Alcor A-2799

Case Report

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1. Summary

Information was derived from multiple sources and was all converted to Mountain Standard Time (MST). For de-identification, dates are not shown. T-0 represents the date of cardiac arrest, T-X represents occurrences before T-0, and T+X represents occurrences following T-0.

A-2799 was a 76-year-old member with whole-body cryopreservation arrangements. The member had a brain bleed caused by alcohol use and withdrawal. Cardiac arrest took place at 02:30 hrs on T-0 days. The member was pronounced legally deceased in Rhode Island at 02:33 hrs on T-0 days in August of 2023.

After stabilization and field blood substitution, the patient was air transported to Alcor for cryoprotectant perfusion and cryogenic cooldown. The patient arrived at Alcor on T-0 days at 21:25 hrs. The cryogenic cooldown was initiated on T+1 days at 02:38 hrs and terminated on T+6 days at 08:10 hrs. The patient was transferred to long-term care at liquid nitrogen temperature on T+30 days at 13:47 hrs.

2. Patient Assessment and Deployments

T-25 days

Alcor was notification at 11:49 hours that a member was in a skilled nursing facility and not doing well. Alcor's Medical Response Director (MRD) was notified immediately and called the nursing facility with no answer. At that time, the MRD called the member's landlord, who had notified Alcor of this situation. The Landlord explained to the MRD that a month earlier she had requested a wellness check since she had not spoken to the member for a couple of days. The police arrived and found the member to be breathing but unresponsive. The member was taken to the hospital where admission turned into a three week stay for treatment of chronic and acute brain bleeds and alcoholic withdrawal symptoms (delirium tremens). Upon discharge from the hospital on T-31 days, the member was admitted to a skilled nursing facility.

At 12:55 hrs, Alcor's Medical Response Director (MRD) called the nursing facility again for an update on the member's condition. The MRD was only able to speak to the social worker, so little medical information was provided. According to the social worker, the member was stable at that time, but was very lethargic, and sometimes was not able to wake for meals, i.e., sometimes the member was able to eat breakfast, but not lunch. The member required assistance for all activities of daily living (ADL) and was incontinent to both urine and bowel movements. The member was only able to answer simple questions with short yes or no answers and was intermittently confused.

The social worker stated that the member was not in hospice care yet and the physician and nursing staff were not concerned that the member's end of life was imminent. However, the nursing facility was still establishing a long-term baseline and would call the MRD in the next few days with more information. The member was possibly going to be granted a guardian due to lack of orientation, and because no one had made contact with next of kin. The MRD explained Alcor's intensions and the procedures that would be used after cardiac arrest. The social worker stated they would be cooperative in allowing Alcor access to the facility and to the member, when appropriate. Communication between the MRD and the social worker continued on a weekly basis.

T-11 days

The MRD called and received the following update from the member's nurse: The member was still confused, but alert throughout the day. The member was eating about 25% of the offered meals. The member was on a puréed diet because of aspiration risk. The member choked on fluids and medications every time, so the doctors were debating an order of nothing to be given to the member by mouth, and possibly the use of a nasogastric tube for medications. With minimal intake, the urine output was 150-300/day by Foley Catheter. The member was not walking, but was in bed at all times. The hospital staff located the member's lawyer, who had been made the Medical Power of Attorney (MPOA). The hospital was debating placing the member into hospice for comfort care, but had not yet to discuss this with the MPOA.

T-10 days

The member had stopped eating and drinking. The nurse had noticed that the member would pocket his food and medications (holding them in the cheeks rather than swallowing) so the physician put in the medical chart that the member was to receive no food or water by mouth (NPO) and that a regimen of medications would be started to treat the member's pain, which included the administration of sublingual morphine at 0.5 mg every four hours. The physician also placed an order for the member to be evaluated by hospice services, as they did not provide this service themselves.

The member's vital signs were stable: blood pressure (BP) 118/80, heart rate (HR) 70, temperature (T) 36°C, respiration rate (RR) 20 and capillary oxygen saturation (SpO_2) 97% on room air. The urine output was minimal. When touched, the member would respond as if in pain. The vital signs remained stable on room air.

A local funeral home that was only 7 minutes from the nursing facility was contacted by Alcor, and arrangements were made to utilize their preparation room. The death certificate and transit permit paperwork were initiated. The Alcor Deployment Committee called for a Level-2 deployment by 2 members of the Alcor Deployment and Recover Team (DART)

Sidebar:
The medical personnel on the Alcor Deployment Committee have established a list of medical indicators to assist in determining whether to call either a Level-1 standby, a high probability of death within seven days, or a Level-2 standby, a medium probability of death within seven days. The Deployment Committee voting members use these criteria when considering if a deployment is necessary.

T-9 days

The Alcor team arrived at the member's location at 09:09 hrs and reported that the member was stable, with the following assessment:

Neurological status: Alert and oriented to self. Very confused. Screamed in pain on movement.

Cardio: Pulses were strong and regular, the skin cool to the touch, capillary refill was less than 3 seconds. No mottling was observed, very pale in fingertips and face.

Pulmonary: Breathing was not labored; the member was on room air. No audible abnormal breath sounds.

Gastrointestinal/Genitourinary (GI/GU): A Foley catheter was in place; urinary output 120-150/shift.

General: Member was on 0.5 mg morphine 4 times/day, sublingual for pain. Unable to move in bed without assistance. There was one deep tissue injury that was necrotic on the coccyx (member could no longer take antibiotics) and a deep tissue injury on each heel.

Vital signs: BP 118/82, HR 70, T 36°C, RR 20, SpO_2 97%. The lawyer who had been appointed as MPOA was agreeable to a level of care that would keep the member comfortable, and also to the hospice evaluation. The nursing facility agreed to have the member remain in their facility under in hospice care

The funeral director had informed the team that the county health department would not be able to issue transit permits over the 3-day holiday weekend. The funeral director was called to set up a time for the team to tour the facility and set up logistics there. The members' room was determined to be large enough to perform the stabilization procedures. All of the nursing staff were cooperative.

T-8 days

The member had further declined neurologically, but the vital signs remained stable. The member showed signs of increased pain. The vitals were: BP 180/110, T 36.5°C, HR 110, RR 20 and labored, SpO_2 90%.

The MPOA agreed to full comfort care and the member's status was changed to "Do Not Resuscitate (DNR) Contact between Alcor's team and the nursing facility was made twice a day.

T-7days

The member had declined further, and was unable to open their eyes or track those in the room unless under painful stimuli. The vitals were: BP 106/57, HR 82, T 36°C, RR 16, SpO_2 91% on room air.

T-5days

The team conducted a shift change of those on deployment. The MRD returned to Arizona with the original DART members after their replacements arrived at the member's location.

T-4 days

The member's vitals were: SpO_2 91% on room air, HR 74, T 35.5°C, BP 122/78, RR 24. Urine output was 50 ml this day.

The decline in vital signs meant the member now had a high probability of death within 7 days. The Alcor Deployment Committee decided at 06:51 hrs to change the deployment from a Level-2 to a Level-1 deployment. The Suspended Animation (SA) team, one of Alcor's strategic

partners, was deployed to carry out whole-body stabilization and field blood substitution, being assisted by the DART team. The SA team included two perfusionists and a surgeon.

At 17:03 hrs, the night nurse started administering hourly pain medications which prompted a drop in SpO_2 to 92%. They placed the member on 2L/min of oxygen by nasal cannula.

Two SA team members and the SA surgeon had landed at 20:19 hrs and proceeded to a local hotel with their equipment. The perfusionists landed at 21:30 hrs and met the rest of the team at the local hotel. At 22:51 hrs the SA stabilization equipment had been set up in a rented minivan and was ready for use if needed.

3. Standby

T-3 days

In the morning, the team met with the nursing staff and replaced the Alcor stabilization equipment with the SA equipment. The member's vital signs were still stable, but the urine output was slowing. The vitals were reported as: HR 80, T 36°C, BP 145/87, RR 20, SpO_2 94% on 2 liter (L) nasal cannula.

The team continued to check on the member in person twice daily. Three team members purchased additional ice chests and approximately 200 lbs. of water ice. The SA surgical and perfusion equipment was set up at the funeral home just outside of the preparation room with approximately 40 lbs. of water ice.

