Alcor A-1803

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-1803 was an 83-year-old member with whole-body cryopreservation arrangements who had been on the Alcor Watch List for years. The Death Certificate gives the cause of death as sepsis, acute hypoxic respiratory failure, non-elevated myocardial infarction, congestive heart failure, and pneumonia. Cardiac arrest was estimated to be at 05:33 hrs on T-0 days and the member was pronounced legally deceased within less than one minute in California on T-0 days in 2022.

After stabilization and field blood substitution, the patient was air transported by private charter to Alcor for cryoprotection. The patient arrived at Alcor on T-0 days at 11:41 hrs. The cryogenic cooldown was initiated on T-0 days at 17:18 hrs and terminated without incident on T-5 days at 17:46 hrs. The patient was transferred to long-term maintenance at liquid nitrogen temperature on T+17 days at 15:09 hrs.

2. Patient Assessment

The member had been monitored by Suspended Animation (SA) with 24-hour care for the past eight years, under a private understanding between the two parties. The member's caregivers had been instructed to relay any changes in the member's health directly to both Suspended Animation and to Alcor.

T-98 days

The member had been having heart and breathing issues for eight months and Suspended Animation team members were visiting the member frequently. The member was hospitalized due to a non-ST (the ST element of the ECG) elevated myocardial infarction and sepsis with acute hypoxic respiratory failure which resulted in an 11-day stay and a stent being placed in the member's first diagonal of the left anterior descending artery. SA kept team members deployed locally throughout the hospital stay.

T-87 days

The member was discharged from the hospital and taken home where additional 24-hour care was needed due to muscle atrophy from being physically unable to leave the hospital bed. Physical therapy was conducted twice a week, and the member began physical recovery.

T-19 days

The member was again hospitalized due to septic shock, respiratory failure, and pneumonia. This resulted in heavy intravenous antibiotic administration. SA again kept team members deployed locally throughout the hospital stay.

T-14 days

The member's mental status became altered, and the member was discharged to home. Upon returning home the member's caregivers were in close contact daily with SA which would make daily trips to visit the member for updated vital signs and health status. After three days of being home the member's mental status improved dramatically but a physical recovery did not occur. The member was drinking and eating minimally.

T-11 days

The member's primary care physician placed an order for home hospice care that could be enacted any time with the Medical Power of Attorney's (MPOA) approval.

T-6 days and T-5 days

Over this weekend, the member refused to leave the bed, or to take medications or water.

3. Deployment

T-4 days

The member's vital signs at 10:57 hrs were: heart rate (HR) 70, blood pressure (BP) 117/72, temperature (T) 36°C, capillary oxygen saturation (SpO_2) 93% on room air. Alcor's Deployment Committee conferred and requested a full Level-1 deployment by SA.

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.

Two SA team members were already on site with the member's caregivers who had also been trained on preliminary standby, stabilization, and transport (SST) procedures. The mobile operating vehicle (MOV) was positioned beside the member's secluded garage; this would be the location for the whole-body blood replacement. The SA thoracic surgeon and perfusionist were notified to fly out with an estimated time of arrival to be mid-day the next day.

Alcor had decided to deploy their Medical Response Director (MRD), Social Services Director (SSD), and two Deployment and Recovery Team (DART) members for assistance and to receive additional training. Alcor's team landed in California at 21:55 hrs.

SA arranged for a private air charter to be on standby at the local municipal airport 30 minutes away. An appointment with a local hospice intake nurse was made by the member's caregiver and MPOA for the following day. The portable ice bath (PIB) was organized and positioned inside the stabilization area set up in the member's garage.

The member's caregiver, stepdaughter, and MPOA were informed of the possibility of transferring the member to Scottsdale, AZ. All were agreeable to the idea if the member was stable enough and a destination hospice could be set up. Alcor's MRD had been in contact with local Scottsdale hospice organizations. The MRD was informed to proceed with the member's evaluation and induction into home hospice in California. The member would then have the opportunity to potentially transfer to inpatient hospice care in Scottsdale.

SA positioned two team members to stay overnight in the member's home with the 24-hour caregiver. In the event of a rapid health decline for the member the protocol would be to notify 911 and provide rapid transport to a local hospital or pronounce on site at the discretion of the Emergency Medical Services (EMS) providers.

4. Standby

T-3 days

The member's vitals at 08:27 hrs were: HR 69/min, BP 127/77, T 36°C, SpO_2 93% room air. At approximately 10:00 hrs the Alcor team and the SA team met in the stabilization area at the member's home, to discuss logistics and planning after which the Alcor MRD performed a visual assessment of the member with the assistance of the caregiver.

Neurological status: The member was responsive to verbal stimuli with eye-opening and tracking, but no verbal response. The member did shake his/her head 'Yes' when a care giver asked, "do you know who I am?"

Cardio/pulmonary: The member had a strong pulse. The heart rate had been 60/min to 70/min, cardiac sounds were regular, and there was some chronic discoloration of the lower extremities, but the extremities were not swollen. Skin turgor was tented. Capillary refill took less than 3 seconds. Capillary oxygen saturation (SpO_2) was 90% to 93% on room air. Breathing was irregular and shallow. The member had no oral intake, and output was 1100ml/24Hr.

Gastrointestinal/Genitourinary (GI/GU): Minimal bowel sounds and a foley catheter was in place. No oral intake since the day before which was minimal (approximately 200 ml). Output has been anywhere from 400-1800 ml per 24-hour period since Saturday (this was Tuesday). The last bowel movement was on Sunday.

Overall: The member was severely lethargic and, without stimuli, goes right back into sleeping. Breathing is through the mouth, and the member is not moving in bed. The member lifted the upper extremities during assessment to try to push away but was too weak to make any difference. He/she is refusing/fighting care.

The hospice intake nurse arrived at 11:00 hrs to evaluate the member and process the intake paperwork. The nurse was extremely cooperative and wanted to assist the member's needs and the team's needs in any way possible. The hospice nurse prescribed 5 mg of morphine for pain management and 0.25mg Ativan for anxiety every 2 hours as needed.

The caregiver requested that hospice provide a 24-hour nursing staff to make a quick pronouncement possible. The hospice nurse explained that there was a nursing shortage in the

area and 24-hour nursing care might not be possible. They would work on a possible long-term solution but for the immediate need they would be able to provide an overnight nurse until the following morning when the case manager arrived. The intake nurse agreed to come by the following day as a courtesy and provided her personal contact information.

At 14:00 hrs SA began calling multiple hospice facilities to see if there was availability for 24-hour nursing care. No facilities in the area had the staffing to allow for 24-hour nursing coverage.

At the end of the day the team learned that it would be possible to transfer the member to a Scottsdale hospice facility, but there were a couple of obstacles. First, the Scottsdale hospices would require a face-to-face evaluation once in Arizona, prior to acceptance. Second, the member would need flight medics vs. a private charter if transferring before being legally deceased and a flight medic would not be available for at least two days. The private charter was on standby after blood substitution was complete. Considering these factors, it was decided to remain in place and figure out how to manage the 24-hour hospice nursing availability.

During the night one SA team member stayed at the home with the caregiver and hospice nurse. The remaining team checked into a hotel 12 minutes away.

T-2 days

The hospice case manager arrived at 7:40 hrs to perform a daily evaluation. She provided her contact information to the team members and increased the prescribed Ativan to 0.5 mg every 2 hours as needed.

At 09:00 hrs the hospice administrator provided the telephone number of a third-party nurse they had worked with in the past. This nurse could be hired privately and pronounce on behalf of the hospice facility. The nurse was contacted and retained by the member's caregiver. The pronouncement would require the attending third party nurse to contact the coroner's office and wait to be provided the information that the death had been recorded prior to the stabilization team gaining access to the member.

The private nurse arrived at 12:15 hrs and indicated she would be performing the day shift while a partner of hers would be performing the overnight shift. By the time of the nurse's initial assessment, the member was no longer responsive. The member's arms and legs would move without purpose.

At 15:43 hrs the member's health was again assessed. The member's vital signs: HR 68/min, BP 109/61, RR 6-12/min, T 37°C, SpO_2 89% on room air.

Neurological status: The member had declined. He/she was nonverbal, not responsive to stimuli, with no eye opening at all. He/she would lift the arms and move the legs with normal end of life non-purposeful movement.

