Physiology and Vital Signs after Removal of Life Sustaining Therapy

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University of Ottawa

Canadian Critical Care Forum, 2014
Disclosures
DCD Implementation in Canada

Deceased donation in Canada by donor type
2006-2012

DCD Donors by Province

British Columbia
Alberta
Ontario
Quebec
Nova Scotia


0 50 100 150 200 250 300 350 400 450 500 550 600 650 700

DCD
NDD

Courtesy of Karen Hornby, CBS
Dead Enough

EPISODE SYNOPSIS: It’s a question you might think medical science would have answered long ago – when are you dead?
Donation after Circulatory Death

Supported by most professionals and public
AND SAVES LIVES

Still discomfort and controversy

• 1. death determination criteria
• 2. cessation of function and irreversibility
• 3. autoresuscitation

Dead donor Rule
Variability in the Determination of Death After Cardiac Arrest: A Review of Guidelines and Statements

Sonny Dhanani, MD, FRCPC\textsuperscript{1,3}, Laura Hornby, MSc\textsuperscript{2,3}, Roxanne Ward, RN, BA (Psy)\textsuperscript{3,4}, and Sam Shemie, MD, FRCPC\textsuperscript{5,6}

Abstract
Introduction: The reemergence of organ donation after circulatory determination of death (DCDD) in Canada demands the

Survey of determination of death after cardiac arrest by intensive care physicians*

Sonny Dhanani, MD, FRCPC; Roxanne Ward, RN, BA (Psy); Laura Hornby, MSc; Nicholas J. Barrowman, PhD; Karen Hornby, BScN, MSc; Sam D. Shemie, MD, FRCPC; for the Canadian Critical Care Trials Group, and the Bertram Loeb Research Consortium in Organ and Tissue Donation

Objective: The controversy regarding death determination in the context of organ donation after cardiocirculatory death requires in-

No diagnostic test/procedure was uniformly performed or omitted. Sixty-five percent of respondents believed autoresuscitation exists
Spontaneous, Unassisted Resumption of Circulation after Cessation of Failed CPR


*no numerical time given

# reported 33 minutes, discovered during transport to morgue
reported to occur from a few seconds to 33 minutes

**No AR in adults or children if no CPR**

did not occur beyond **7 minutes** after cessation of failed CPR (from cases with monitoring and exact times documented)
Vital Signs After Cardiac Arrest Following Withdrawal of Life-Sustaining Therapy: A Multicenter Prospective Observational Study

Sonny Dhanani, MD1,2,3; Laura Hornby, MSc4,5; Roxanne Ward, BScN, MSc1,2; Andrew Baker, MD6,7; Peter Dodek, MD8,9; Jane Chamber-Evans, BScN, MSc4,10,11; Rob Fowler, MDCM7,12; Jan O. Friedrich, MD6,7; Robert M. Gow, MBBS2,3,13; Demetrios J. Kutsogiannis, MD14,15; Lauralyn McIntyre, MD16,17,18,19; Franco Momoli, PhD18,19,20; Karine Morin, LLM21; Tim Ramsay, PhD18,19; Damon Scales, MD7,12; Hilary Writer, MD1,2,3; Serafettin Yildirim, BMgmt22; Bryan Young, MD23,24; Sam Shemie, MD4,25,26; on behalf of the Canadian Critical Care Trials Group and in collaboration with the Bertram Loeb Chair and Research Consortium in Organ and Tissue Donation
Monitoring after WLST

consent to WLST  consent to study

WLST  death declaration  study end

30 mins

Waveform Analysis
• 85% subjects were mechanically
• 80% subjects were receiving sedation/analgesia
• 34% of subjects were receiving vasopressors
• Of those mechanically ventilated, 62% were extubated at or shortly after withdrawal of life-sustaining therapies and the others remained intubated.

• 80% subjects had sedation/analgesia continued or added after withdrawal of life-sustaining therapies

• All subjects died and clinically observed autoresuscitation was not reported within the study sample.