T-2 days

The member's vital signs remained stable, but urine output continued to decrease. The member was only alert to painful stimuli. Hospice nurses had continued to provide 2L/min of oxygen through a nasal cannula, however, at 20:15 hrs a hospice nurse removed the oxygen without giving notice to the standby team of this change in care. The team only learned about the change the next day (see the Discussion section).

T-1 days

At 05:49 hrs, the member's vitals were declining. Urine output was approximately 60 cc. The vitals were: T 35.6°C, HR 105, SpO_2 79%, BP 139/77, RR 24. Breathing was shallow and labored. The member was barely responsive to painful stimuli.

At 10:25 hrs, SpO_2 dropped to 73%. At 11:34 hrs, the SpO_2 was reported as 69%. The team made the decision to have 24/7 onsite monitoring of the member. The team remained at the bedside in shifts overnight.

The SA team decided to evaluate their equipment and prepare for continuous onsite monitoring. The medication syringes were drawn up for a patient weighing 140 lbs. and placed on ice. Additional ice was procured to replenish the ice chests and approximately 200 lbs. was positioned in the member's room. At 10:00 hrs, continuous monitoring commenced with a minimum of two team members onsite at all times.

T-0 days

In the morning, the member's vital signs began to significantly decline. At 01:45 hrs the two onsite team members notified the rest of the team to prepare. Two additional team members arrived at the bedside at 01:55 hrs, and the surgeon and perfusionist arrived at the funeral home at 02:10 to prepare for the field blood substitution procedure. Assuming the member had continued to decline, at 02:15 hrs a hospice nurse was notified that the member might be close to cardiac arrest.

4. Stabilization

Cardiac arrest took place at 02:30 hrs with a nurse at the bedside. A nurse supervisor was requested to make the legal pronouncement. The member was pronounced legally deceased at 02:33 hrs and the patient was immediately transferred to the portable ice bath (PIB) that already contained 3 gallons of water. There were four team members available during the initial stabilization, making it possible for them to perform many tasks concurrently.

Approximately 100 lbs. of water ice was immediately applied to the patient's head and torso. The Autopulse was secured and initiated at 02:34 hrs to provide automated chest compressions. A 25mm blue EZIO needle was placed at 02:34 hrs into the patient's left tuberosity for access to the patient's vasculature, and the full medications protocol was begun (see the below Table of Medications Administered for the names of the medications, the dosages, and the times of administration).

The patient was intubated at 02:35 hrs with a 37 French (Fr) Combitube, the blue tube was identified as the airway, the impedance threshold monitoring device, CMI PC-900B capnograph, and SAVe ventilator were attached and initiated. The right and left nasopharyngeal thermistors were placed at a 10 cm depth into the nasopharynx and secured with nasal wax and Tegaderm to prevent water from entering the nose and interfering with temperature readings. The thermistors were secured to the patient's skin.

An additional 25mm blue EZIO needle was placed in the patient's right tuberosity at 02:36 hrs to expedite medications administration. An additional 100 lbs. of water ice was gradually added at the patient's head and torso. The cooling mask was placed over the patient's face and the circulation pump was activated to improve external cooling. An additional 60 lbs. of ice and 3 gallons of ice water was added to the patient's head and torso. The medications protocol was concluded at 02:44 hrs. Because the patient was dehydrated, the additional 250 cc of Hetastarch was also administered through the EZIO's via 60 cc syringes, and concluded at 02:47 hrs.

All equipment was gathered and prepared for removal. The nursing staff informed the team that in order to release the patient, the attending physician would need to give authorization. The team lead called and texted the attending physician on his private cellphone at 02:51 hrs. The physician responded via text at 02:55 hrs authorizing the removal of patient. The remaining paperwork was completed by the onsite Alcor representative. The patient was covered with a privacy drape and removed from the facility at 03:00 hrs.
The patient was loaded into the transport van at 03:04 hrs and taken directly to the funeral home by two team members. Two additional team members proceeded to acquire additional ice enroute to the funeral home.

5. Field Surgery and Blood Substitution

The patient arrived at the funeral home at 03:10 hrs and the funeral director informed the team lead that the death certificate was ready for digital signature. At 03:13 hrs the Autopulse battery was depleted and replaced, with a total of 40 seconds elapsed with no compressions. The team lead notified the attending physician via text to digitally sign the death certificate. The patient was unloaded from the transportation van at 03:15 hrs.

The patient was moved into the funeral home elevator and taken to the preparation room. The perfusion circuit had been set up and primed. The nasopharyngeal temperatures (NPT) at 03:24 hrs (left 25°C, right 30°C) were not cold enough (should be 20°C or less before surgery is started, per the Alcor protocol at that time). An additional 40 lbs. of water ice was added to the head and torso. The circulation pump was continuously running ice water through the cooling mask. The pump was switched to AC power at 03:40 hrs to ensure constant mask flow. The patient was draped for surgery at 03:47 hrs. The second Autopulse battery was depleted but not replaced as the decision to proceed with the surgery was made at 03:48 hrs as the NPTs were not getting lower and it was felt that it was better for the patient to begin blood substitution with the cold solution as quickly as possible (this is now the Alcor protocol).

The patient's skin was cleaned and prepped. The first incision was made at 03:52 hrs. Per the surgeon's report, the sternum was exposed, and a Stryker sternal saw was used to open the chest at 03:56 hrs. The ribs were spread open, and the pericardium was opened. The right atrial appendage and ascending aorta were identified. 3-0 Prolene was used to make pursestring sutures on the atrial appendage and ascending aorta. The ascending aorta was cannulated with a 21 Fr. Edwards arterial cannula and a 29-37 Fr dual-stage Medtronic cannula for the inferior vena cava. The cannulae were secured and then filled with perfusate, venous first, then arterial. The open-circuit perfusion was started with 5L/min room air oxygenation at 04:22 hrs. The streptokinase was immediately added to the open-circuit solution. Perfusion flow was held at 1.5 L/min and a pressure of approximately 105 mm/Hg was maintained at the head of the arterial cannula.

Closed circuit perfusion was started at 04:35 hrs with approximately 10 liters (L) of perfusate left in reserve. 72 cc of full concentration Vital-Oxy was added to the recirculating perfusate. At this time, two team members placed water ice into double-bagged gallon Ziplock bags for use in the Ziegler case during transport. During recirculation, the heat exchanger became clogged with an unidentified sediment. The clog was cleared, and the flow and cooling returned to normal.

SA again contacted the attending physician at 05:18 hrs to again urge signoff on the death certificate. At 05:48 hrs the attending physician notified the team lead that the care facility had not filed the notes for time of death correctly. Alcor's onsite team member contacted the facility to correct the error.

The patient's chest was closed using #6 surgical steel with the cannulae secured using 2-0 Ethibond. The cannulae were positioned to protrude from the chest for easy connection prior to cryoprotectant perfusion at Alcor. The skin was secured.

At 06:01 hrs the nursing facility informed the team that their notes had been submitted and they sent the team a copy. The team lead then forwarded the notes to the attending physician. At 06:04 hrs the physician notified the team lead he was signing the death certificate.

At 06:05 hrs, only 1L of MHP2 remained in the circuit reservoir. Blood substitution was ended at 06:08 hrs and the cannulae were clamped and capped for transport. The patient would remain in the ice bath with circulating ice water until transferred into the Ziegler case.

The equipment was packed, and the operating area was cleaned. The transit permit was received at 06:24 hrs. The Alcor team member then proceeded to assist the funeral director with booking a flight for the patient. The Ziegler case was wrapped in R-19 fiberglass insulation and lined with both a light-duty body-bag inside a heavy-duty body-bag.

The patient was placed inside the two body bags and then inside the Ziegler case at 06:36 hrs. The prepackaged double-bagged water ice was added between the body bags. Approximately 150 lbs. of water ice was placed in the Ziegler case with the patient. The Ziegler case was sealed and covered with the cardboard shipping tray. Upon removing the Ziegler case from the funeral home, the team realized the elevator was too small for the shipping tray. The Ziegler case was removed from the shipping tray and insulation and loaded onto the elevator. Once at street level, the Ziegler case was returned to the shipping tray with insulation at 07:00 hrs and loaded into the Alcor rental minivan for transport to a nearby international airport.