Cardiopulmonary: HR 68/min, BP 109/61, RR 6-12/min, T 37.0°C, SpO2 89% on room air. The member was now having 1-2 breath pauses per minute of anywhere from 8-20 seconds long. GI/GU nothing of note.

Overall: The member was probably 12-24 hours from cardiac arrest. The member was receiving lorazepam for anxiety and morphine for pain management every two hours.

Because it could be done in the MOV, and because it would keep the member's temperature from rising after blood replacement with the cooled perfusate, the decision was made at 15:00 hrs to attempt continuous perfusion of the member until the time for departure on the private air charter. An additional 30 liters of MHP2 perfusate were obtained from SA's California facility giving a total of 60 liters to be used. Once the cooling was finished the perfusionist would be instructed to drop the flow rate to 0.5L/min and the head pressure to 50 mmHg. Additionally, the perfusionist would utilize an E-cylinder of oxygen to match the L/min flow rate of perfusate.

The stabilization medications were prepared at 18:00 hrs and placed in a refrigerator for storage. The medications were prepared for a 150 lbs. patient and the full medications protocol was to be used.

The member's status remained unchanged for the rest of the day. The night shift nurse came on at 20:00 hrs and the nurse was brought up to speed on the situation. Overnight, one SA team member stayed at the home with the overnight caregiver and hospice nurse.

T-1 days

Alcor's MRD left at 07:00 hrs to return to Alcor. Alcor's SSD and the DART team members remained onsite to assist with SST.

The hospice case manager arrived at 08:00 hrs to perform the daily evaluation. The member's vitals were: HR 90/min, BP 93/60, RR 17/min, T 36.2°C, SpO_2 85% on room air, with periods of apnea. The member's urine output was 300 ml/24hr and was the color of dark amber. The member's feet and hands were still warm with no discoloration. The case manager increased the prescribed medications to 10 mg of morphine and 1 mg of Ativan every 2 hours as needed.

There was a noticeable decrease in the member's blood pressure to 75/52 at 13:00 hrs. The heart rate and SpO_2 were without change. The member's vitals were steady for the remainder of the afternoon. At 20:33 hrs there were long pauses of agonal breathing.

The primary care physician was ready to sign the death certificate at any hour of the night. The funeral director was also on call to submit the paperwork to obtain the transit permit. The SST team members would wait at the nearby airfield and be ready to load the patient onto the private plane once the transit permit was received.

At 22:00 hrs the member's BP was down to 59/37 with HR at 77/min, agonal RR at 16/min, SpO_2 of 78%, and the hands had begun to appear mottled. The two SA team members, the surgeon, the perfusionist, Alcor's SSD, and two DART team members all stayed at the home for the evening.

T-0 days

The attending nurse notified the team at 05:20 hrs that the member was close to cardiac arrest. The team took preplanned positions and prepared the equipment and medications for rapid deployment.

At 05:28 hrs the attending nurse placed a call to the coroner's office hoping that an alert of the pending cardiac arrest might result in a sense of urgency and help shorten the time it might otherwise take to get the cardiac arrest recorded and the patient released to the SST Team for stabilization. The coroner's office, however, recorded the time of the alert call as the official time of legal death, and relayed that the time of legal death had just been filed for the Death Certificate. Once off the phone, the nurse listened for additional heart sounds and declared the last heart sounds at 05:33 hrs. These attempts to be helpful were appreciated, but they resulted in the time of cardiac arrest at 05:33 hrs being recorded as after to the time of pronouncement at 05:28 hrs. These times were kept in this report, along with this explanation, since it was o the death certificate.

5. Stabilization

At 05:33 hrs the attending nurse granted the stabilization team access to the patient. Due to the tight hallways, it had earlier been planned that the SA team lead and the two DART team members would carry the patient from the bedroom to the PIB in the stabilization area using a transfer sling. At 05:34 hrs the patient was placed in the PIB with 5 gallons of water. There would be 5 team members available for the initial stabilization allowing many tasks to be performed simultaneously.

The patient's clothing was removed at 05:35 hrs while approximately 60 lbs. of water ice was added around the patient's head and the Autopulse chest compression device was placed around the patient's chest and started to improve external cooling. At 05:36 hrs approximately 80 lbs. of water ice was added to the PIB while a 41 French (Fr) Combi-tube airway was placed to allow ventilation of the lungs with room air, and the EZIO 25mm 15-gauge needle was placed in the right tuberosity for access to the vasculature so that stabilization medications could be administered.

The intubation detection bulb identified the blue tube to be the airway access on the Combi-tube. The CIM 900B capnograph, Zoll impedance threshold device was attached to the airway to monitor end-tidal carbon dioxide ($ETCO_2$) being expired to monitor the effectiveness of the cardiopulmonary support, and an AutoMedx SAVe ventilator was connected and initiated. The right and left thermocouple probes were placed at an approximate 10 cm depth in the patient's nares, secured, and was logging to separate HOBO temperature loggers. The nares were occluded with wax at 05:36 hrs and both the mouth and nose covered with Tegaderm to prevent water ingress into the nasopharynx, possibly affecting the temperature measurement.

Administration of the full medications protocol was initiated at 05:37 hrs using the right EZIO access. A slight bulge in the skin was noted at the EZIO site so a second EZIO 25mm 15-gauge needle was placed in the left tuberosity where the remaining medications were administered (for the names of the stabilization medications, the dosages, and the times of administration, see the below Table of Medications Administration).

The face mask was placed on the patient's face at 05:39 hrs to increase ice water circulation to the face and head, and the pump was initiated. An additional 30 lbs. of water ice was placed over

the patient at 05:40 hrs, and the recirculating tubing was coiled on top of the ice around the patient's abdomen at 05:41 hrs.

At 05:44 hrs an additional 90 lbs. of ice was added over the patient's body and 14 lbs. around the patient's head when the administration of medications was completed. The patient was covered with a privacy drape at 05:46 hrs. The patient was kept in the PIB in the stabilization area for external cooling. At 05:48 hrs in the MOV the perfusion circuit was primed, and the heat exchanger bath was set up with water and ice.

The Autopulse indicated low power at 06:05 hrs. At 06:14 hrs the battery was replaced in 30 seconds, while manual chest compressions were provided by another team member. The patient was then transferred to the MOV and prepped for surgery. During the transfer, the PIB hit a crack in the concrete that caused the patient to shift and the Autopulse to stop. Manual compressions were performed for 20 seconds, and the Autopulse was reset.

At 06:15 hrs the patient was loaded into the MOV with a right NPT of 31.7°C and left NPT of 29.5°C. The surgical tray was placed over the PIB, and a full drape was used to cover the patient. At 06:30 hrs the NPTs were 28.8°C on the left and 30.9°C on the right. The Autopulse was stopped so that the patient could be prepped for surgery.

6. Field Surgery and Washout

The first incision on the chest was made at 06:31 hrs and a Stryker sternal saw was used to divide the sternum. A spreader was used to open the chest, and the heart was exposed at 06:34 hrs. The ventilator was discontinued as the lungs were inflated and were obstructing the view of the heart. At 06:42 hrs the ascending aorta was cannulated with a 21 Fr. curved tip aortic canula and sutured with 2-0 proline. At 06:44 the inferior vena cava was cannulated through the right atrium with a 29/37 dual stage venous cannula and sutured with 2-0 proline.

The E-cylinder that was attached to the membrane oxygenator was turned on at 2 L/min. While attempting to fill the patient circuit lines and cannulae with MHP2 perfusate to prevent bubbles, the automated drive pump shut off at 06:47 hrs and produced no flow. A manual hand pump was attached to the circuit at 06:50 hrs to produce temporary flow. Open circuit perfusion began at 06:52 hrs at 2L/min in conjunction with trouble shooting the automated drive unit. At 06:56 hrs 250,000 IU of streptokinase, a thrombolytic used to break up existing blood clots, was added to the perfusion circuit.

At 07:00 hrs the automated drive unit was power cycled and tested for operation. At 07:01 hrs the patient circuit was re-attached to the automated drive unit and flow resumed at 2 L/min. At this time one of the SA team members noticed the perfusion temperature logger was not displaying clearly. The thermocouple probes were detached and connected to the additional ports on the nasopharyngeal temperature loggers.

