Independent Cryonics Educators Program

3.5: Cooldown and storage

After standby, stabilization, transport, and cryoprotective perfusion, the final stage of the cryopreservation process is cooldown and storage. The patient will be cooled in a controlled manner below the glass transition temperature (Tg) for long term care. This ensures that there is no metabolism whatsoever. The vast majority of patients at Alcor and other cryonics organizations are cooled to the temperature of liquid nitrogen, -196°C. (A few patients are held at a temperature between Tg and liquid nitrogen.) This is cold enough to inhibit all potentially harmful chemical reactions, including those caused by the toxicity of any cryoprotectants that have been introduced.

Whole body patients will be wrapped in a plastic sheet and strapped to a wire-mesh stretcher before being lowered into a large, insulated cooling box. Neuro patients will be transferred to a small dewar. In the case of whole body patients, the cooling box is covered with a lid containing a space and a fan to circulate vapor over the patient. The liquid nitrogen vaporizes, drawing heat from the patient while the fan further enhances cooling. The cooldown process is controlled by software.

The temperature is dropped rapidly, drastically slowing metabolism within minutes, reaching a temperature between -80 degrees Celsius and -110 degrees Celsius. Since different tissues in the body may cool at varying rates, a simple plunge all the way to the final temperature is not advisable. To allow thermomechanical stress to relax, the temperature is held at this intermediate level for 12 hours.

The patient is removed from the cooling box and transferred to a larger dewar after being placed in a sleeping bag sprayed with liquid nitrogen. (If a patient later has to be moved to a different vessel, the liquid nitrogen-soaked sleeping bag will delay any rise in the patient's temperature.) The temperature will then be dropped more slowly – at 1.0 degree Celsius per hour – over 3 to 4 days to minimize thermal stress and fracturing. This process typically uses about 100 liters of liquid nitrogen during each 24-hour period.

Pods placed in dewar

In a neuropatient cooldown, cephalons are cooled in nitrogen vapor from start to finish. There will be an initial plunge down to -110 degrees Celsius. This is followed by gradual cooling as short bursts of liquid nitrogen are injected into the neuro dewar. The length of each burst and the time between bursts is calculated to achieve the desired cooling rate. As with whole body patients, this part of the cooling process takes around three days. When cooldown is complete, the neuro dewar is slowly filled with liquid nitrogen.

Whereas a whole body patient is enclosed in a protective aluminum pod, a neuro patient's cephalon is placed in a cylindrical aluminum storage cylinder which is itself placed inside a cube-shaped Styrofoam box with detachable lid. This "neuro canister" is lined internally with soft Dacron fiber. The can is filled with liquid nitrogen and an aluminum lid is wired into place. The lid and the can are labeled with the date and the patient identification number. The can is moved to a storage dewar for immersion in liquid nitrogen.

If cryoprotective perfusion has been impossible as a result of blood clotting or other circulatory problems, ice will start to form below 0 degrees Celsius. In such cases, a slower rate of cooling is used throughout the process to minimize thermal stress resulting from uneven cooling. Slower cooling also gives cells time to dehydrate by osmosis during freezing of water outside cells. Freeze-induced dehydration of cells is a standard practice in the field of cryobiology during cryopreservation. It prevents water from freezing inside cells (intracellular ice formation) which is more damaging than ice growing in between cells (extracellular ice formation).

The dewars housing cryonics patients are replenished weekly with liquid nitrogen. Although the desired temperature could be maintained for several months with a refill, the weekly schedule provides an ample safety margin.

[Updated 07/30/22]

References

https://www.alcor.org/docs/cryopreservation-procedures-section-19-cryogenic-cooling.pdf

https://www.alcor.org/docs/cryopreservation-procedures-section-03-protocol.pdf

Next: 4.1: Minimizing ice crystals using vitrification

ICE Program

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