6. Patient Transport

T-0 days

The patient left the funeral home at approximately 08:00 hrs, arrived at the airline cargo department at approximately 10:00 hrs, and was received by the cargo department at 10:38 hrs. The patient's flight was left at approximately 12:00 hrs and landed in Phoenix at 19:00 hrs. The patient was received by the Alcor team at 20:57 hrs.

7. Surgery and Cryoprotectant Perfusion

The mixing reservoir had been loaded with 10 liters B1 solution to prime the circuit. Cryoprotectant perfusion would start with a 10.75 Brix concentration because washout was done in the field.

The patient arrived at the back door at 21:24 hrs and was brought into the operating room (OR) at 21:25 hrs. The insulation and packaging materials were removed. The initial nasopharyngeal temperatures (NPT) from the datalogger at 21:31hrs were: 0.8°C and -0.3°C (the probes were not labelled right or left). To prepare for moving the patient to the OR table, ice bags were removed from around the patient at 21:35 hrs, while the patient was still in the Zeigler case. At 21:40 hrs the patient was moved onto the OR table and draped for cannulation. At 21:43 hrs the ice bags were placed back around patient's head and thorax.

The main pump was placed under computer control at 21:50 hrs. The data acquisition system was connected to the patient at 21:50 hr. The nasopharyngeal thermistor was placed in the patient's left nare. The initial nasopharyngeal temperature (NPT) reading was 1.0°C (see the Discussion section). The flow rate was 2.5 L/min at 21:51 hrs. The arterial pressure was 48:97 mmHg at 21:51 hrs.

The cannulae were still in place from the field blood substitution procedure. The surgical team prepared to connect the cannulae to the OR tubing circuit at 21:47 hrs. At 21:49 hrs the patient's scalp was cut to make a single burr hole. The arterial cannula was connected to the perfusion tubing at 21:51 hrs. The venous cannula was connected at 21:52 hrs. The single burr hole, to monitor brain temperature and swelling, was drilled at 21:54 hrs. At 21:57 hrs a temperature thermistor was placed in the burr hole and sutured to secure.
The main pump was placed on recirculation at 22:00 hrs. The refractive index (RI) of the effluent from the arterial line was 10.0 Brix and the RI of the venous effluent was 10.4 Brix. More B1 solution was added to the mixing reservoir. The mixing reservoir level was at 3 liters at 22:04 hrs. The burr hole temperature was 1.4°C at 22: 04 hrs.

8. Cryoprotectant Perfusion

The cryoprotectant ramp with M22 cryoprotectant was started at 22:07 hrs; no fluid losses to the table were seen. At 22:09 hrs, plastic wrap was placed over the patient and the table to improve gas nitrogen cooling of the patient. The gaseous nitrogen was turned on to cool the patient at 22:10 hrs.

The arterial RI at 22:16 was 3.2 Brix. The venous RI was 10.3 Brix. At 22:56 hrs it was noted that the patient's skin was beginning to look tanned, an expected result of contact with the cryoprotectant. The eyes had not yet collapsed, another common and non-damaging result of contact with the cryoprotectant. The shoe of the effluent dump pump was found to have a hole in the tubing at 23:01 hrs. The tubing was replaced at 23:05 hrs.

The RI of the arterial line at 23:27 hrs was 30.22 Brix, 50% of the concentration needed to vitrify the tissues (CNV). The 30-minute pause for equilibration was initiated and the target temperatures were lowered from 3°C to -3°C

Sidebar:
Per the cryoprotection protocol, the ramp is to be paused at 30 Brix (50% of the desired terminal concentration) to allow the patient to come to osmotic equilibrium. The cephalic patient enclosure and the chiller are switched from +3°C to -3°C operation. At the end of the 30-minute pause, the ramp is resumed at the maximum addition rate (maximum without losing total volume in the circuit) to go to 105% of the desired end concentration (52.5 Brix) and held between 102% and 105% concentration until the terminal concentration is obtained.

The 30-minute pause for equilibration was terminated at 23:57 hrs and the main pump was set to full speed for the remainder of the procedure.

T+1 days

The patient's eyes had not yet collapsed at 01:28 hrs. At 01:46 hrs the 30-minute countdown to termination of cryoprotectant perfusion was started. The venous RI was 51.37 Brix. The right eye appeared to be concave at 01:58 hrs, but not the left eye.

Sidebar:
Per the cryoprotection protocol, a 30-minute countdown to the termination of cryoprotection is initiated, after which the final sub-zero terminal concentration ramp is resumed. The normal

endpoint criterion for whole body patients is over 100% for over 30 minutes from the venous return and for neuro patients, it is over 100% target cryoprotectant concentration for over 30 minutes from both jugular veins. The addition pump speed is minimized, with frequent corrections, to compensate for latency.

Cryoprotectant perfusion was terminated at 02:16 hrs. The venous RI was 53.22 Brix, the arterial RI was 54.35 Brix. The patient was moved into the Patient Care Bay at 02:27 hrs for cryogenic cooldown.

9. Cooling to Liquid Nitrogen Temperature

Computer-controlled cryogenic cooldown was initiated at 02:38 hrs on T+1 days, plunging to -80°C and descending thereafter at -1°C/hour to liquid nitrogen temperature.

On T+4 days at 17:02 hrs, the system low temperature alarm was triggered, and gas temperatures were slowly decreasing. The problem was corrected (see the Discussion section) and the temperature drop halted.

On T+6 days at 08:10 hrs, cooldown was terminated. Upon transfer from the cooldown box to the vertical cooldown dewar, the team noted four degrees of rewarming measured by the NPT probe.

On T+30 days at 13:47 hrs, the patient was transferred to long-term care at liquid nitrogen temperature.

10. Timeline and Time Summaries

Timeline

T-0	02:30	Time of Cardiac arrest
T-0	02:33	Time of legal pronouncement
T-0	02:33	Start of ice bath cooling
T-0	02:34	Start of chest compressions
T-0	02:34	Placement of first IO (left tuberocity)
T-0	02:34	Administration of first medication (propofol)
T-0	02:35	Placement of airway
T-0	02:35	Administration of sodium citrate
T-0	02:36	Placement of second IO (right tuberocity)
T-0	02:47	Administration of final medication (Hetastarch)
T-0	03:04	Start transport of patient to location of surgery
T-0	03:10	Arrival at funeral home
T-0	03:48	Termination of cardiopulmonary support (R NPT=28.4°C)
T-0	03:52	Start of field surgery
T-0	04:20	End of field surgery
T-0	04:22	Start of open circuit blood substitution
T-0	04:35	Switch to closed circuit perfusion
T-0	06:08	Completion of closed circuit perfusion
T-0	08:00	Departure of transport vehicle to airport or to Alcor
T-0	10:00	Patient shipper left at cargo dept/airport
T-0	21:25	Arrival of patient at Alcor OR (NPT 0.8°C)
T-0	21:50	NPT probes attached to data acquisition system (1.0°C)
T-0	21:50	Main pump switched to computer control
T-0	21:50	Circuit on computer control
T-0	21:52	Connected both cannulae to tubing circuit (start surgery)
T-0	21:54	Single burr hole drilled (end of surgery)
T-0	21:56	Start open-circuit washout
T-0	22:07	Switch to cryoprotectant ramp
T-0	23:27	Start pause at 50% of CNV achieved
T-0	23:57	Off pause with sub-zero terminal concentration ramp
T+1	01:46	Start 30-minute countdown to end of ramp
T+1	02:16	Termination of cryoprotection (venous RI = 51.37 Brix)
T+1	02:38	Start of cryogenic cooldown
T+6	08:10	Termination of cryogenic cooldown
T+30	13:47	Transfer of patient to long-term maintenance at LN2