At 07:08 hrs perfusion was switched to closed-circuit. The flow rate stayed at 2-2.5 L/min with cannula head pressures fluctuating between 88 mmHg and 60 mmHg.

At 07:21 hrs the flow was stopped to attempt deflation of the lungs and to look for possible leakage from the sutures around the cannulae. At 07:25 hrs flow was resumed but discontinued twice more to pinpoint where the leakage was originating. Flow was resumed at 07:28 hrs. Additional suturing of the cannulae was performed to minimize leakage.

At 07:40 hrs the oxygen was reduced to 1.5 L/min to match the perfusion flow. At 07:54 hrs the chest retractor was removed, and the sternum was closed with surgical wire with the cannulae still exposed. The chest skin was then closed.

At 08:08 hrs the perfusion flow was reduced to 1 L/min and the oxygen was adjusted to match. The PIB was secured for travel and the perfusionist prepared the equipment for departure to the airport. At 08:35 hrs the MOV left for the airfield and the perfusion flow and O_2 was reduced to 0.5 L/min.

7. Patient Transport

The team and the patient arrived at the airfield in the MOV at 09:15 hrs. The transit permit was in the process of being signed by the patient's attending physician. It would then be processed by the permit office.

The MHP2 perfusate was running low so flow was reduced to 0.35 L/min. Preparations were made to transfer the patient from the PIB into two body bags with bagged water ice for transport to Alcor. At 09:38 hrs the transit permit was being processed. The MHP2 perfusate was depleted and blood substitution was discontinued at 09:43 hrs. The cannulae were looped together into a circuit to prevent air ingress and at 09:52 hrs the patient was removed from the PIB and placed into two body bags.

The patient was moved to the aircraft at 10:04 hrs and 150 lbs. water ice was added to the body bags at 10:06 hrs. At 10:08 hrs the transit permit was issued, and the aircraft was prepared for departure. The aircraft took off from the California airfield at 10:17 hrs and landed at Scottsdale Municipal Airport at 11:20 hrs. The Alcor operating room (OR) had been prepped and the OR staff were waiting for the patient. The patient was transferred from the aircraft to the Alcor transport van at 11:28 hrs and departed for Alcor at 11:31 hrs.

8. Cryoprotectant Surgery and Perfusion

The patient arrived in the operating room (OR) at 11:41 hrs. The nasopharyngeal temperature (NPT) reading on the SST team's datalogger was 0.5°C. Ice bags were removed from around the patient, still in the PIB, to prepare for moving the patient to OR table. The patient was moved to OR table at 11:43 hrs. The data acquisition system was connected to the patient at 11:48 hrs, with the NPT thermocouple being placed in the left nare. The initial temperature reading was 2.1°C (see the Discussion section).

Ice bags were placed back around the patient's head and thorax at 11:48 hrs while the surgeon prepared the surgical instruments. The cannulae were still in place from the field washout. The surgical team began connecting the cannulae to the OR tubing circuit.

At 11:56 hrs the venous line was connected first to allow effluent to leave the patient. Air bubbles were removed from the tubing. The arterial line was connected at 11:58 hrs and air bubbles were removed. At 11:58 hrs the perfusion system was placed on open-circuit computer control. The arterial pressure was increased to 70 mmHg. There were 14 liters of B1 solution in the mixing reservoir.

Pulmonary edema was noted at 11:59 hrs by the surgeon (see the Discussion section). The M22 cryoprotectant ramp was started at 12:00 hrs. The arterial pump speed suddenly peaked at 12:01 hrs but no fluid loss to table was seen. The perfusion flow was excellent. With only 8 liters remaining in the mixing reservoir, at 12:04 hrs the circuit was switched to closed-circuit recirculation.

Incisions were made in the patient's scalp at 12:05 hrs for the bilateral burr holes that would allow the temperature of the brain and the shrink distance of the brain to be recorded. It was noted at 12:06 hrs that the tubing circuit return line was clearing, and the perfusion flow rate remained excellent. Bilateral burr holes were drilled at 12:07 hrs using a Codman perforator. Normal saline was poured over the site while drilling to cool the perforator and the skull.

A thermocouple was placed in the left burr hole at 12:10 hrs and ligated to the scalp. At 12:11 hrs a small amount of effluent was noted to be flowing from patient's mouth, most likely due to the pulmonary edema. The patient and the OR table were covered with plastic wrap at 12:17 hrs to improve external cooling with nitrogen gas. At 12:29 hrs 2800 ml of effluent had leaked from the patient's mouth to table and was discarded.

It was noted at 13:12 hrs that the skin around the eye sockets was dehydrating and the patient's skin in general was yellowing from contact with the M22 perfusate. This is normal and expected. Both corneas had not collapsed by 13:37 hrs.

The 30-minute pause for patient equilibration was initiated at 14:21 hrs. The refractive index reading from the venous line was 30.0 Brix and the target temperature was set to -3.0°C. At 14:34 hrs there was significant retraction of the lips above the teeth.

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 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.

At 14:49 hrs the cryoprotectant concentrate pump was turned on at full speed ending the 30-minute pause in increasing the cryoprotectant concentration for osmotic equilibration. The right cornea had retracted from dehydration at 14:55 hrs, but the left cornea had not. At 15:02 hrs it was noted that both corneas had collapsed. By 16:19 hrs the patient dehydration was uniformly dramatic.

The 30-minute countdown to termination of cryoprotectant perfusion was started at 16:36 hrs because the arterial cryoprotectant concentration was 52.9 Brix and the venous concentration was 51.5 Brix. The effluent had reached the [1.00] M22 concentration target of 51.5 Brix.

At 17:04 hrs the cryoprotectant perfusion ramp was terminated. The final refractive index readings were 52.5 Brix venous and 52.2 Brix arterial.

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% for over 30 minutes from both jugular veins. The addition pump speed is minimized, with frequent corrections, to compensate for latency.

9. Cooling to Liquid Nitrogen Temperature

All lines and equipment were removed from the patient. The patient was moved into the Patient Care Bay at 17:11 hrs for cryogenic cooldown. The patient was placed in the cooldown enclosure at 17:15 hrs.

Computer controlled cryogenic cooldown was initiated at 17:20 hrs on T-0 days, plunging to -110°C and descending thereafter at -1°C/hour to liquid nitrogen temperature. On T+5 days at 17:46 hrs, the cooldown was terminated. On T+17 days at 15:09 hrs the patient was transferred to long-term maintenance at liquid nitrogen temperature.

10. Timeline and Time Summaries

Timeline

T-0	05:28	Time of pronouncement of legal death
T-0	05:33	Time of cardiac arrest
T-0	05:34	Start of ice bath cooling
T-0	05:35	Start of chest compressions
T-0	05:36	Placement of first IO (right tuberosity)
T-0	05:36	Placement of airway
T-0	05:37	Placement of second IO (left tuberosity)
T-0	05:37	Administration of first medication (propofol)
T-0	06:15	Transport patient to MOV for surgery
T-0	06:30	Termination of cardiopulmonary support (LNPT 28.8°C)
T-0	06:31	Start of field surgery (median sternotomy)
T-0	06:51	End of surgery
T-0	06:52	Start of open circuit washout
T-0	07:08	Start of closed-circuit perfusion
T-0	07:10	Administration of final medication (Vital-Oxy)
T-0	08:35	Departure of transport vehicle to airport
T-0	09:43	Completion of closed-circuit perfusion
T-0	10:04	Patient moved into aircraft awaiting transit permit
T-0	11:41	Arrival of patient at Alcor OR (NPT = 0.5°C)
T-0	11:48	NPT probes attached to data acquis. system (NPT=2°C)
T-0	11:54	Connect venous cannula to tubing circuit
T-0	11:56	Connect arterial cannula to tubing circuit
T-0	11:58	Circuit on computer control
T-0	12:00	Start of cryoprotectant ramp
T-0	12:05	Start of surgery at Alcor (start burr holes)
T-0	12:07	Completion of burr hole surgery
T-0	14:21	Pause at 50% of CNV achieved
T-0	14:49	Off pause with sub-zero terminal concentration ramp
T-0	16:36	Start 30-minute countdown to termination of ramp
T-0	17:04	Termination of cryoprotection (V=52.5 Brix, A=52.2 Brix)
T-0	17:20	Start of cryogenic cooldown
T+5	17:46	Completion of cryogenic cooldown
T+17	15:09	Transfer of patient to long-term care at LN2 temp.

