Michael G. Fara, Breehan Chancellor, Aaron S. Lord, and Ariane Lewis, "Controversies in Cardiopulmonary Death," *The Journal of Clinical Ethics* 28, no. 2 (Summer 2017): 97-101.

Features

Controversies in Cardiopulmonary Death

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ABSTRACT

We describe two unusual cases of cardiopulmonary death in mechanically ventilated patients in the neurological intensive care unit. After cardiac arrest, both patients were pulseless for a protracted period. Upon extubation, both developed agonal movements (gasping respiration) resembling life. We discuss these cases and the literature on the ethical and medical controversies associated with determining time of cardiopulmonary death. We conclude that there is rarely a single moment when all of a patient's physiological functions stop working at once. This can pose a challenge for determining the exact moment of death.

INTRODUCTION

Declaration of death is a common event in the intensive care unit (ICU). Upon occasion, determining the exact moment of death can be challenging. We describe two unusual cases of cardiopulmonary death in mechanically ventilated patients in the neurological ICU. We use these cases to highlight some of the challenges that can arise when determining the exact moment of cardiopulmonary death, particularly in mechanically ventilated patients.

CASE PRESENTATION

Case 1

A 74-year-old woman with stage IIIB lung cancer, paroxysmal atrial fibrillation (episodes of arrhythmia), and a history of pulmonary embolism (blockage of a pulmonary artery in the lungs) and deep vein thrombosis who was on treatment-dose enoxaparin presented to the emergency room with three hours of left-sided weakness. Imaging revealed a clot in the right middle cerebral artery, and she was taken for embolectomy. Following clot retrieval, she became acutely unresponsive, and emergent brain magnetic resonance imaging and angiogram indicated scattered multifocal embolic infarcts (strokes caused by blood clots in the brain) and no evidence of blocked blood vessels.

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The patient was brought to the neurological ICU and intubated for poor airway protection. During intubation, she developed atrial fibrillation with rapid ventricular response, then became hypotensive and required vasopressors. Cardioversion was attempted, but she went into ventricular fibrillation, then pulseless electrical activity (PEA). Cardiopulmonary resuscitation (CPR) was performed and the return of spontaneous circulation (ROSC) was achieved after 20 minutes. Post-arrest, she was comatose, and therapeutic hypothermia was started. The patient required vasopressors, but was able to tolerate cooling with Arctic Sun (a device that cools temperature using pads of chilled water). Eight hours post-arrest, troponin rose to 65 and repeat electrocardiagrams revealed an ST-elevation myocardial infarction (a "classic" heart attack). At this time (24 hours after admission), the patient's family changed her code status to do not resuscitate, but requested continued life support while awaiting the arrival of additional family members.

Despite vasopressor administration at escalating doses, the patient became markedly hypotensive and her blood pressure became undetectable by manual cuff. Her extremities were cold and dusky, and her body temperature was 33 degrees Celsius (91.4 degrees Fahrenheit), despite discontinuation of Arctic Sun. On auscultation, there were no audible heart sounds, although the monitor continued to show a rhythm of atrial fibrillation, consistent with PEA. There were no palpable radial, carotid, or femoral pulses, and the patient was not spontaneously initiating respirations on the ventilator. She was unresponsive to noxious stimulation, despite having received no sedation for 12 hours, and her pupils were unreactive to light. Given her family's earlier declaration that she would not wish to be resuscitated in the event of cardiopulmonary arrest, and given that she was in PEA, she was monitored for 10 minutes, and, as there was no change, a decision was made to stop vasopressors and discontinue mechanical ventilation, as these interventions were medically futile. After the endotracheal tube was removed, the patient was noted to have spontaneous agonal respirations with subtle visible chest rise. Her respiratory rate slowly decreased for approximately 20 minutes before it ceased altogether. Throughout this time, the patient remained pulseless and cold, with no audible heart sounds. After cessation of respiration, she was declared dead.

Case 2

A 75-year-old woman with Alzheimer disease, hypertension, hyperlipidemia, type II diabetes, and chronic kidney disease was admitted to the hospital after a fall and was found to have a large temporal brain mass. Computed tomography of her chest, abdomen, and pelvis was unremarkable. She underwent uncomplicated craniotomy for resection, and pathological examination revealed metastatic carcinoma. Positron emission tomography showed increased endometrial uptake, consistent with a primary uterine malignancy. On postoperative day seven, while awaiting transfer to a nursing home, she suddenly vomited, then became acutely tachypneic (had abnormally rapid breathing) and hypoxemic (had an abnormally low concentration of oxygen in her blood), and then bradycardic (had a low heart rate). Code status was re-addressed immediately with the patient's family, who stated that she was full code (that is, she desired CPR).