• The median time from withdrawal of life-sustaining therapies to clinical declaration of death was 60 minutes (range, 11-2960 minutes).
Did we achieve our Primary Objective?

• **Feasibility**
  - Recruitment – 91% (41/45) of patients enrolled
  - Consent rate – 87%
  - Protocol compliance – 76%

Prospective, observational study of vital sign waveform data for 30 minutes after clinical determination of death
Example 1

Limitations
**Description of monitored activity after WLST**

**ECG and ABP activity**

- Any form of activity was documented, regardless of scale, quantity, quality, or clinical relevance
- At times, difficult to interpret artifact, activity, and meaningful activity
- Focus on “activity” versus “function”
ECG activity

- In 3/33 patients, ABP and ECG activity stopped at the same time.

- In 5 patients, ECG persisted, intermittently, after absence of ABP activity.
  - Median of 11 minutes 11 seconds (range, 37 seconds - 36 minutes 29 seconds) after absence of ABP activity.

- In 25 patients, ECG persisted, continuously, after absence of ABP activity.
  - Median of 3 minutes 10 seconds (range 0 - 38 minutes) after absence of ABP activity.
(a) At 13:07:50, change in waveform activity: possible cessation of all activity with artifact, or possible true cessation of waveform activity.

(b) At 13:09:40, electrocardiogram and arterial blood pressure activity cessation, with electroencephalogram artifact.
(c) At 13:10:40, electrocardiogram and arterial blood pressure activity resumption after 60 seconds of absence, with electroencephalogram artifact. Variable electrical rhythm on electrocardiogram and negligible systolic and pulse pressures on arterial blood pressure.

(d) electrocardiogram and arterial blood pressure activity cessation at 13:11:10, with electroencephalogram artifact.
6 episodes of ABP activity after absence of ≥60s

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<tr>
<th>Case</th>
<th>Absent</th>
<th>Activity</th>
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<tbody>
<tr>
<td>Case 1</td>
<td>62</td>
<td>172</td>
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<td>Case 2</td>
<td>79</td>
<td>20</td>
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<td>Case 3</td>
<td>80</td>
<td>1</td>
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<td>Case 4</td>
<td>60</td>
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Absence for minimum of 60 seconds

Absence continues until end of monitoring
ABP activity

- 30/33 patients had absence of ABP prior to absence of ECG activity (3 at the same time) without recurrence of activity

- 4 patients had identification of ABP activity after absence of > 60 seconds
  - Within 2 minutes
  - Short duration
  - Low amplitude
Two recordings showed a salvo of 5 to 20 heartbeats 1.23 and 6 minutes after asystole, followed by EKG silence.

An arterial catheter in two of these patients did not record measurable tracings during the cardiac activity.
International guideline development for the determination of death.

Shemie SD, Hornby L, Baker A, Teitelbaum J, Torrance S, Young K, Capron AM, Bernat JL, Noel L; The International Guidelines for Determination of Death phase 1 participants, in collaboration with the World Health Organization

'the permanent loss of capacity for consciousness and all brainstem functions, as a consequence of permanent cessation of circulation or catastrophic brain injury'.
**EEG Activity**

- All 4 patients had EEG findings consistent with coma at the time of WLST.

- In 3 patients, isoelectric EEG occurred prior to cessation of ECG and ABP. No return of EEG activity was noted.

- In one patient, delta and theta waveform bursts on EEG persisted following the cessation of both ECG and ABP.
Example 3

- EEG
- ABP
- EKG

Time from WLST (HH:MM:SS)
The EEG became isoelectric 17 minutes after WLST

Example 3
ECG and ABP stopped at 21 minutes following WLST.

At 22 minutes and 25 seconds after WLST this patient had return of ECG and ABP for 40 seconds, however, the EEG remained isoelectric during
Activity versus Function?

- EEG
- ABP
- EKG

Time from WLST (HH:MM:SS)

Scoping review the scientific literature regarding the relationship between brain activity and function and arrest of systemic circulation, with the purpose of describing human neurophysiology during the dying process.