Time Summaries

Event Duration hr:min		days	time	
FIELD STABILIZATION				
00:00	From:	T-0	05:33	Time of cardiac arrest
	Till:	T-0	05:33	Time of pronouncement of legal death
00:01	From:	T-0	05:33	Time of cardiac arrest
	Till:	T-0	05:34	Start of ice bath cooling
00:02	From:	T-0	05:33	Time of cardiac arrest
	Till:	T-0	05:35	Start of chest compressions
00:04	From:	T-0	05:33	Time of cardiac arrest
	Till:	T-0	05:37	Administration of first medication (propofol)
01:33	From:	T-0	05:37	Administration of first medication (propofol)
	Till:	T-0	07:10	Administration of final medication (Vital-Oxy)
FIELD SURGERY AND WASHOUT				
00:58	From:	T-0	05:33	Time of cardiac arrest
	Till:	T-0	06:31	Start of field surgery (median sternotomy)
00:20	From:	T-0	06:31	Start of field surgery (median sternotomy)
	Till:	T-0	06:51	End of surgery
01:19	From:	T-0	05:33	Time of cardiac arrest
	Till:	T-0	06:52	Start of open circuit washout
02:51	From:	T-0	06:52	Start of open circuit washout
	Till:	T-0	09:43	Completion of closed circuit perfusion
04:10	From:	T-0	05:33	Time of cardiac arrest
	Till:	T-0	09:43	Completion of closed circuit perfusion
CRYOPROTECTANT SURGERY AT ALCOR				
06:08	From:	T-0	05:33	Time of cardiac arrest
	Till:	T-0	11:41	Arrival of patient at Alcor OR (NPT = 0.5°C)
00:24	From:	T-0	11:41	Arrival of patient at Alcor OR (NPT = 0.5°C)
	Till:	T-0	12:05	Start of surgery at Alcor (start burr holes)
00:02	From:	T-0	12:05	Start of surgery at Alcor (start burr holes)
	Till:	T-0	12:07	Completion of burr hole surgery

CRYOPROTECTANT PERFUSION AT ALCOR				
06:27	From:	T-0	05:33	Time of cardiac arrest
	Till:	T-0	12:00	Start of cryoprotectant ramp
00:19	From:	T-0	11:41	Arrival of patient at Alcor OR (NPT = 0.5°C)
	Till:	T-0	12:00	Start of cryoprotectant ramp
00:06	From:	T-0	11:54	Connect venous cannula to tubing circuit
	Till:	T-0	12:00	Start of cryoprotectant ramp
05:10	From:	T-0	11:54	Connect venous cannula to tubing circuit
	Till:	T-0	17:04	Termination of cryoprotection (V=52.5 Brix, A=52.2 Brix)
05:04	From:	T-0	12:00	Start of cryoprotectant ramp
	Till:	T-0	17:04	Termination of cryoprotection (V=52.5 Brix, A=52.2 Brix)
CRYOGENIC COOLDOWN AT ALCOR				
00:16	From:	T-0	17:04	Termination of cryoprotection (V=52.5 Brix, A=52.2 Brix)
	Till:	T-0	17:20	Start of cryogenic cooldown
11:47	From:	T-0	05:33	Time of cardiac arrest
	Till:	T-0	17:20	Start of cryogenic cooldown
05:39	From:	T-0	11:41	Arrival of patient at Alcor OR (NPT = 0.5°C)
	Till:	T-0	17:20	Start of cryogenic cooldown

11. Table of Medications Administered

T-0 days

TIME	MEDICATION	DOSE	PURPOSE
05:37 hrs	Propofol	200 mg	Anesthetic; reduces cerebral metabolic demand; reduces the theoretic possibility of increased awareness during aggressive CPS.
05:37 hrs	Sodium citrate	50 mg 1st dose Note 1	Anticoagulant; prevents blood clot formation.
05:38 hrs	Sodium citrate	50 mg 2nd dose Note 1	Anticoagulant; prevents blood clot formation.
05:38 hrs	Heparin	50,000 IU	Anticoagulant; prevents blood clot formation.
05:38 hrs	Vasopressin	80 IU Note 2	Vasopressor; increases blood pressure during CPS.
05:39 hrs	Minocycline	200 mg	Antibiotic and neuroprotectant
05:39 hrs	SMT (S-methyl-isothiourea)	400 mg Note 4	Neuroprotectant (iNOS inhibitor); protects the brain from ischemic injury; raises blood pressure.
05:40 hrs	Decaglycerol/THAM	400 cc total (1st dose 50 cc) Note 5	Decaglycerol inhibits cerebral edema.
05:40 hrs	Antacid	250 cc total (1st dose 50 cc) Note 6	A buffer used to protect the stomach from acid erosion.
05:40 hrs	Decaglycerol/THAM	400 cc total (2nd dose 50 cc) Note 5	Decaglycerol inhibits cerebral edema.
05:40 hrs	Antacid	250 cc total 2nd dose 50 cc) Note 6	A buffer used to protect the stomach from acid erosion.
05:40 hrs	Decaglycerol/THAM	400 cc total (3rd dose 50 cc) Note 5	Decaglycerol inhibits cerebral edema.
05:41 hrs	Decaglycerol/THAM	400 cc total (4th dose 50 cc) Note 5	Decaglycerol inhibits cerebral edema.
05:41 hrs	Vital Oxy (w/ saline)	70 mL total Note 7	Antioxidants: melatonin, vitamin E (D-alpha tocopherol), PBN (alpha Phenyl t-Butyl Nitrone) and anti-inflammatory carprofen.
05:42 hrs	Antacid	250 cc total (3rd dose 50 cc) Note 6	A buffer used to protect the stomach from acid erosion.

05:42 hrs	Antacid	250 cc total (4th dose 50 cc) Note 6	A buffer used to protect the stomach from acid erosion.
05:42 hrs	Antacid	250 cc total (5th dose 50 cc) Note 6	A buffer used to protect the stomach from acid erosion.
05:42 hrs	Decaglycerol/THAM	400 cc total (5th dose 50 cc) Note 5	Decaglycerol inhibits cerebral edema.
05:43 hrs	Decaglycerol/THAM	400 cc total (6th dose 50 cc) Note 5	Decaglycerol inhibits cerebral edema.
05:43 hrs	Decaglycerol/THAM	400 cc total (7th dose 50 cc) Note 5	Decaglycerol inhibits cerebral edema.
05:44 hrs	Decaglycerol/THAM	400 cc total (8th dose 50 cc) Note 5	Decaglycerol inhibits cerebral edema.
06:56 hrs	Streptokinase	250,000 IU Note 8	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 received 20 grams of sodium citrate because the patient's weight was over 40 kg.

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. The patient's nasopharyngeal temperature was 37°C and met the requirement for the second dose, but the total dose was given at the same time rather than the second dose being given concurrently with Vital-Oxy.

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. An antacid can be given in several doses, totaling 250 mL, and inserted through the nasogastric tube in an airway.

6. 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.

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. 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

When the patient arrived in the OR at 11:41 hrs, the SST team's datalogger showed the nasopharyngeal temperature (NPT) to be at 0.5°C. At 11:48 hrs when the OR data acquisition system was connected to the patient, the initial temperature reading was 2.1°C. It is common for loggers to be offset by 1 or 2°C and the temperature step from 0.5°C to 2.1°C 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.

