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# Lazarus Syndrome — Challenges Created by Pediatric Autoresuscitation

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**Abstract:** Pediatric autoresuscitation is extremely rare, with only 4 documented cases in the literature. The longest recorded time between stopping cardio pulmonary resuscitation (CPR) and return of spontaneous circulation is 2 minutes. We report a previously well 18-month-old who attended the emergency department after an unexplained cardiac arrest. After 10 cycles of CPR, resuscitation was stopped; 6 minutes later, the patient had a return of spontaneous circulation and was transferred to the pediatric intensive care unit. The patient remains alive but with significant neurological impairment. There are a variety of theories regarding the pathology of pediatric autoresuscitation. The most commonly accepted model is that there is a degree of autopoietic end-expiratory pressure impeding venous return as a consequence of vigorous ventilation during CPR. This case challenges clinicians to reassess our current definition of death and reaffirms the need for clearer guidelines surrounding the certification of death.

## CASE

An 18-month-old male boy attended the emergency department (ED) after an unexplained collapse. Cardiopulmonary resuscitation (CPR) was started at the scene and continued by the paramedic crew and subsequently ED staff. The rhythm was asystole before changing to pulseless electrical activity (broad complex bradycardia with the trace monitored through defibrillation pads and electrodes). Resuscitation followed current resuscitation guidelines (Paediatric Advanced Life Support, Resuscitation Council UK) with consideration given to potential reversible causes (ie, hypothermia, hypoxia, hypotension, hypo/hyperkalaemia, toxins, tension pneumothorax, cardiac tamponade, thromboembolic). Pupils were size 3 and unreactive on arrival to ED. The patient was intubated and ventilated using a bag-valve mask with pressure blow-off valve with end tidal CO<sub>2</sub> monitoring. After 10 cycles of CPR with 5 doses of intravenous adrenaline, CPR was ceased with the agreement of the entire resuscitation team (including 3 consultants) in keeping with current guidelines. No echocardiography was performed during the resuscitation. There was no sign of life, no palpable pulse (carotid or femoral), no response to painful stimulus, and no pupillary response to light. Corneal reflex or gag reflex was not assessed at this time.

After stopping resuscitation, the medical team left the room, and the family remained with the child accompanied by a staff nurse. The monitors were turned off and the patient remained on the bed. The parents noted a small movement approximately 6 minutes later. A further movement was noted prompting a reassessment at which time a pulse was palpable. The team was recalled, resuscitation recommenced with the patient in sinus at a rate of 70 beats per minute. The patient was transferred to pediatric intensive care unit.

## INVESTIGATIONS

No conclusive etiology for cardiac arrest was identified, although respiratory compromise was suspected. Before the cardiac arrest, the patient was sitting in their car seat, and the parents commented on a choking event occurring. Furthermore, the patient was an ex-preterm, born at 24 weeks. They had a relatively uneventful neonatal course with no chronic lung disease or apparent neurological impairment. The patient had previously been seen by ears, nose and throat as an outpatient owing to noisy breathing and diagnosed with mild laryngomalacia. Thirteen days postarrest, the patient had a microlaryngobronchoscopy due to difficulty in extubation. Granulation tissue was noted in the glottic and subglottic area. The subglottic granulation tissue was causing a mild stenosis and was excised.

The initial venous blood gas identified an elevated potassium (6.7 mmol/L), but it was a difficult sample to obtain and was acquired at over 30 minutes from the initial collapse (this was treated and subsequent levels were normal). Inflammatory markers, renal function, liver function, and the remainder of the electrolytes were normal. Toxicology investigations were all negative. Computed tomography brain was performed an hour after admission and did not identify any significant abnormalities. Magnetic resonance imaging brain on day 3 postarrest identified significant changes in keeping with a hypoxic-ischemic event.

A child protection evaluation did not identify any concerns: investigations were normal, and there was no prior involvement by Children's Social Services.

## OUTCOME

The patient survived, although with significant cerebral impairment and was extubated on day 4. The child has significant hypertonia, has seizures, and is unable to communicate or swallow. The family has reviewed this article before publication.