Preliminary Results: 860 citations reviewed, 19 articles to be included
Timing of Loss of Consciousness (exhaustion of oxygen stores) and EEG Changes Following Arrest of Circulation in Humans and Animals

**Losasso 1992**
(case report-1 person) developed diffuse EEG slowing and suppression within 10-20 s after asystole

**Rossen et al., 1943**
n=137 males
Average time of 6.8 s from arrest of cerebral circulation to loss of consciousness,

**Moss and Rockoff, 1980** (case report- 1 person)
During 27 sec period of ventricular asystole, cerebral electrical activity lost within 15 s

**Stertz et al., 1991, (n= 37 dogs), VF & Hossmann 1988, (n= 143 cats), CI**
EEG isoelectric within 15 s

**Steen et al., 1985, (n=10 monkeys)**
EEG isoelectric after 15±3 s

**Hosmann and Kleihues, 1973**
(n=200 cats, 21 monkeys) EEG became isoelectric within 20 s following cerebral ischemia

**Moss and Rockoff, 1980** (case report- 1 person)
EEG isoelectric within 15 s

**Bircher et al., 1982**
(n=6 dogs)
Time to EEG silence as 26(5) (20-30) s

**Clute and Levy 1990**
n= 10 pts
After brief cardiac arrest, the mean time to EEG changes* was 10.2 (0.4)SEM (3.3-21.1 )s

**Lind et al., 1975**
(review article)
Cerebral ischemia led to an isoelectric electroencephalogram with a mean time of 37 (26-44)s
Surges of electroencephalogram activity at the time of death: a case series.
Chawla 2009
• 7 pts
• In each case, loss of blood pressure, as monitored by indwelling arterial line, was followed by a decline in BIS= PSI activity
• followed by a transient spike in BIS/PSI activity that approached levels normally associated with consciousness. This spike in electroencephalogram (EEG) activity had short duration and the activity then declined to a level of activity associated with burst suppression.

Processed electroencephalogram during donation after cardiac death.
Auyong 2010
• 3pts
• BIS showed considerable changes traditionally associated with anesthesia immediately after withdrawal of care.
Bedside staff and patient families had minimal objections to research during the dying process, resulting in high recruitment and consent rates.

Prospective collection of ECG, ABP and EEG data during the dying process is possible.

Lessons learned:
- Artifact, activity, and meaningful activity
- Definitions of cessation, resumption, and autoresuscitation
- Standard electronic platform for data capture and review
Future study needed...

- ECG may persist well beyond ABP cessation

- ABP activity may resume after cessation
  - Within 2 minutes
  - Short duration
  - Low amplitude

- EEG may cease minutes before cessation of ABP

- Pilot study findings support current DCD practices
Death Prediction and Physiology after Removal of Therapy

500 patients
13 Canadian sites
# DePPaRT

**Collaborators/Co-investigators**

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<th>CZECH REP</th>
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Why is this important?

Further study is needed...and possible

No evidence that current DCD standards are unsafe

Transplant saves lives
# Organs Transplanted from Ontario DCD Donors

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<tr>
<th>ORGAN</th>
<th>TRANSPPLANTED ORGAN COUNT*</th>
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<td>Kidney-Both</td>
<td>11</td>
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<tr>
<td>Kidney-Left</td>
<td>264</td>
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<td>Kidney-Right</td>
<td>256</td>
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<td>Liver</td>
<td>112</td>
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<td>Lung Both</td>
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<td>Lung-Left</td>
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<td>Lung-Right</td>
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<td>Pancreas-Whole</td>
<td>20</td>
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<td><strong>Total</strong></td>
<td><strong>732</strong></td>
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*Includes accepted out of province offers

June 1, 2006 – June 30, 2014
"elucidate the natural history of cessation of physiological function after the removal of life support in those expected to die."

When is dead, dead?

Objective research can inform the discussion about “death” with descriptive physiologic data