Cryoprotectant Surgery and Perfusion at Alcor

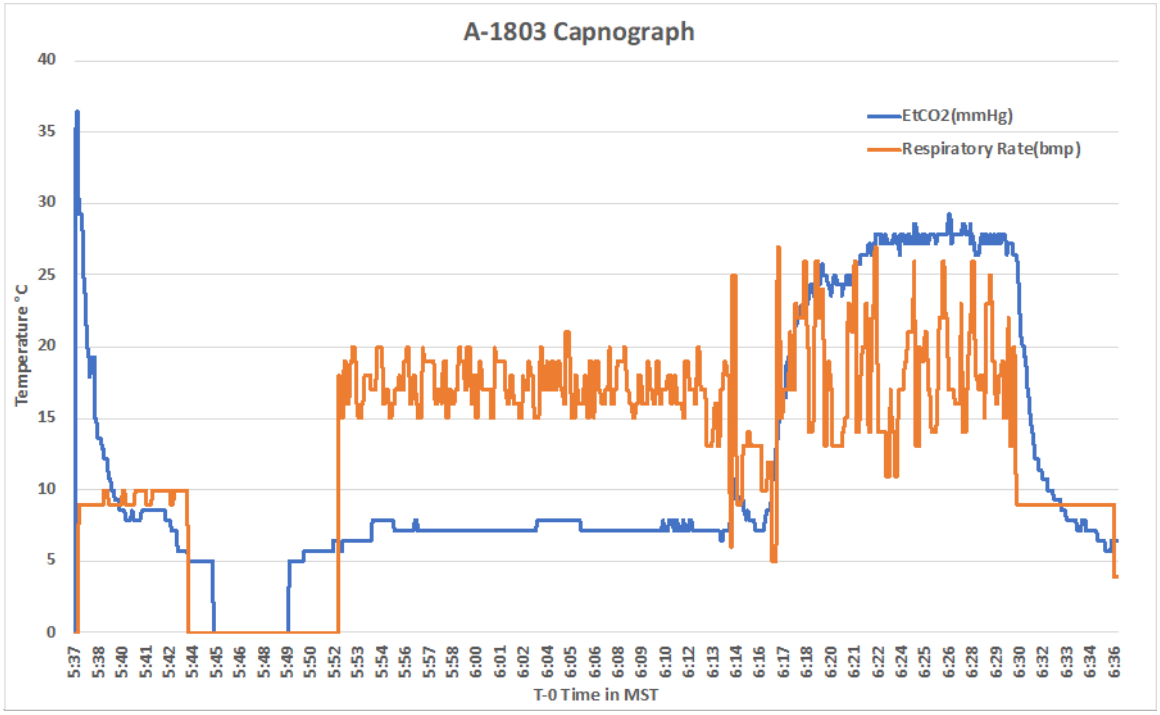
In this case, no initial M22 bolus was indicated, nor introduced into the circuit. The cryoprotectant ramp was run per the normal protocol. The patient's circulatory system showed no outward signs of brain or body edema, noted by the incredibly high initial main pump flow rate required to maintain a rather low 70mmHg computer-controlled arterial pressure. It was noted however that the lungs became edematous during the procedure, causing a percentage of the cryoprotectant perfusate to be lost to the table, but this did not negatively affect perfusion. Refractive index readings indicated good perfusate uptake.

The pressure signals for both the arterial and venous cannulas are sampled via Luer-ported straight adapters which connect each cannula to the supply or return tubing, so we are sampling the pressure at the ends of the cannulas external to the body. The graph traces do not account for pressure drop across the cannulas.

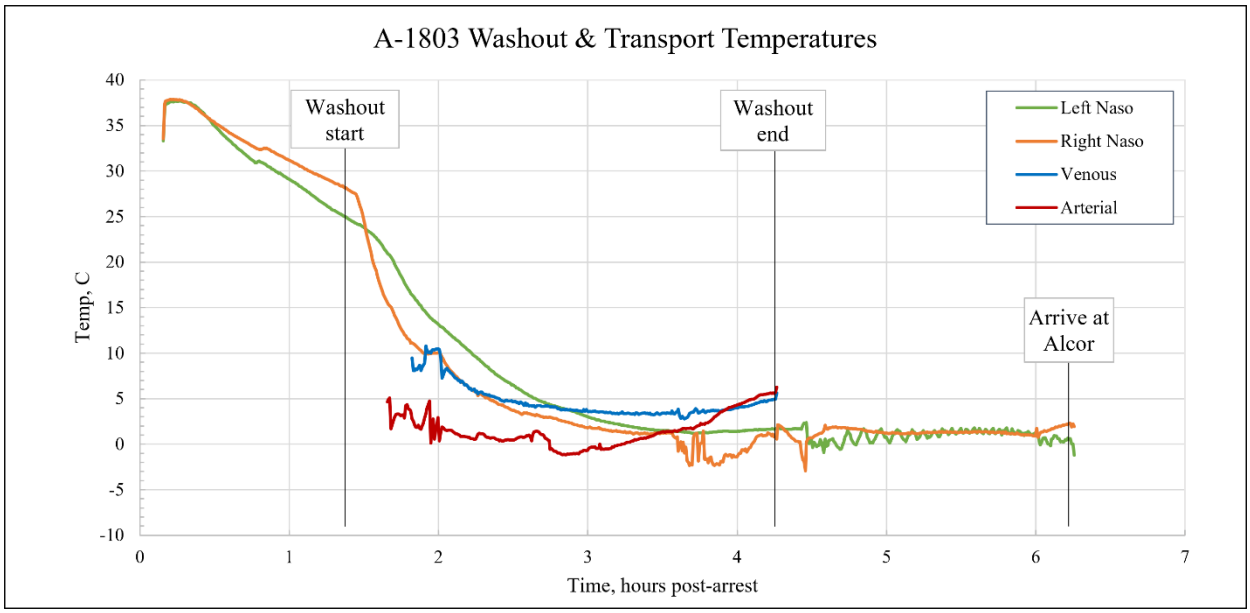
The venous return line connects to the mixing reservoir at a lower elevation and so acts a siphon; the negative pressure trace represents the negative head pressure between the exterior end of the venous cannula and the mixing reservoir. If fluttering or poor return flow are observed, either the table height or the reservoir height will be adjusted by the perfusionist until normal flow resumes. Ideally the height difference should be adjusted to almost cause fluttering because this will minimize venous pressure, maximize arterial flow, and minimize tissue and pulmonary edema. This is particularly important when the arterial flow rate is high, as it was in this case.

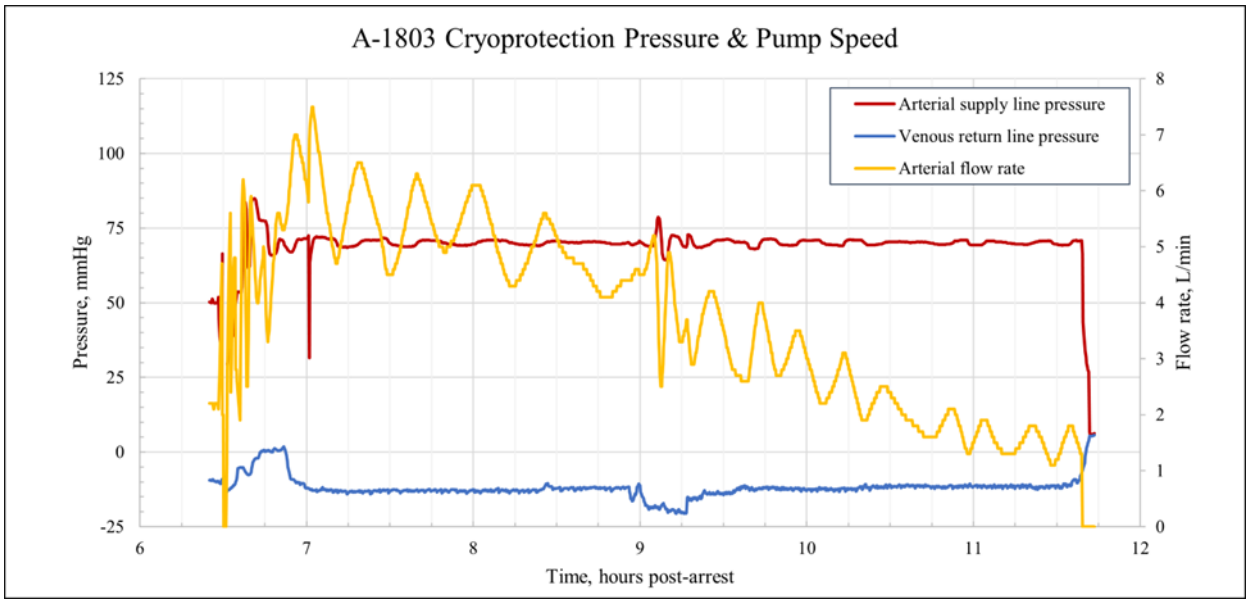
13. Cryoprotection and Temperature Graphs

