-for-transplantation/organ-donation-for-transplantation-early-identification-of-potential-organ-donors.pdf; 2014, Accessed date: 12 July 2018.
[35] National Institute for Health and Clinical Excellence. Organ donation for transplantation: Organisation and policy. http://pathways.nice.org.uk/pathways/organ-donation-for-transplantation/organ-donation-for-transplantation-organisation-and-policy.pdf; 2014, Accessed date: 12 July 2018.
[36] Hoste P, Hoste E, Ferdinande P, Vandewoude K, Vogelaers D, Van Hecke A, et al. Development of key interventions and quality indicators for the management of an adult potential donor after brain death: a RAND modified Delphi approach. BMC Health Serv Res 2018;18(1):580.
[37] Seys D, Bruyneel L, Decramer M, Lodewijckx C, Panella M, Sermeus W, et al. An international study of adherence to guidelines for patients hospitalised with a COPD exacerbation. COPD 2017;14(2):156–63.
[38] van Zelm R, Coeckelberghs E, Sermeus W, De Buck van Overstraeten A, Weimann A, Seys D, et al. Variation in care for surgical patients with colorectal cancer: protocol adherence in 12 European hospitals. Int J Colorectal Dis 2017;32(10):1471–8.
[39] Eurotransplant International Foundation. Statistics report library. http://statistics.eurotransplant.org, Accessed date: 12 July 2018.
[40] European Directorate for the Quality of Medicines & Healthcare. Guide to the Quality and Safety of Organs for Transplantation. https://www.edqm.eu/en/organ-tissues-cells-transplantation-guides-1607.html; 2016, Accessed date: 12 July 2018.
[41] Dominguez-Gil B, Coll E, Elizalde J, Herrero JE, Pont T, Quindos B, et al. Expanding the donor pool through intensive care to facilitate organ donation: Results of a Spanish Multicenter Study. Transplantation 2017;101(8):e265–72.
[42] Souter MJ, Blissitt PA, Blosser S, Bonomo J, Greer D, Jichici D, et al. Recommendations for the critical care management of devastating brain injury: prognostication, psychosocial, and ethical management: A position statement for healthcare professionals from the Neurocritical Care Society. Neurocrit Care 2015;23(1):4–13.
[43] Niemann CU, Feiner J, Swain S, Bunting S, Friedman M, Crutchfield M, et al. Therapeutic hypothermia in deceased organ donors and kidney-graft function. N Engl J Med 2015;373(5):405–14.
[44] Mascia L, Pasero D, Slutsky AS, Arguis MJ, Berardino M, Grasso S, et al. Effect of a lung protective strategy for organ donors on eligibility and availability of lungs for transplantation: a randomized controlled trial. JAMA 2010;304(23):2620–7.
[45] Hua F, Xie H, Worthington HV, Furness S, Zhang Q, Li C. Oral hygiene care for critically ill patients to prevent ventilator-associated pneumonia. Cochrane Database Syst Rev 2016;10 Cd008367.
[46] Campbell H, Hotchkiss R, Bradshaw N, Porteous M. Integrated care pathways. BMJ 1998;316(7125):133–7.
[47] Panella M, Marchisio S, Di Stanislao F. Reducing clinical variations with clinical pathways: do pathways work? International J Qual Health Care 2003;15(6):509–21.
[48] Rotter T, Kinsman L, James E, Machotta A, Gothe H, Willis J, et al. Clinical pathways: effects on professional practice, patient outcomes, length of stay and hospital costs. Cochrane Database Syst Rev 2010;3:CD006632.
[49] Vanhaecht K, Panella M, van Zelm R, Sermeus W. An overview on the history and concept of care pathways as complex interventions. Int J Care Pathw 2010;14(3):117–23.
[50] Blot K, Bergs J, Vogelaers D, Blot S, Vandijck D. Prevention of central line-associated bloodstream infections through quality improvement interventions: a systematic review and meta-analysis. Clin Infect Dis 2014;59(1):96–105.
[51] Haynes AB, Weiser TG, Berry WR, Lipsitz SR, Breizat AH, Dellinger EP, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. N Engl J Med 2009;360(5):491–9.
[52] de Vries EN, Prins HA, Crolla RM, den Outer AJ, van Andel G, van Helden SH, et al. Effect of a comprehensive surgical safety system on patient outcomes. N Engl J Med 2010;363(20):1928–37.