Time Summaries

Event Duration hr:min		days	time	
FIELD STABILIZATION				
00:03	From: Till:	T-0 T-0	02:30 02:33	Time of Cardiac arrest Time of legal pronouncement
00:03	From: Till:	T-0 T-0	02:30 02:33	Time of Cardiac arrest Start of ice bath cooling
00:04	From: Till:	T-0 T-0	02:30 02:34	Time of Cardiac arrest Start of chest compressions
00:04	From: Till:	T-0 T-0	02:30 02:34	Time of Cardiac arrest Administration of first medication (propofol)
00:13	From: Till:	T-0 T-0	02:34 02:47	Administration of first medication (propofol) Administration of final medication (Hetastarch)
FIELD SURGERY AND BLOOD SUBSTITUTION				
01:22	From: Till:	T-0 T-0	02:30 03:52	Time of Cardiac arrest Start of field surgery
00:28	From: Till:	T-0 T-0	03:52 04:20	Start of field surgery End of field surgery
01:52	From: Till:	T-0 T-0	02:30 04:22	Time of Cardiac arrest Start of open circuit blood substitution
01:46	From: Till:	T-0 T-0	04:22 06:08	Start of open circuit blood substitution Completion of closed circuit perfusion
03:38	From: Till:	T-0 T-0	02:30 06:08	Time of Cardiac arrest Completion of closed circuit perfusion
CRYOPROTECTANT SURGERY AT ALCOR				
18:55	From: Till:	T-0 T-0	02:30 21:25	Time of Cardiac arrest Arrival of patient at Alcor OR (NPT 0.8°C)
00:27	From: Till:	T-0 T-0	21:25 21:52	Arrival of patient at Alcor OR (NPT 0.8°C) Connected both cannulae to tubing circuit (start surgery)
00:02	From: Till:	T-0 T-0	21:52 21:54	Connected both cannulae to tubing circuit (start surgery) Single burr hole drilled (end of surgery)

Event Duration hr:min		days	time	
CRYOPROTECTANT PERFUSION AT ALCOR				
19:37	From: Till:	T-0 T-0	02:30 22:07	Time of Cardiac arrest Switch to cryoprotectant ramp
00:42	From: Till:	T-0 T-0	21:25 22:07	Arrival of patient at Alcor OR (NPT 0.8°C) Switch to cryoprotectant ramp
00:15	From: Till:	T-0 T-0	21:52 22:07	Connected both cannulae to tubing circuit (start surgery) Switch to cryoprotectant ramp
04:24	From: Till:	T-0 T+1	21:52 02:16	Connected both cannulae to tubing circuit (start surgery) Termination of cryoprotection (venous RI = 51.37 Brix)
04:09	From: Till:	T-0 T+1	22:07 02:16	Switch to cryoprotectant ramp Termination of cryoprotection (venous RI = 51.37 Brix)
CRYOGENIC COOLDOWN AT ALCOR				
00:22	From: Till:	T+1 T+1	02:16 02:38	Termination of cryoprotection (venous RI = 51.37 Brix) Start of cryogenic cooldown
24:08	From: Till:	T-0 T+1	02:30 02:38	Time of Cardiac arrest Start of cryogenic cooldown
05:13	From: Till:	T-0 T+1	21:25 02:38	Arrival of patient at Alcor OR (NPT 0.8°C) Start of cryogenic cooldown

11. Table of Medications Administered

T-0 days

TIME	MEDICATION	DOSE	PURPOSE
02:34 hrs	Propofol	200 mg	Anesthetic; reduces cerebral metabolic demand; reduces the theoretic possibility of increased awareness during aggressive CPS.
02:35 hrs	Sodium citrate	100 mg Total (1st dose 50 mg) Note 1	Anticoagulant; prevents blood clot formation.
02:35 hrs	Sodium citrate	100 mg Total (2nd dose 50 mg) Note 1	Anticoagulant; prevents blood clot formation.
02:36 hrs	Heparin	50,000 IU	Anticoagulant; prevents blood clot formation.
02:36 hrs	Vasopressin	80 IU Total (1st dose 40 IU) Note 2	Vasopressor; increases blood pressure during CPS.
02:37hrs	Minocycline	200 mg	Antibiotic and neuroprotectant
02:38 hrs	SMT (S-methyl-isothiourea)	400 mg Note 3	Neuroprotectant (iNOS inhibitor); protects the brain from ischemic injury; raises blood pressure.
02:38 hrs	Decaglycerol/THAM	400 cc total (1st dose 50 cc) Note 4	Decaglycerol inhibits cerebral edema.
02:38 hrs	Decaglycerol/THAM	400 cc total (2nd dose 50 cc) Note 4	Decaglycerol inhibits cerebral edema.
02:39 hrs	Decaglycerol/THAM	400 cc total (3rd dose 50 cc) Note 4	Decaglycerol inhibits cerebral edema.
02:39 hrs	Decaglycerol/THAM	400 cc total (4th dose 50 cc) Note 4	Decaglycerol inhibits cerebral edema.
02:39 hrs	Vital Oxy (w/ saline)	70 ml total Note 5	Antioxidants: melatonin, vitamin E (D-alpha tocopherol), PBN (alpha Phenyl t-Butyl Nitrone) and anti-inflammatory carprofen.
02:40 hrs	Vasopressin	80 IU Total (2nd dose 40 IU) Note 2	Vasopressor; increases blood pressure during CPS.
02:42 hrs	Antacid	250 cc total (1st dose 50 cc) Note 5	A buffer used to protect the stomach from acid erosion.
02:42 hrs	Decaglycerol/THAM	400 cc total (5th dose 50 cc) Note 4	Decaglycerol inhibits cerebral edema.

02:43 hrs	Decaglycerol/THAM	400 cc total (6th dose 50 cc) Note 4	Decaglycerol inhibits cerebral edema.
02:44 hrs	Decaglycerol/THAM	400 cc total (7th dose 50 cc) Note 4	Decaglycerol inhibits cerebral edema.
02:44 hrs	Decaglycerol/THAM	400 cc total (8th dose 50 cc) Note 4	Decaglycerol inhibits cerebral edema.
02:45 hrs	Hetastarch	250 ml Total (1st dose 50 cc) Note 6	Restore volume in dehydrated patients and increase cerebral perfusion during CPS.
02:45 hrs	Hetastarch	250 ml Total (2nd dose 50 cc) Note 6	Restore volume in dehydrated patients and increase cerebral perfusion during CPS.
02:46 hrs	Hetastarch	250 ml Total (3rd dose 50 cc) Note 6	Restore volume in dehydrated patients and increase cerebral perfusion during CPS.
02:46 hrs	Hetastarch	250 ml Total (4th dose 50 cc) Note 6	Restore volume in dehydrated patients and increase cerebral perfusion during CPS.
02:47 hrs	Hetastarch	250 ml Total (5th dose 50 cc) Note 6	Restore volume in dehydrated patients and increase cerebral perfusion during CPS.
04:23 hrs	Streptokinase	250,000 IU Note 7	A thrombolytic used to break up existing blood clots.

Notes:

1. The standard formulation for sodium citrate is 20% w/v, in sterile packaging provided by the manufacturer. 10 grams of sodium citrate are given to patients who weigh less than 40 kg, and 20 grams are given to patients who weigh over 40 kg. This patient weighed 68 kg and therefore received 20 grams of sodium citrate.

2. Vasopressin is a fixed dosage of 40 IU, per dose for two doses. The second 40 IU dose is to be administered concurrently with Vital-Oxy, I.V. Vasopressin is to be administered only if the patient's temperature is above 20°C as it is ineffective at cold temperatures.

3. SMT (S-methyl isothiourea) is a powder, (1 vial = 400 mg) dissolved in 10 mL of saline and injected through a 0.2 µ filter. SMT is unstable in solution with a use life of approximately six hours.

4. Decaglycerol/THAM is administered as a custom formulation of 20% w/v decaglycerol and 4.5% w/v THAM (tromethamine) in water (pH = 10.4 and pKa = 8.3). It is a fixed dose of 200 ml.

5. The medications protocol dilutes 70 mL or less, based on body weight, of Vital-Oxy into 150 mL of saline for a total of 220 cc of diluted Vital-Oxy saline. Each mL of Vital-Oxy

contains 194 mg Sigma Cremophor EL (or Sigma Kolliphor EL), 155 mg ethanol, 19.4 mg PBN, 3.24 mg carprofen, 1.55 mg melatonin, and 198 IU vitamin E.

6. Hetastarch is a volume expander used to restore volume in dehydrated patients and increase cerebral perfusion during CPS. It is administered 250 mL as a fixed dosage by I.V.