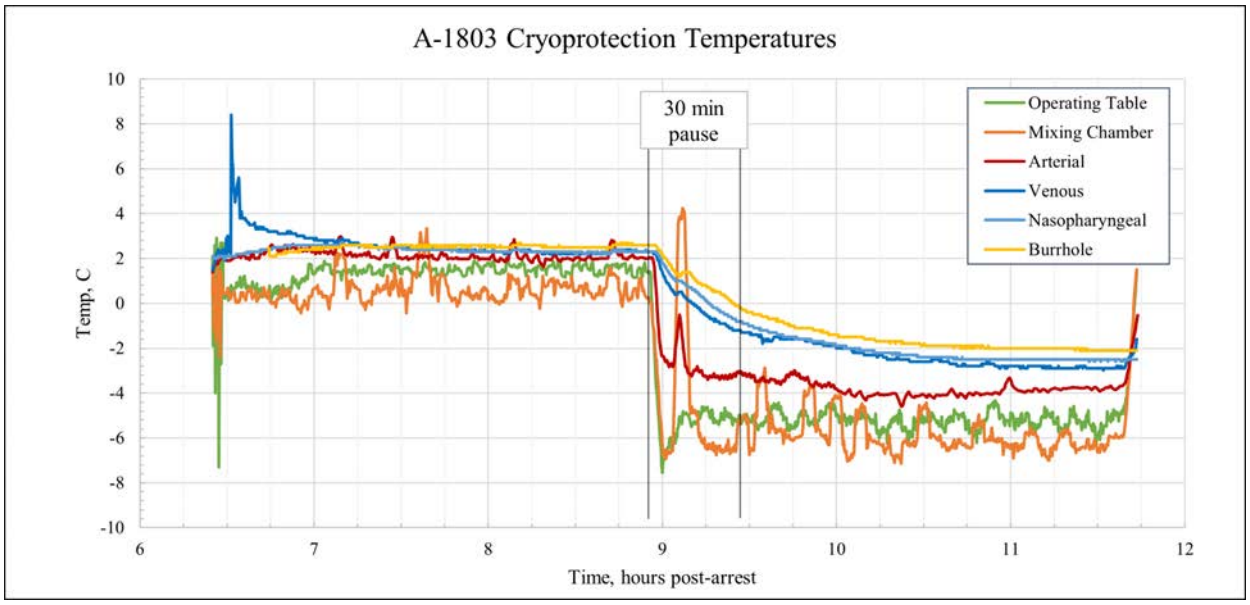
Graphs provided by SA:

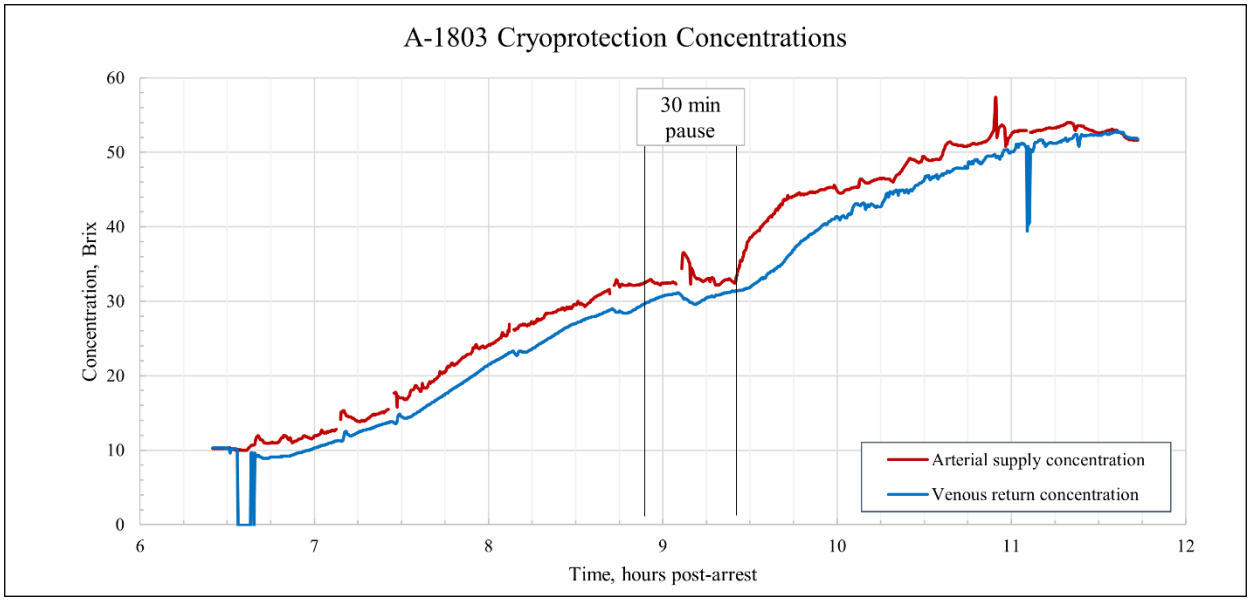


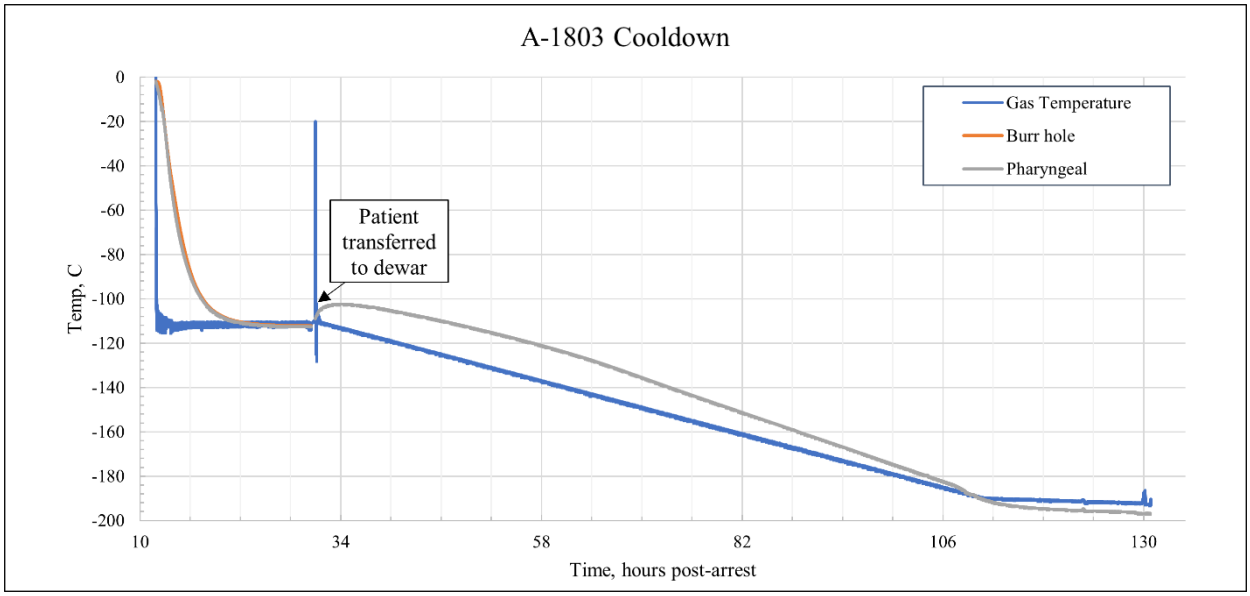
Graphs provided by Alcor:



