Autoresuscitation after Cardiac Arrest

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Affiliations

- CHEO
- Canadian National Transplant Research Program
- Canadian Blood Services
- Gift of Life Don de vie
Acknowledgements

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**Determination of Death Practices in Intensive Care Research Program**
A story
What is it?

Does autoresuscitation actually exist?

What is the impact on donation?

How are we looking for these answers?
Irreversibility

Point in time when the heart and circulation stops and...

Can not

Will not

Would not
Autoresuscitation
• Return of spontaneous circulation following cardiac arrest (Bernat, 2006)

Lazarus Phenomenon
• Return of spontaneous circulation (ROSC) following discontinuation of CPR (Linko, 1982)
Autoresuscitation or Lazarus phenomenon?
Spontaneous Resumption of Circulation

A. Never seen it myself
B. Have seen it once myself
C. Have seen it more than once myself
D. Have heard reports of others who have seen it
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 circulatory death requires investigation. No diagnostic test/procedure was uniformly performed or omitted. Sixty-five percent of respondents believed autorevivification exists.

1. Variability in practice
2. Perceptions of autorevivification
3. Need for further work
Timeline of Autoresuscitation Studies

**Levels of monitoring:**
- **a:** arterial line monitoring and continuous EKG and observation
- **b:** continuous ECG monitoring with constant observation
- **c:** not continuously monitored

**Legend:**
- **RED** = Autoresuscitation, no CPR
- **GREEN** = “Lazarus Phenomenon”, i.e. auto-resuscitation following discontinuation of CPR
- **ORANGE** = does not fit clearly into either category

**Timing:**
- ≤65 sec
- 5 min
- 6 min
- 7 min
- 8 min
- 10 min
- 15 min
- 20 min

**Cases:**
- **108 cases**
  - Stroud, 1948
  - Willius, 1924
  - Robinson 1912
  - Enselberg, 1952
  - Rodstein & Bornstein, 1970

- **1 case**
  - Weise et al., 2007

- **2 cases**
  - Klockgether et al., 1987
  - Ben-David et al., 2001

- **3 cases**
  - Kamaraiinen, 2007
  - Skulberg, 1991
  - Rogers et al., 1991

- **2 cases**
  - Linko et al., 1982
  - Maeda et al., 2002

- **3 cases**
  - Frolich 1998
  - Maleck et al., 1998
  - Letellier et al., 1982
  - MacGillvray, 1999
  - Abdullah, 2001
  - Skulberg (2), 1991
  - Bray, 1993

- **1 case**
  - Voelckel & Kroesen, 1996

- **1 case**
  - Quick & Bastani, 1994

- **2 cases**
  - Kamaraiinen, 2007
  - Skulberg, 1991

- **3 cases**
  - Frolich 1998
  - Maleck et al., 1998
  - Letellier et al., 1982
  - MacGillvray, 1999
  - Abdullah, 2001
  - Skulberg (2), 1991
  - Bray, 1993

**Notes:**
- * = prehospital arrest, no monitoring at time of cardiac arrest
A systematic review of autoresuscitation after cardiac arrest

K. Hornby, MSc; L. Hornby, MSc; S. D. Shemie, MD

Objective: There is a lack of consensus on how long circulation must cease for death to be determined after cardiac arrest. The ranging from a few seconds to 33 mins; however, continuity of observation and methods of monitoring were highly inconsistent.

- No autoresuscitation without CPR
- Lazarus after failed CPR up to 7 minutes
- No reports in children
- Only case reports, no prospective monitoring

Hornby K et al CCM 2010
ILLUSTRATIVE CASE

A Pediatric Case of Autoresuscitation

Justin T. Tretter, MD, Galna S. Radunsky, DO, Daniel J. Rogers, MD, and Louis E. Daugherty, MD

Abstract: Autoresuscitation (the Larazarus phenomenon) after cessation of cardiopulmonary resuscitation has been systematically reviewed in the adult literature, with only 3 reported cases in pediatrics, although its mechanism remains unclear. We describe a pediatric case of comparatively delayed autoresuscitation with survival far surpassing previously reported pediatric cases.
So far, 38 cases of delayed return of spontaneous circulation have been published in medical literature.\(^\text{1}\) The majority of the articles dealing with this phenomenon were published in journals of anaesthesia and resuscitation.