7. The standard administration of streptokinase is 250,000 IU dissolved in 5 mL of 9% sodium chloride, and 25,000 IU for the abbreviated medications protocol. Streptokinase is not administered with the other stabilization medications, but added to the field blood substitution solution upon starting perfusion, or to the first cryoprotection flush in the Alcor operating room. This medication previously needed to be infused through a 0.2 µ filter. The medication now in use is already sterile-filtered and can be reconstituted in the vial.

12. Discussion

Standby and Stabilization

After speaking with the care facility there was no mention that a supervisor would be needed for pronouncement of legal death. The supervisor was asleep at the time of cardiac arrest, and was called to make the legal declaration. This delayed moving the patient by a few crucial minutes.

Additionally, there was no prior knowledge that the attending physician's authorization would be needed to remove the remains from the care facility. This was an additional delay that was minor due to having the physician's private cell phone number to aid in getting the release.

Field Surgery and Washout

There was a noticeable delay in accessing the patient's chest for cannulation. The surgeon used on this case had been trained multiple times but wanted to take additional precautions for the initial sawing of the sternum. This will be reviewed and addressed for future procedures.

Patient Transport to Alcor

The Ziegler case used for this patient was a standard size for human remains transport. This does not leave the desired room for ample ice to be added to the Ziegler to make sure the patient will remain cold during a lengthy transport. For this reason, the mega mover was not used in order to add additional water ice.

Cryoprotectant Surgery and Perfusion at Alcor

When the patient arrived in the OR at 21:25 hrs, the SST team's datalogger showed the nasopharyngeal temperatures (NPT) to be at 0.8°C and -0.3°C (the channels were not labelled left and right). At 21:50 hrs when the OR data acquisition system was connected to the patient, the initial temperature reading was 1.0°C. It is common for loggers to be offset by 1 or 2°C. and the temperature difference occurred when moving the thermocouple plug from the field logger to the OR perfusion system. This rewarming was not due to any delay in procedure.

The perfusion went well in spite of the fact that at the end of cryoprotectant perfusion the right eye appeared to be concave, but not the left eye. Signs of this were the fast burr hole temperature

change, ultra-high flow rate for the body size (small patient, 5.5L/min), minimal leakage, and the huge volume gain in the dump reservoir from dehydration.

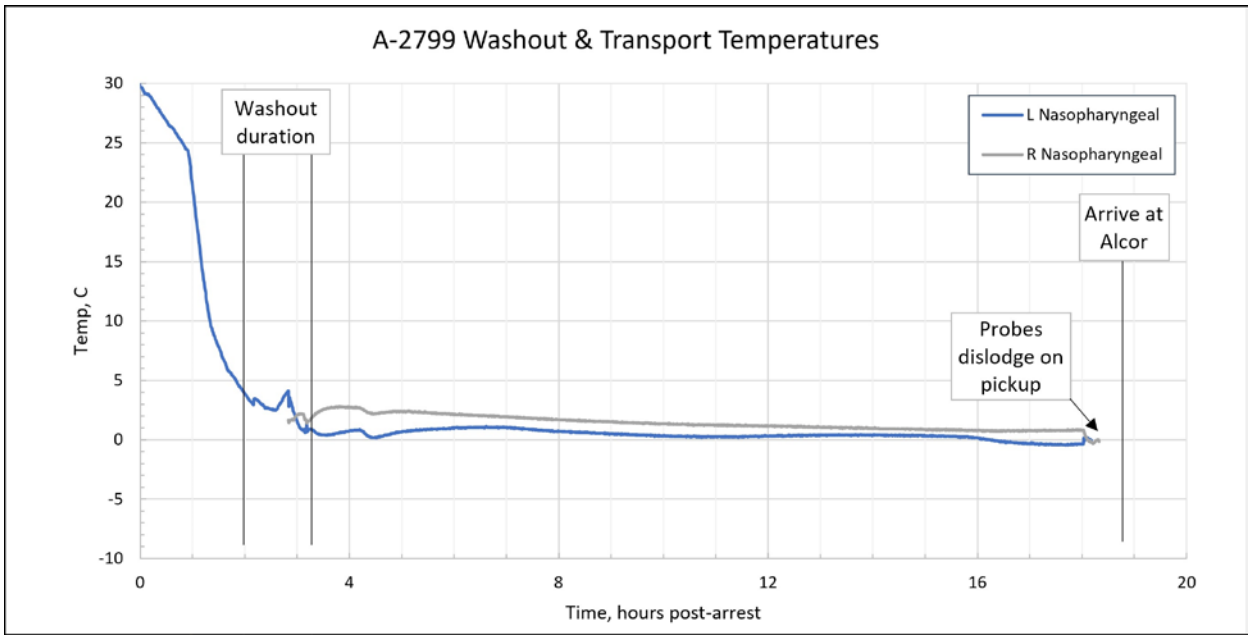
The OR perfusionist used a packet of medical grease to seal the 3D printed refractometer fluid heads onto the refractometry sampling device. This prevented air from being pulled into the sampling space and eliminated leaks from the mating surface, resulting in more reliable readings than those that have plagued recent cryopreservation procedures in the OR.

Cryogenic Cooldown

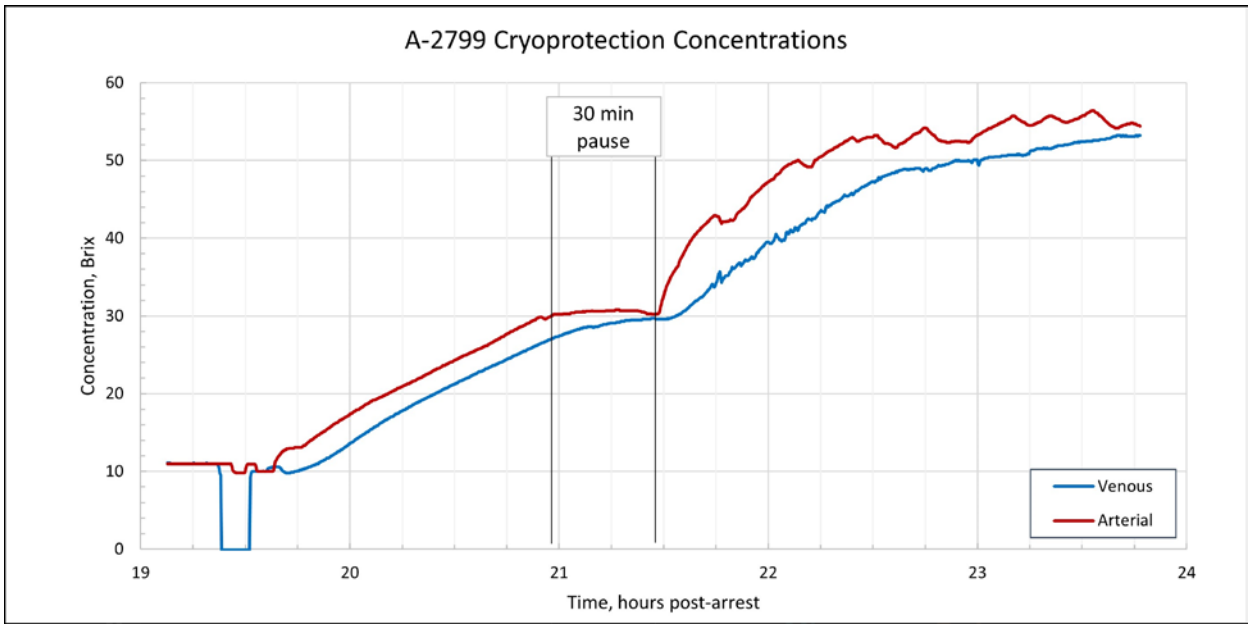
The cooldown system low temperature alarm was triggered on T+4 days, and gas temperatures were slowly decreasing. This is an unusual failure mode, because overcooling is typically observed to be extremely rapid as the result of an injection valve sticking open. However, this temperature drop was very gradual and did not stop even when the system interlock disengaged.