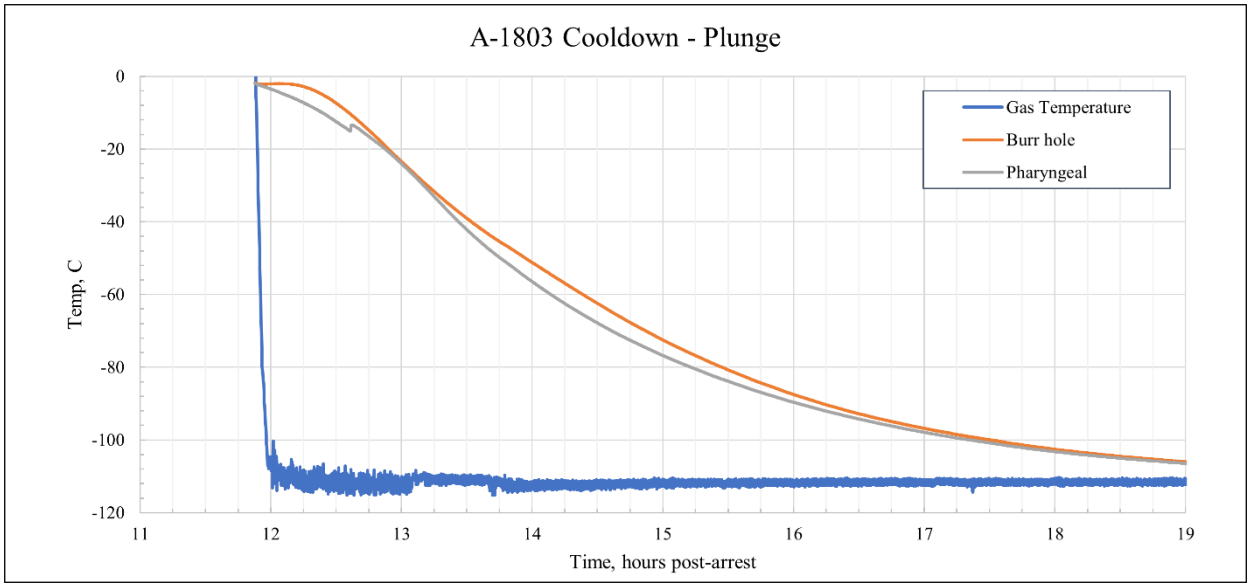

A-1803 Cryoprotection Pressure & Pump Speed
Arterial supply line pressure
Venous return line pressure
Arterial flow rate
Pressure, mmHg
Flow rate, L/min
Time, hours post-arrest
125
100
75
50
25
0
-25
8
7
6
5
4
3
2
1
0
6
7
8
9
10
11
12

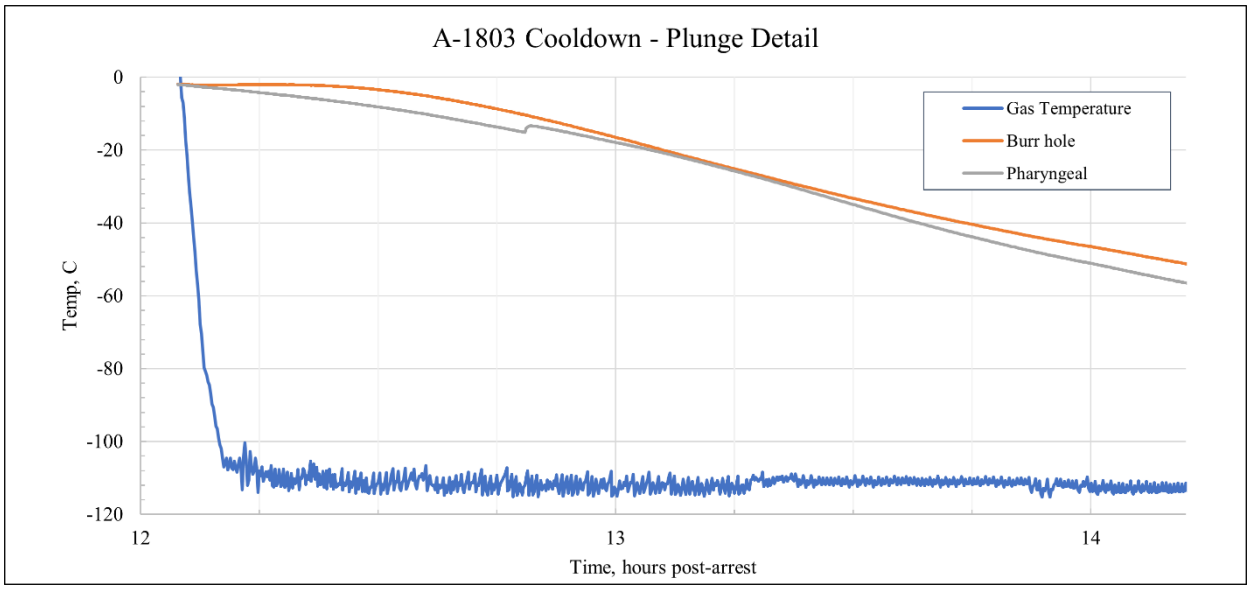

A-1803 Cryoprotection Temperatures
30 min pause
Operating Table
Mixing Chamber
Arterial
Venous
Nasopharyngeal
Burrhole
Temp, C
Time, hours post-arrest
10
8
6
4
2
0
-2
-4
-6
-8
-10
6
7
8
9
10
11
12





The patient was transferred from the horizontal cooldown box to the TallBoy dewar at 11:56 hrs on T+1 days to continue cooldown to liquid nitrogen temperatures. A spike is observed in the gas temperature as the receiving dewar was insufficiently pre-chilled. This resulted in slight rewarming of the patient from -110°C to -104°C before cooling resumed, and the cooldown proceeded uneventfully until completion.





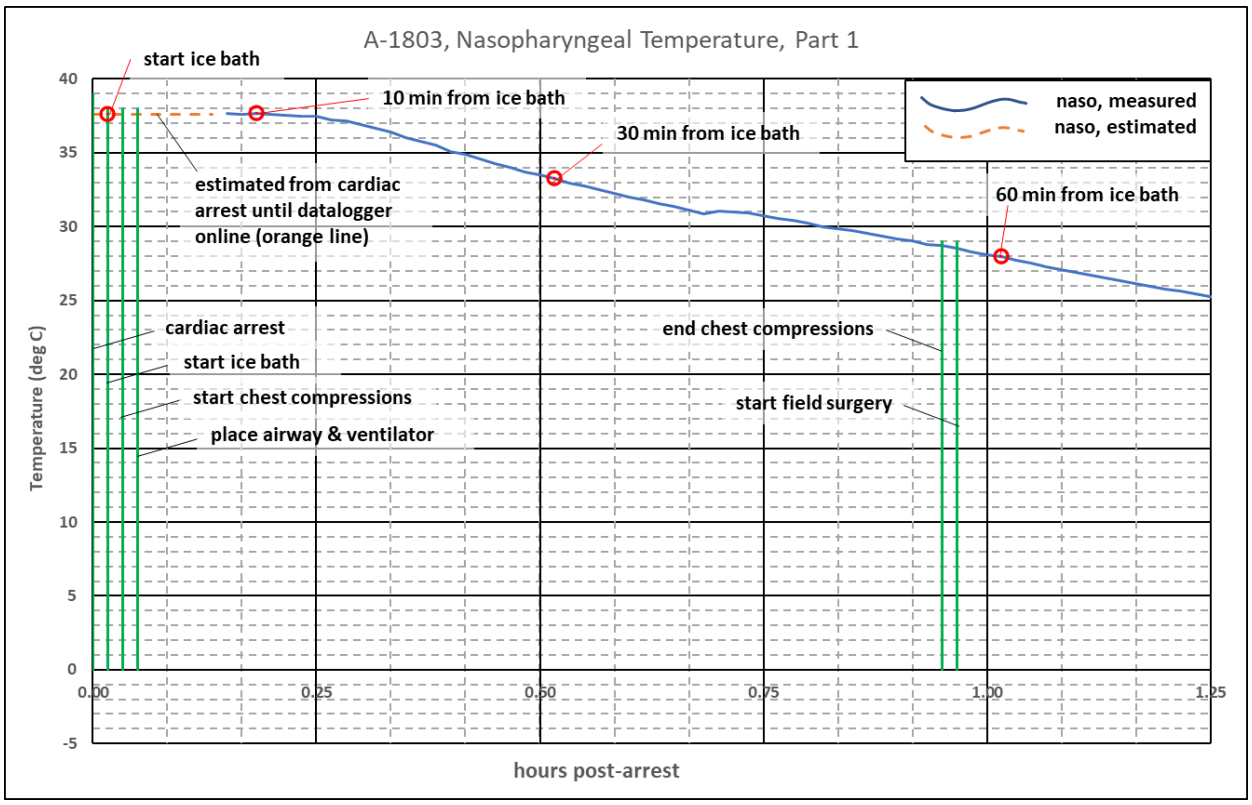
A moment of anomalous warming is observed in the nasopharyngeal temperature curve; this is not interpreted as an isotherm. The cause of the anomaly is unknown.