The patient was transferred to the neurological ICU and within minutes developed cardiac arrest with PEA. CPR was performed; the patient was intubated; epinephrine was administered. After 20 minutes, the bedside monitor showed occasional, narrow-complex electrical activity every 10 to 15 seconds, consistent with PEA, but the patient had no heartbeat or palpable pulse and no sign of spontaneous respirations. Further intervention was felt to be futile, so the patient was pronounced dead and the endotracheal tube was removed. At this time, the patient was noted to have brief agonal movements of her mouth and head every 15 seconds, but no evidence of chest rise or audible breath sounds, no heartbeat, and no pulse. The rate of these movements gradually slowed, then ceased altogether, after approximately 10 minutes.

DISCUSSION

Legal definitions of death vary between jurisdictions, both within the United States and internationally,[1] but most jurisdictions in the U.S. adopt a definition similar to that of the Uniform Declaration of Death Act (UDDA).[2] The UDDA states, "An individual who has sustained either (1) irreversible cessation of circulatory and respiratory functions, or (2) irreversible cessation of all functions of the entire brain, including the brain stem, is dead. A determination of death must be made in accordance with acceptable medical standards."

The motivation for this definition of death came from a perceived need for universal recognition of death by neurologic criteria as a kind of death, given advances in cardiopulmonary support. Controversies surrounding this definition largely focus on the second criterion, that defines brain death as a type

of death. Some have voiced religious or moral objections to this criterion,[3] while others have raised concerns about the lack of uniformity of its application across healthcare settings.[4]

The first part of the definition—death as the irreversible cessation of circulatory and respiratory functions—has been subject to less controversy. As illustrated by these cases, though, perhaps this definition is not as straightforward as it seems, and death can be a continuum rather than a single event, making it challenging to pinpoint the moment at which a patient fulfills the two criteria for cardiopulmonary death.[5]

Prior to extubation, our patients both seemed to meet the criteria of cessation of circulatory and respiratory functions—each had no audible heartbeat and no palpable pulse, and ventilation was being provided purely mechanically. After extubation, our first patient began to show signs of respiratory activity (agonal respirations and subtle chest rise) and was therefore alive, so she either was not dead before extubation, despite having no apparent circulatory or respiratory function, or we witnessed autoresuscitation.[6] Our second patient, despite having some intermittent agonal movements of the mouth and head, had no heartbeat and no evidence of chest rise, so she was determined to have cessation of circulatory and respiratory functions and death was declared. Why was her mouth still moving, though? If an end-tidal carbon dioxide detector were employed or if an electromyogram of her diaphragm were conducted, might they have suggested that respirations were still occurring? What lengths must be taken to declare that a patient truly has cessation of respiration? Clinically, before extubation, there was no obvious difference between our two patients. Is it necessary to wait until patients are removed from mechanical ventilation to determine whether they still have spontaneous breaths and are therefore still alive?

Delayed ROSC after cessation of CPR, an effect termed the Lazarus phenomenon, has been reported in the medical literature. Adhiyaman, Adhiyaman, and Sundaram reported 38 cases of delayed ROSC at a mean of seven to eight minutes after cessation of CPR, and noted that almost half of the patients had good neurological recovery, and 35 percent were eventually discharged home with no significant neurological sequelae.[7] The possibility of this phenomenon occurring, particularly in patients who are eligible to become tissue or organ donors after death by cardiac criteria, prompts a critically important ethical discussion about time of death. What constitutes irreversible cessation of a bodily function? At one extreme, showing that cessation of circulatory or respiratory function is irreversible would require proving that there are no possible interventions that could restore it. Adopting this interpretation would, at a minimum, require subjecting patients to a battery of invasive attempts at resuscitation just to prove that they are dead, a practically untenable and morally questionable practice. At the other extreme, cessation of function might be viewed as irreversible, if it were reasonable to suppose that it would not spontaneously resume. Since it is sometimes reasonable to suppose things, even if they turn out not to be true, adopting this interpretation runs the risk of prematurely declaring patients to be dead, then witnessing them "come back to life."