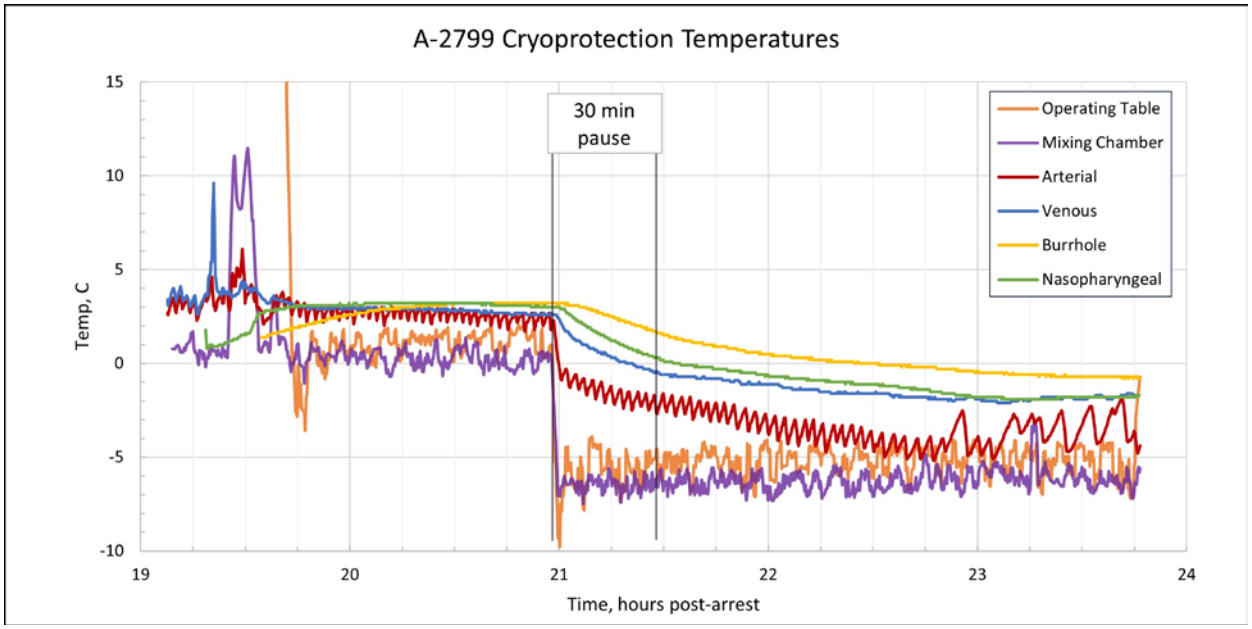
The team determined that debris lodged in the solenoid must have prevented the valve from closing fully, allowing cold gas to leak continuously into the cooldown chamber. Upon actuating the valve several times via manual override, the debris was cleared, the temperature drop halted, and the system returned to normal behavior. The solenoid was inspected after cooldown completion and no damage was found to the sealing surfaces. This cooldown occurred at the same time as another whole-body cooldown, leading the team to use backup cooldown hardware that had not been serviced in several years. It is assumed that foreign material was introduced into the tubing after an extended period of sitting on the shelf.

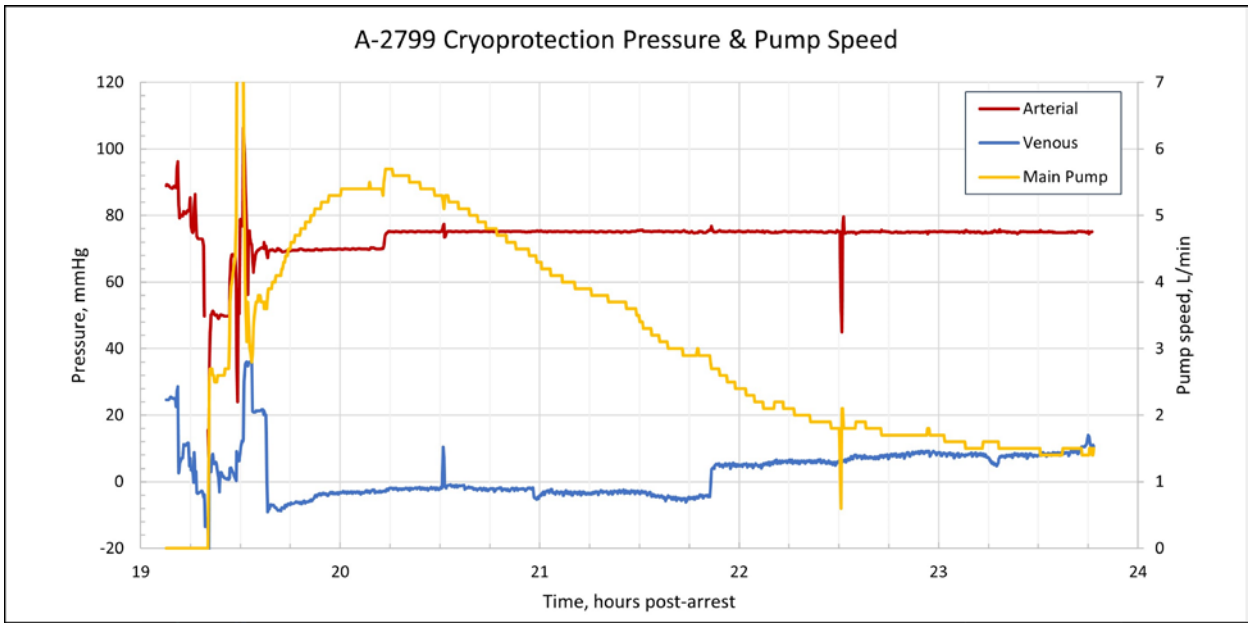
13. Cryoprotection and Temperature Graphs