**Table 3.** Role of true cardiopulmonary arrest in the aetiology of the Lazarus Phenomenon.

<table>
<thead>
<tr>
<th>Role</th>
<th>Aetiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>True cardiopulmonary arrest</td>
<td>PEEP</td>
</tr>
<tr>
<td></td>
<td>Myocardial reperfusion</td>
</tr>
<tr>
<td></td>
<td>Myocardial stunning</td>
</tr>
<tr>
<td></td>
<td>Alkalosis</td>
</tr>
<tr>
<td></td>
<td>Hypothermia</td>
</tr>
<tr>
<td></td>
<td>Hyperkalaemia</td>
</tr>
<tr>
<td></td>
<td>Q-T syndrome</td>
</tr>
<tr>
<td></td>
<td>Transient asystole</td>
</tr>
<tr>
<td></td>
<td>Cardiomyopathy</td>
</tr>
<tr>
<td>Other factors (physician</td>
<td>Minimal vital signs</td>
</tr>
<tr>
<td>oversight/inexperience)</td>
<td>Delayed action of drugs</td>
</tr>
</tbody>
</table>

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Trust ... depends on clear parameters of practice of determination of death

Fundamental Principle

DEAD DONOR RULE

1. Must be dead before donation
2. Donation process can’t cause or expedite death
Dead Enough

EPISODE SYNOPSIS: It’s a question you might think medical science would have answered long ago – when are you dead?
Autoresuscitation after asystole in patients being considered for organ donation*

Kevin N. Sheth, MD; Tyree Nutter, RN, BSN, MA; Deborah M. Stein, MD, MPH, FCCM; Thomas M. Scalea, MD; James L. Bernat, MD

extubation to death was 22 mins. No patients exhibited autoresuscitation during the 5-min waiting observation period, including the first 2 mins after asystole.

Conclusions: The absence of autoresuscitation in our series suggests that a 2-min observation period is sufficient for the determination of death after cardiac arrest, including patients younger than 18 yrs. These data may inform practice guidelines. (Crit Care Med 2012; 40:158–161)
Don’t wait?
  …risk of violating dead donor rule

Wait too long?
  …risk of deteriorating organs

How much time after cardiopulmonary function is lost does one wait to ensure that spontaneous recovery will not occur?

DeVita 2001
“at least 2 mins of observation required and more that 5 min not recommended”

SCCM, 2001

“international perspectives on the time interval required to confirm death after cardiac arrest generally vary from 2-10 minutes”

CMAJ, 2006
Pediatric heart transplantation after declaration of cardiocirculatory death.

“Denver surgeons recovered hearts for transplantation from three dying newborns soon after the hearts had stopped beating—after 3 minutes in the first case, and after 75 seconds in the other two. “
Death Prediction and Physiology after Removal of Therapy Study
Total Active Sites: 16
13 in Canada, 3 in Czech Republic
1 pediatric

Consent rate: 94%
Protocol compliance: ~90%
Planned study completion: ~Fall 2017
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, MD12; 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

Critical care medicine 2014
6 episodes of ABP activity after absence of ≥60s

<table>
<thead>
<tr>
<th>Case</th>
<th>Time in Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>62 172</td>
</tr>
<tr>
<td>Case 2</td>
<td>79 20</td>
</tr>
<tr>
<td>Case 3</td>
<td>80 1 89 35</td>
</tr>
<tr>
<td>Case 4</td>
<td>60 30 75 40</td>
</tr>
</tbody>
</table>

- Absence for minimum of 60 seconds
- Absence continues until end of monitoring

Legend:
- absent
- activity
ROSC after 1 minute

- ECG activity different from ABP function

- 4 patients had identification of ABP activity after absence of > 60 seconds
  - Within 2 minutes
  - Short duration
  - Low amplitude
Biomedical death – absence of circulation

Clinical death

“complete (global) ischemia of the entire organism, with a chance of resuscitation to recovery with good cerebral function”, Safar 1988

“Although loss of brain function is almost immediate, there is no specific duration of clinical death at which the non-functioning brain clearly dies” Whetstine, 2005
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
EEG isoelectric after 15±3 s

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

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

1. Cessation of function
Loss of Neurological Function after abrupt Circulatory Arrest

1. Clinical loss of consciousness: 4-21 seconds

2. Isoelectric EEG: 10-30 seconds

Figure 2: Mechanisms of ischemia. This is for illustrative purposes only to demonstrate the various clinical contexts which were identified in the articles included in this review. It is understood that values for blood flow and time, as well as the slope will vary according to clinical situation.
Neurological Monitoring Sub-Study

- Led by Teneille Gofton in London, ON

Collaborators: Loretta Norton, Eyad Althenayan, Mike Sharpe, Derek Debicki, Houman Khosravani, Damian Cruse, Adrian Owen, Matar Slassarav, Ian Ball
Concept of Death
(Religious, Spiritual, Cultural)

Operational Definition of Human Death

Neurological and Circulatory Dying Sequences

Tests

Out of Scope:
Abstract
Not provable

In Scope:
Biological
Medical
Evidence-informed

Canadian Blood Services and Canada Sponsored the Forum in collaboration with the W.H.O.
Does autoresuscitation exist?

natural history of the dying process