

## EDITORIAL

# Bioethicists must rethink the concept of death: the idea of brain death is not appropriate for cryopreservation

**Claudio Cohen**

Universidade de São Paulo, Legal Medicine, Medical Ethics and Social and Occupational Medicine.

Death has historically been believed to be an event that coincided with the onset of clinical death. It is now understood that death is a series of physical events, not a single event, and that the determination of permanent death is dependent on other factors beyond the simple cessation of breathing and heartbeat. We may need to accept the concept of the life cycle assessment introduced by nanotechnology or astrobiology, a process that is often called transhumanism (1).

Cryopreservation is the use of antifreezing solutions and proteins or cryoprotectants and cooling to very low temperatures for the long-term storage of human bodies, animals, organs or tissues, typically at liquid nitrogen temperatures (-196°C). Cryopreservation is not freezing.

At these low temperatures, any biological activity, including biochemical reactions that would lead to cell death, is effectively stopped. However, when cryoprotectant solutions are not used, the cells being preserved are often damaged when approaching low temperatures in the freezing process or when being warmed to room temperature. To be biologically useful, cryoprotectants must easily penetrate the cells and not be toxic to them.

Cryopreservation is used for embryo storage, for example, when in vitro fertilization has produced more embryos than are needed at a given time. Semen can be successfully used almost indefinitely after cryopreservation, with successful storage reported for as long as 21 years. Oocyte cryopreservation is a new technology in which eggs are extracted, frozen, and stored. They may later be thawed, fertilized, and transferred to the uterus as embryos.

As of 2010, there were more than 200 people in cryogenic storage, all of them in the United States or Russia. Most are stored in the Alcor and the Cryonics Institute, but more than ten are in Russia, and two are in Trans Time.

All modern cryonics organizations require full payment for all future costs associated with storage "in perpetuity" before patient cryostorage. The costs of cryonics vary significantly, ranging from the basic fee of \$10,000 for neuro-(head or brain only) cryopreservation at the European cryonics company KrioRus to more than \$200,000 for

whole-body cryopreservation by Alcor (this value includes overseas and last-minute fees). Alcor's neuropreservation (head only) is priced at \$80,000 (2).

Cryonicists do not believe that cryopreserved humans or animals are dead. They often refer to a person who has been declared legally dead and cryopreserved as being in a state of deanimation. However, the process of bringing a person or animal from a state of cryopreservation to life is called resuscitation, a term that is used among cryonicists. The term "revival" may be more appropriate than "resuscitation" (3).

At the present time, we should not define death exclusively as brain death. We cannot assume that a cryopreserved individual is either dead or still alive, as cryonicists believe. A cryopreserved individual is legally dead, but cryonicists say that he/she can be reanimated. This reanimation should not be associated with resurrection.

To address these issues, we must reassess the concept of death. Such a reassessment occurred in 1988, when the scientific community reviewed and changed the definition of death from cardio-respiratory arrest to brain death. Various religions and the legal system now accept this concept.

A central premise of cryonics is that long-term memory, identity stored in durable cell structures, and patterns within the brain do not require continuous brain activity to survive. This premise is generally accepted in medicine; it is known that, under certain conditions, the brain can stop functioning and can later recover, with the maintenance of long-term memory. Additional scientific premises of cryonics include the following: (a) the brain structures that encode personality and long-term memory persist for some time after clinical death, (b) these structures are preserved by cryopreservation, and (c) future technologies that could restore encoded memories to functional expression in a healed person are theoretically possible (4).

In simpler terms, we need to understand cryopreservation as a concept of life similar to the one used for frozen embryos. Some people view frozen embryos as living, but others do not. As soon as they are implanted in a uterus, however, they are ultimately given life, which is the equivalent of human reanimation.

The bioethical question posed by this issue is whether a cryopreserved human being is entitled to rights. We can accept the cryonics patient as legally dead, or he/she can be regarded as a "potential person". We need to respect his/her living will when opting for "reanimation" as we accept a "do not resuscitate" (DNR) decision.

A moral premise of cryonics is that cryopreserving people is the right thing to do when there is no other

Email: ccohen@usp.br

Tel.: 55 11 9222-4022

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hope, but the individual's autonomy should be respected, as it is when a person agrees to participate in a genetic experiment with germ stem cells. Some cryonicists believe, as a matter of principle, that anyone who would ordinarily be regarded as dead should instead be made a "permanent patient", subject to whatever advances the future might bring (5).

We must differentiate between the concept of brain death and clinical death, which is the medical concept that refers to the cessation of blood circulation and breathing, the two criteria necessary to sustain life. Death occurs when the heart stops beating in a regular rhythm, a condition called cardiac arrest. During clinical death, all tissues and organs in the body steadily accumulate a type of injury called ischemic injury. The term is also sometimes used in resuscitation research.

The importance of this paradigm shift is that death is a metaphysical concept that may be changed in the future according to the needs of cryopreservation experimentation.

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