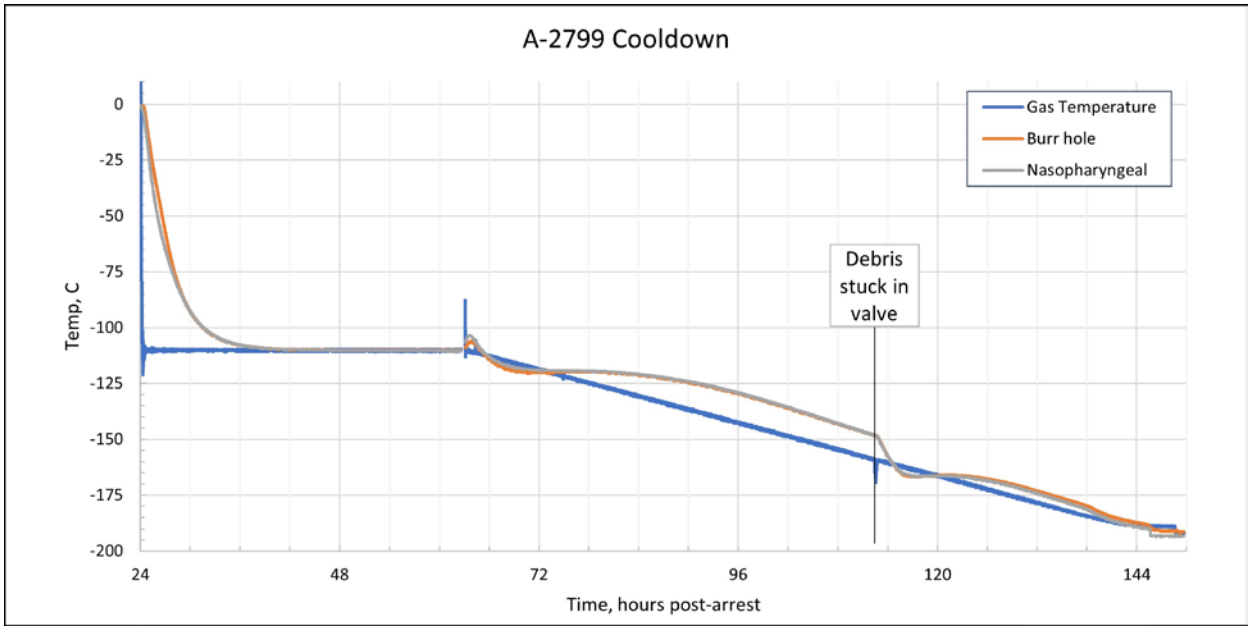


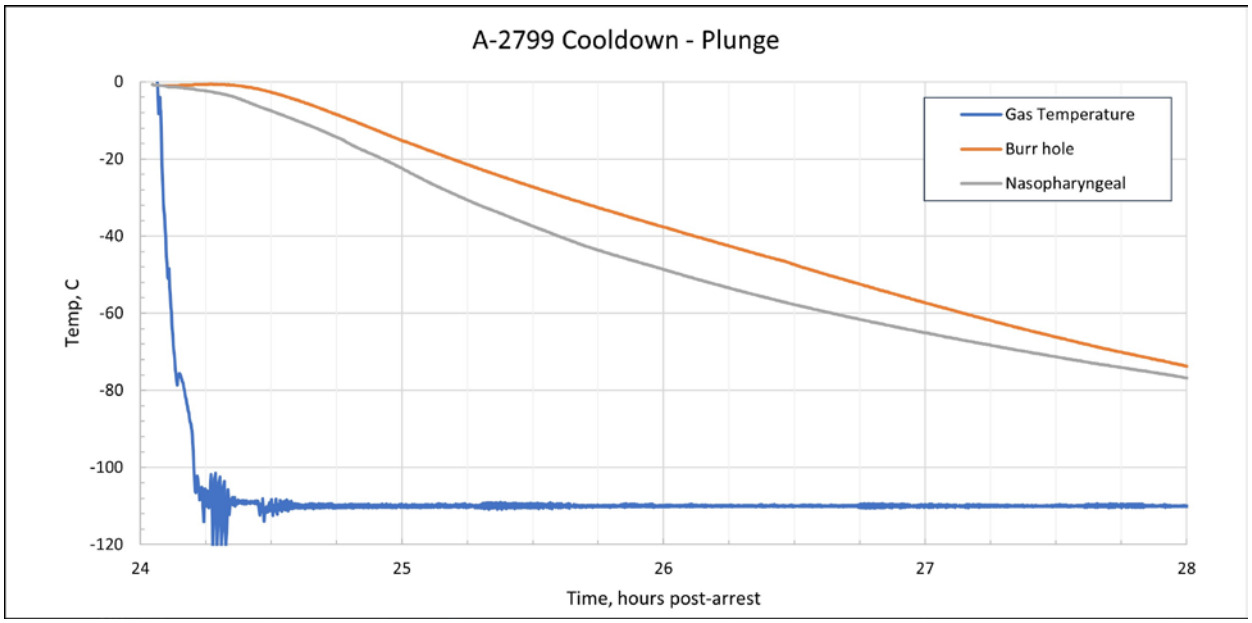
NOTE: The washout arterial supply temperature data was absent, only nasopharyngeal temperature measurements were recorded.




A-2799 Cryoprotection Temperatures
30 min pause
Operating Table
Mixing Chamber
Arterial
Venous
Burrhole
Nasopharyngeal
Temp, C
Time, hours post-arrest


A-2799 Cryoprotection Pressure & Pump Speed
Arterial
Venous
Main Pump
Pressure, mmHg
Pump speed, L/min
Time, hours post-arrest


A-2799 Cooldown
Gas Temperature
Burr hole
Nasopharyngeal
Debris stuck in valve
Temp, C
0
-25
-50
-75
-100
-125
-150
-175
-200
24
48
72
96
120
144
Time, hours post-arrest

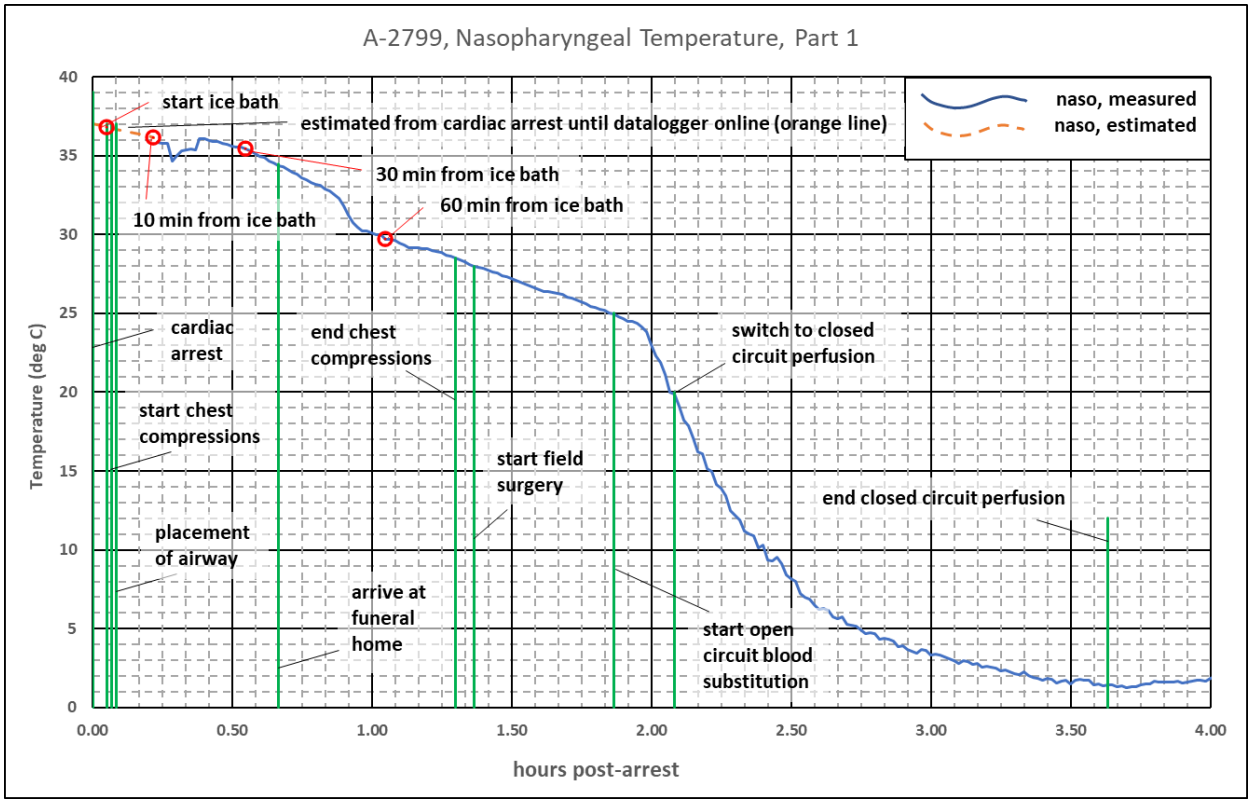

A-2799 Cooldown - Plunge
Gas Temperature
Burr hole
Nasopharyngeal
Temp, C
0
-20
-40
-60
-80
-100
-120
24
25
26
27
28
Time, hours post-arrest