## DISCUSSION

Lazarus syndrome, named from the biblical story, or autoresuscitation, is defined as a delayed return of spontaneous circulation (ROSC) after cessation of CPR. This phenomenon is rare, with 49 cases documented in a literature review in 2014<sup>2</sup> and a further 10 noted in an updated review in 2018. Four pediatric cases have been published. Of the 4 cases, ROSC returned between 30 seconds to 2 minutes after stopping CPR. In our case, the time frame of 6 minutes would make this the longest documented pediatric case. Adult cases have been reported to have ROSC up to 10 minutes after CPR.

None of the previously reported pediatric cases had a favorable outcome. For 3 patients, care was withdrawn either immediately or within the first few days postarrest. The fourth survived for approximately 5 months but passed away in the setting of dilated cardiomyopathy. In our case, the child is alive 1 year after this event but has been left with severe neurological sequelae, with a significant effect on both his and his family's quality of life.

The role of bedside ultrasound or cardiac echo in pediatric cardiac arrests remains unclear. Supporters would suggest that it has the potential to rapidly identify tamponade, tension pneumothorax, thromboembolism, and hypovolemia using predominantly adult studies to back up their conclusions. The evidence in pediatric cardiac arrest is lacking and limited to case series and reports. To date, neither Advanced Paediatric Life Support, the European Resuscitation Council Guidelines, or the American Heart Association Guideline suggests the use of bedside echo in pediatric cardiac arrest.

The physiological theories surrounding autoresuscitation vary with no universally accepted mechanism. Adult physicians postulate a role for hyperkalemia, myocardial stunning postinfarction, or hyperventilation. For those cases involving children, hyperventilation appears to be the most consistent etiology proposed. The hyperventilation hypothesis is based on a degree of autopoietic end-expiratory pressure, as a result of vigorous ventilation during CPR. The resulting increase in intrathoracic pressure compresses the vena cava and other large thoracic vessels, reducing venous return, and thus cardiac output. This may also impact the distribution and thus the effect of resuscitation drugs. When CPR is terminated, the reduction in intrathoracic pressure allows venous return and potentially ROSC.

The most profound question this case raises surrounds the definition of death. There is no internationally accepted diagnosis of death. In the United Kingdom, guidance was issued in 2008 by the Academy of Medical Royal Colleges. In this document, death is defined as “the irreversible loss of those essential characteristics which are necessary to the existence of a living human person and, thus, the definition of death should be regarded as the irreversible loss of the capacity for consciousness, combined with irreversible loss of the capacity to breathe.”

The document addresses many key principles surrounding the process of death.

It acknowledges that, although there is no legal definition of death, the courts have adopted the brain-stem death criteria into law. In the case of cardiopulmonary arrest, death can be confirmed if irreversible cessation of neurological (pupillary), cardiac, and respiratory activity has occurred.

The guidelines further state that the individual should be observed by the person responsible for confirming death for a minimum of 5 minutes to establish that irreversible cardiorespiratory arrest has occurred, although it fails to clarify the manner in which the patient is observed. If there is a spontaneous return of a pulse or respiratory effort, a further 5-minute period of observation should occur. It is unclear from the passage whether this 5-minute period is only for observation or active resuscitation. After a further 5-minute period of cardiopulmonary arrest, the patient should be reassessed for pupillary response, corneal reflex, and response to supraorbital pain. Death is then confirmed if all remain absent. Other guidelines recommend a 10-minute period before reassessment and confirmation of death.

From the definition of death noted previously, our patient may have met the legal criteria to be certified as dead. However, 6 minutes postterminating CPR, a palpable pulse and movements were noted. The clinical question turns significantly at this point and in this scenario becomes “when is someone deemed alive following a cardiac arrest?” Does a palpable pulse in isolation signify life? When combined with movement, despite no response to painful stimulus or pupillary response, is this enough to warrant recommencing active support? Are these movements a sign of life or simply a feature of spinal reflexes?

In this case, the actions taken followed current resuscitation guidelines; CPR was started in a bid to regain a cardiac output and signs of life, which when obtained were acted upon. The family was consulted, and a decision was reached for intensive care, with the patient remaining alive to date, although with a poor neurological outcome. However, this

is not a universally held view, with those supporting a more neurological certification of death stating their belief that death is not a singular event but a process. This debate highlights the need for revisiting the national policy on certification of death, which includes rare and challenging scenarios like the one encountered in this case. Furthermore, as mentioned in previous publications on the same topic, consideration should be given to how these cases may impact on organ donation protocols.