Independent Cryonics Educators Program

2.7: What difference does time make after cardiac arrest?

The faster that cryonics procedures can be carried out following the collapse of the body's systems, the better. Given the requirement to await legal death before starting, we can take the preceding sentence to mean "as fast as possible following legal death". The more time that has passed before starting each part of the cryonics procedure, the worse the outcome (all other factors being equal).

Other factors are not equal, however, one of the biggest being the temperature of the patient. (Others being cause of clinical death and the general condition of the patient.) As soon as the body ceases to function normally and blood circulation ceases, ischemic damage begins to accumulate along with hypoxia. "Ischemia" means "lack of blood flow". "Hypoxia" means "insufficient oxygenation of cells" and happens because of ischemia as blood ceases to carry oxygen to the cells. Hypoxia causes more problems in some organs and tissues than others. The most critical for our purposes is ischemic and hypoxic damage to the brain.

It's commonly believed that the brain "dies" after 4 to 6 minutes without oxygen. That belief came about because, until relatively recently, we had been unable to revive a brain after that time. The cause was reperfusion injury – the cascade of damaging processes that begins when circulation is restored without special measures being taken. The cryonics process is not trying to revive the brain at that point, so it is largely irrelevant. What we can say is that the warmer a brain is and the longer it remains warm, the worse its condition will be. We can also say that the blood-brain barrier breaks down – very roughly after 20-24 hours after cardiac arrest – and this will make it impossible to adequately cryoprotect the brain.

When a case is local to Alcor, stabilization will be immediately followed by cryoprotective perfusion. When cases are not local, an SST team will often perform a washout. This replaces most of the blood with a transport solution. This helps maintain viability of tissues during transport. A remote washout extends the time available for starting perfusion. With or without washout, if there is any doubt about perfusability, cryoprotective perfusion will be attempted. Beyond that time, it will be a "straight freeze," meaning cooling to liquid nitrogen temperature without any cryoprotectant chemicals, resulting in extensive freezing injury.

The brain is the limiting factor in the extent of delay that makes eventual revival difficult or impossible. Blood circulation below the heart can be stopped in the rest of the body for at least 30 minutes. Injury to the spinal cord prevents the extension of this time. Even after 6 hours of no blood circulation at warm temperatures, detached limbs may be successfully reattached. Bone, tendon, and skin can survive as long as 8 to 12 hours. Unfortunately, the brain tends to accumulate ischemic injury faster than any other organ.

In 1990, the laboratory of resuscitation pioneer Peter Safar discovered that reducing body temperature by three degrees Celsius after restarting blood circulation could double the time window of recovery from clinical death without brain damage from 5 minutes to 10 minutes. More recent research by Dr. Peter Rhee uses even lower temperatures to multiply the time available to perform surgeries that would otherwise be impossible.

Other researchers have recovered dogs after 12 minutes of clinical death at normal body temperature with practically no brain injury. By adding a drug treatment protocol, that time has been extended to 16 minutes of clinical death at normal body temperature with no lasting brain injury. A cat was put into complete circulatory arrest and maintained under laboratory conditions at normal body temperature. The cat was resuscitated with eventual return of brain function after one hour of complete circulatory arrest.

After days of no blood circulation and without intervention by a cryonics team, cells in the brain will be badly structurally damaged. Whether they could ever be reconstructed then becomes increasingly doubtful. However, if the time is hours rather than days, the prognosis is far more promising. The basic structural and chemical integrity of a brain in the first minutes and even hours after cardiac death is surprisingly good. Living neurons can still be cultured from brains after 8 hours of warm cardiac arrest.

The poor structural state of brain cells after a day or more of no blood flow at normal body temperature is why the prognosis of patients declared “brain dead” while on life support is poor even for cryonics. Most candidates for cryonics suffer cardiac death, which is more amenable to future medical repair than brain death as currently defined. Basic cell structure must persist even longer before inevitable protein breakdown occurs.

[Updated 07/30/22]

References

- The Cryobiological Case for Cryonics
- A Brief Scientific Introduction to Cryonics

Next: 2.8: Cryonics, aging, and disease

ICE Program

Part I: ICE: Why is it important.

Part 2: Introduction to cryonics

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