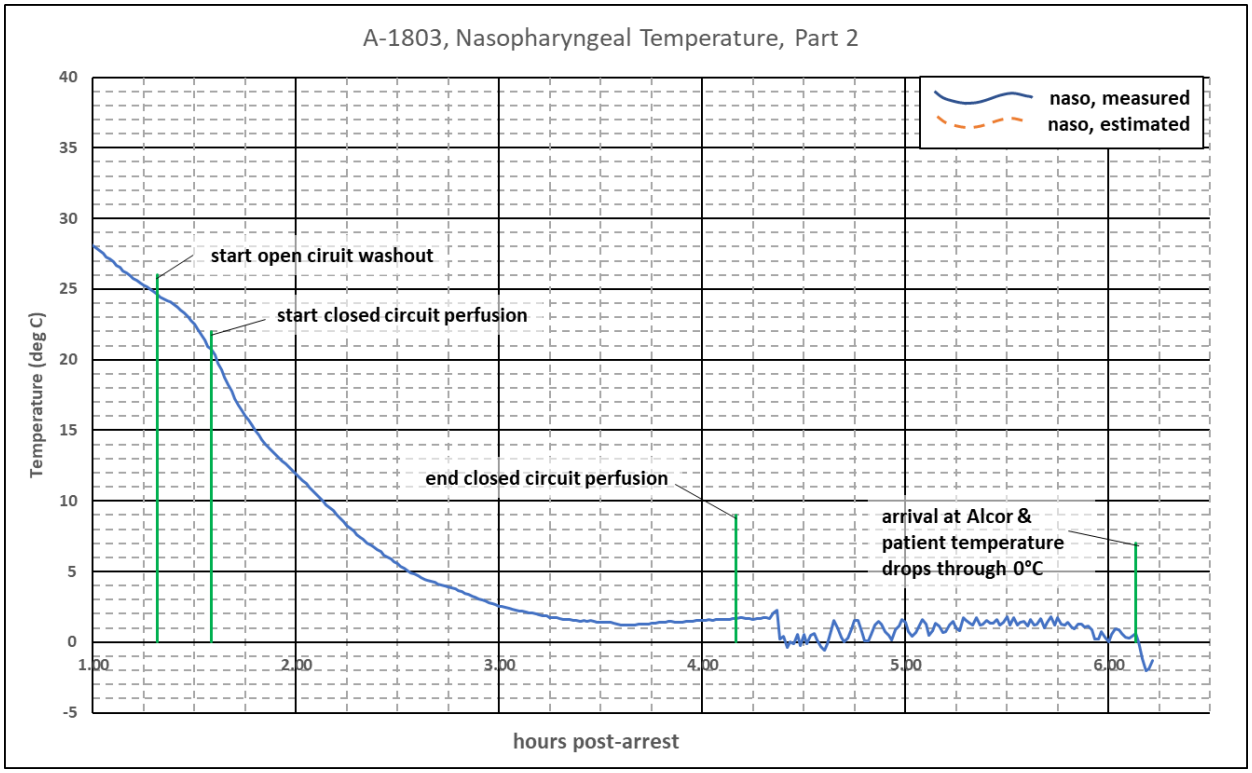
14. S-MIX

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 06:09. As shown below, and due to lowering of the body temperature, S-MIX duration is shorter, at 00:46.

event	segment #	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	05:33	00:00	37.6			
	seg 1		00:01	00:01	0.0	no	no	00:01
Start of ice bath cooling		T-0	05:34	00:01	37.6			
	seg 2		00:01	00:01	0.0	no	no	00:01
Start of chest compressions		T-0	05:35	00:02	37.6			
	seg 3		00:01	00:01	0.0	no	no	00:01
Placement of airway with ventilator		T-0	05:36	00:03	37.6			
	seg 4		00:54	00:54	-8.9	yes	no	00:22
Termination of cardiopulmonary support		T-0	06:30	00:57	28.7			
	seg 5		00:01	00:01	-0.2	no	no	00:01
Start of field surgery		T-0	06:31	00:58	28.5			
	seg 6		00:21	00:21	-3.9	no	no	00:10
Start of open circuit washout		T-0	06:52	01:19	24.7			
	seg 7		00:16	00:16	-3.9	no	yes	00:00
Start of closed circuit perfusion		T-0	07:08	01:35	20.8			
	seg 8		02:35	02:35	-19.1	no	yes	00:00
Completion of closed circuit perfusion		T-0	09:43	04:10	1.7			
	seg 9		01:58	01:58	-1.1	no	no	00:010
Arrival of patient at Alcor OR		T-0	11:41	06:08	0.6			
totals:			06:08	06:08	-37.0			00:46

The below plots show events related to the S-MIX calculation. 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.

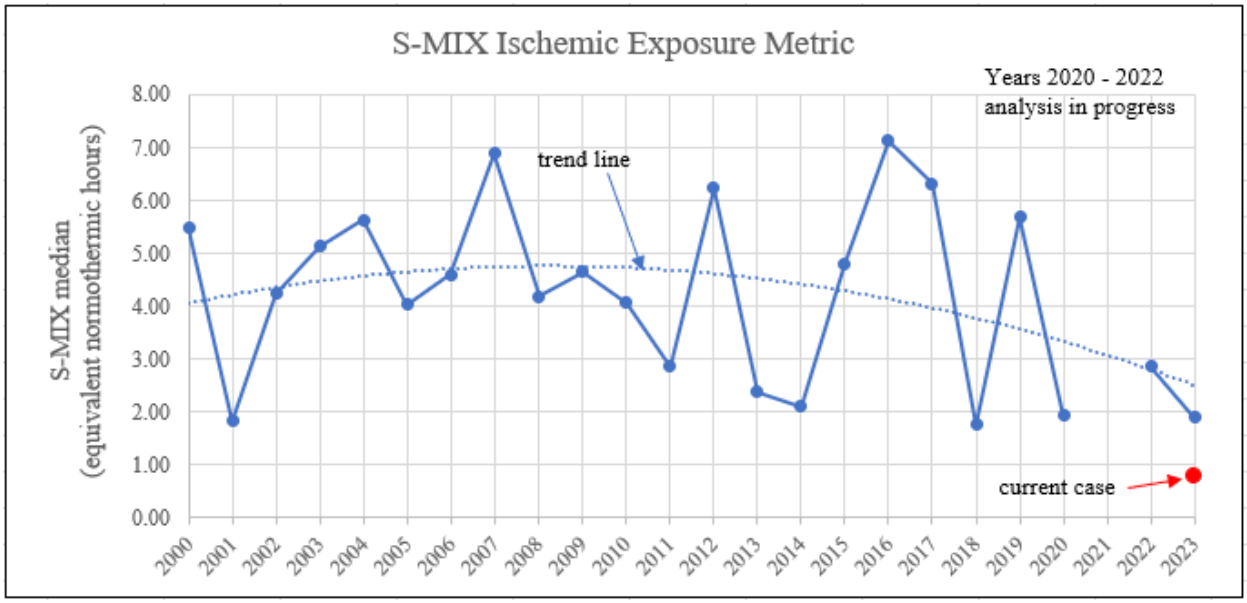




The below table provides cooling data for 10, 30, and 60 minutes after the team first applies water ice.

Patient Cooling Rate			(patient weight 66 kg; 145 lb)	
Note: time = 0 at start of ice bath	0 min elapsed	10 min elapsed	30 min elapsed	60 min elapsed
Naso temperature (°C)	37.6	37.7	33.3	28.0
Temperature drop (°C) from t = 0	0.0	0.1	-4.4	-9.7
Cooling rate (°C/min) from t = 0	N/A	0.01	-0.15	-0.16

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 prior to this report being published. However, when the CT scanner is viable and whole body patients are being scanned, additional information will be added to this report.