In clinical practice, a plausible sense of irreversibility of lost circulatory or respiratory function probably lies somewhere between these two extremes.[8] Various medical organizations have offered position statements to help physicians and institutions make ethically sound interpretations of the law when declaring a patient dead. For example, the Society of Critical Care Medicine defends a view that physicians should observe a patient for at least two minutes before concluding that a loss of cardiopulmonary function cannot be reversed, and that observing for more than five minutes is unnecessary.[9] The U.S. Institute of Medicine recommends waiting at least five minutes in cases when a patient is a potential organ donor,[10] and some physicians, citing the Lazarus phenomenon, have urged waiting at least 10 minutes.[11] It is generally accepted that more data concerning the incidence of unassisted ROSC after cardiac arrest are needed, particularly for patients who are potential organ donors.[12]

The very notion of using a time-based criterion in determining cardiac death is challenged by the possibility of heart transplantation after cardiac arrest. In 2008, physicians from the Denver Children's Hospital described three cases of successful pediatric heart transplantation after cardiac death; all three recipients survived at six-month follow up.[13] This generated considerable controversy, including a public call for a moratorium on the practice for children in the U.S.[14] At issue is the fact that successful heart donation requires that the donated heart be functional in the recipient. Therefore, at the time of donation, there cannot have been an irreversible cessation of the donor's circulatory function, and so if the donor was not brain dead (as the children at Denver Children's Hospital were not), they were not dead at all by the UDDA definition.[15] This has led some to argue that, under current laws, both in the U.S. and elsewhere, heart donation in the absence

of brain death constitutes a criminal offence, and so the legal definition of cardiopulmonary death should perhaps be changed, removing the requirement of irreversibility of circulatory function.[16]

The Lazarus phenomenon involves spontaneous restoration of circulatory function after cardiac arrest. Our first patient, however, appeared to have spontaneous restoration of respiratory function despite sustained absence of circulation. It is probable that, in actuality, this only appeared to be a "restoration," and that even before extubation she had an endogenous, agonal respiratory drive at a rate too slow to trigger spontaneous breaths while mechanically ventilated. Agonal respiration during cardiac arrest is not unusual, and was noted to occur in 55 percent of cases in one observational study.[17] Given that our first patient was cooled, however, it is, in principle, physiologically possible for her to have had no respiratory drive for a prolonged period, and then later to have recovered it, despite absent circulatory function, and therefore, presumably, absent cerebral perfusion. For example, with the benefit of deep hypothermia, cardiac arrest may be induced for relatively long periods during cardiothoracic surgery, after which patients make complete neurological recovery.[18] Additionally, some degree of neuronal recovery has been observed in normothermic cats (cats with normal body temperatures) that were subjected to complete occlusion of cerebral blood flow for more than an hour.[19]

These possibilities highlight the difficulty of determining not so much irreversibility, but the mere fact of cessation of respiratory function in a patient who is mechanically ventilated. The only sure way to determine that a mechanically ventilated patient has no respiratory function is to disconnect the patient from the ventilator. This forms the basis of the apnea test that is routinely used as part of the determination of brain death. This, of course, prompts concern that disconnecting a living patient from a ventilator might constitute a potentially fatal withdrawal of care. While for most patients, as for ours, this concern would be academic and have no bearing on the patients' prognosis or clinical course, it is easy to imagine cases when the concern would be ethically critical, for example, for potential organ donors. One possible solution to this problem, in cases such as organ donation, when it is essential to determine that respiratory function has completely ceased while at the same time ensuring that the immediate cause of death was not iatrogenic, would be to employ extracorporeal membrane oxygenation. While such a procedure would be too invasive, costly, and distressing for family members in routine cases, it would offer a way to maintain organ support while observing a patient's intrinsic respiratory activity for enough time to be sure that it has truly ceased. This proposal raises, however, ethical concerns of its own, which has led some to argue that it should not be used in this setting.[20]

CONCLUSION

The cases we have presented illustrate that determining the exact moment of death can, in some cases, be challenging. The root of the difficulty is that an integrated physiologic system does not necessarily fail all at once.[21] It is important for intensivists to take this into account when declaring time of death, particularly when a patient is on a ventilator. In many cases, particularly when organ donation is not being considered, it may be prudent to allow the determination of time of death to be influenced by consideration of the patient's family members. It could be distressing and potentially confusing, for example, for a family member to be told that a patient is dead while there are still some agonal head movements, as in our second case. In these cases there is little to be lost in waiting until there is literally no sign resembling life before declaring a patient dead.

MASKING OF THE CASES

Some details of these cases have been excluded to protect the identity of the patients and their family members.

NOTES

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