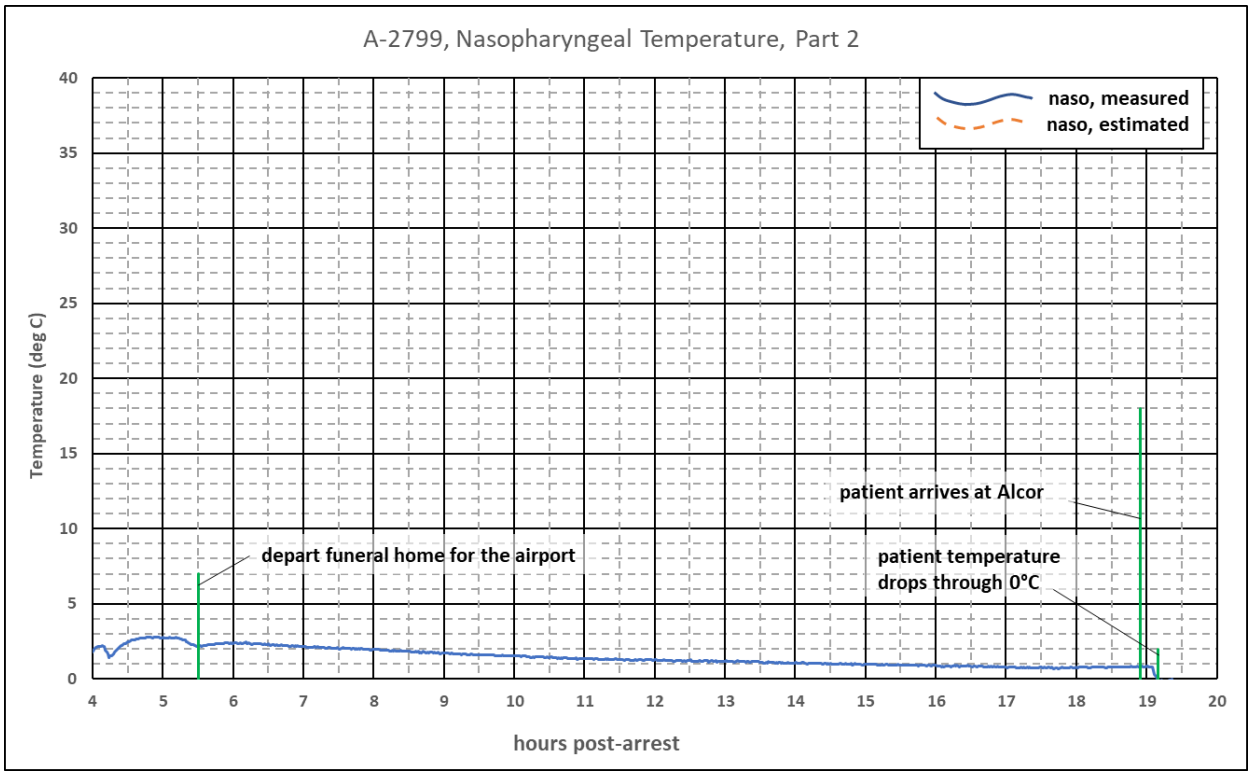
14. S-MIX

The Standardized Measure of Ischemic Exposure (S-MIX) expresses the total ischemic exposure prior to the start of cryogenic cooling as the equivalent duration of normothermic ischemia. An S-MIX of 00:00 (hh:mm) is the ideal case of no ischemic damage. The higher the S-MIX time, the more damage. Factors that improve the S-MIX, and that are quantitatively accounted for in the below table are: shorter times at higher temperatures, ventilation during cardiopulmonary support (CPS), and oxygenation during blood washout. The duration from cardiac arrest to 0°C is 19:10. As shown below, and due to lowering of the body temperature, S-MIX duration is shorter, at 02:21.

event	seg-ment #	days (T+X)	time (MST) duration	post-arrest	Tnaso (deg C)	CPS w/ ventil.	washout oxygen.	S-MIX (hh:mm)
Time of Cardiac arrest		T-0	02:30	00:00	37.0			
	seg 1		00:03	00:03	-0.2	no	no	00:03
Start of ice bath cooling		T-0	02:33	00:03	36.8			
	seg 2		00:01	00:01	-0.1	no	no	00:01
Start of chest compressions		T-0	02:34	00:04	36.7			
	seg 3		00:01	00:01	-0.1	no	no	00:01
Placement of airway		T-0	02:35	00:05	36.7			
	seg 4		00:35	00:35	-2.3	yes	no	00:16
Arrival at funeral home		T-0	03:10	00:40	34.4			
	seg 5		00:38	00:38	-5.9	yes	no	00:13
Termination of cardiopulmonary support		T-0	03:48	01:18	28.5			
	seg 6		00:04	00:04	-0.5	no	no	00:02
Start of field surgery		T-0	03:52	01:22	28.0			
	seg 7		00:30	00:30	-3.0	no	no	00:15
Start open circuit blood substitution with oxygenation		T-0	04:22	01:52	25.0			
	seg 8		00:13	00:13	-5.1	no	yes	00:00
Switch to closed circuit perfusion		T-0	04:35	02:05	19.9			
	seg 9		01:33	01:33	-18.4	no	no	00:12
Completion of closed circuit perfusion		T-0	06:08	03:38	1.5			
	seg 10		01:52	01:52	0.7	no	no	00:10
Departure of transport vehicle to airport		T-0	08:00	05:30	2.2			
	seg 11		13:25	13:25	-1.3	no	no	01:08
Arrival of patient at Alcor		T-0	21:25	18:55	0.8			
	seg 12		00:15	00:15	-0.9	no	no	00:01
patient temperature passes thru 0°C		T-0	21:40	19:10	0.0			
totals:			19:10	19:10	-37.0			02:21

The below plots show events related to the S-MIX calculation. Note that due to the extended transport time (13:25 hrs), nearly half of the S-MIX occurs with the patient below 2.5°C. The red dots can be used to construct a metric for how fast the patient is initially cooled (see the Patient Cooling Rate table below). This is a critical period since body temperature is highest and ischemic damage most rapid.

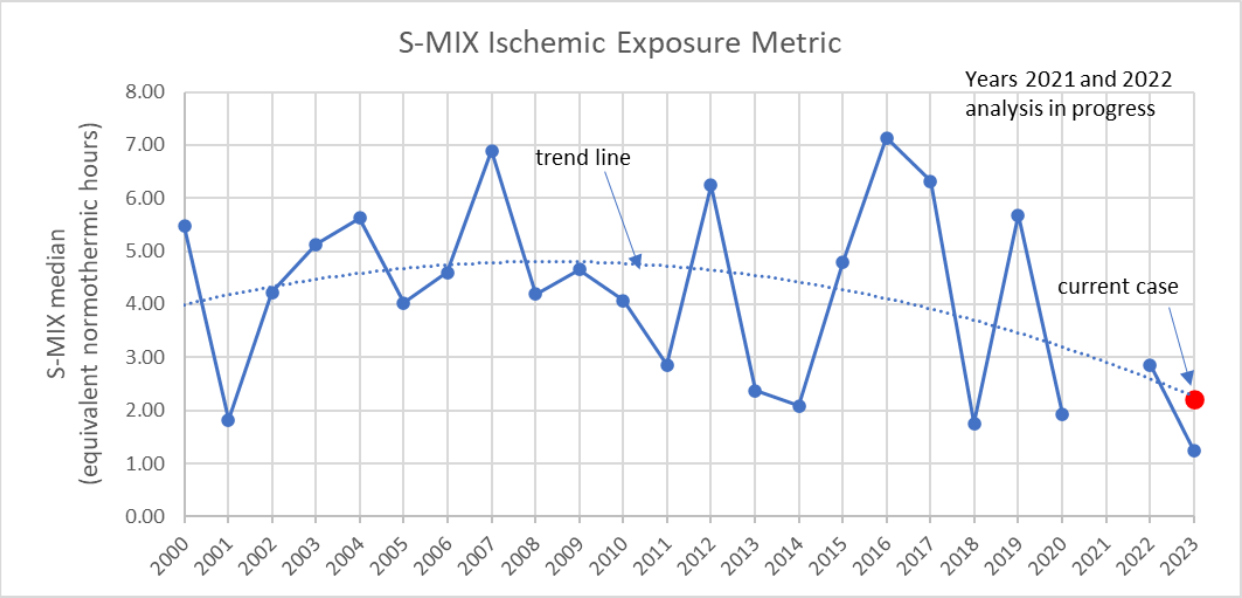

A-2799, Nasopharyngeal Temperature, Part 1
Temperature (deg C)
hours post-arrest
naso, measured
naso, estimated
start ice bath
estimated from cardiac arrest until datalogger online (orange line)
30 min from ice bath
60 min from ice bath
10 min from ice bath
cardiac arrest
end chest compressions
switch to closed circuit perfusion
start chest compressions
start field surgery
end closed circuit perfusion
placement of airway
arrive at funeral home
start open circuit blood substitution


A-2799, Nasopharyngeal Temperature, Part 2
Temperature (deg C)
hours post-arrest
naso, measured
naso, estimated
patient arrives at Alcor
depart funeral home for the airport
patient temperature drops through 0°C

The below table provides cooling data for 10, 30, and 60 minutes after the team first applies water ice.

Patient Cooling Rate			(patient weight 68 kg; 150 lb)	
Note: time = 0 at start of ice bath	0 min elapsed	10 min elapsed	30 min elapsed	60 min elapsed
Naso temperature (°C)	36.8	36.2	35.4	29.7
Temperature drop (°C) from t = 0	0.0	-0.6	-1.4	-7.1
Cooling rate (°C/min) from t = 0	N/A	-0.06	-0.05	-0.12

The following plot shows the trend of S-MIX achieved since 2000.



15. CT Scans

Cryoprotectant Distribution (Post-cryopreservation CT scan)

As this was a whole-body cryopreservation, no post-cryopreservation CT scans were obtained. When the in-house scanner is functional and whole-body patients are being scanned, additional information will be added to this report.