Alcor A-2296

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-2296 was a 72-year-old member with whole body cryopreservation arrangements. The member had reported no health problems and was not on the Alcor Watch List but was in the ICU with breathing problems. Cardiac arrest occurred at 04:10 hrs on T-0 days and the member was pronounced legally deceased in California at 04:11 hrs on T-0 days in 2023.

After stabilization and field washout, the patient was driven to Alcor for cryoprotectant perfusion. The patient arrived at Alcor at 14:59 hrs on T-0 days. The cryogenic cooldown was initiated at 20:08 hrs on T-0 days and terminated on T+5 days at 02:12 hrs. The patient was transferred to long-term care at liquid nitrogen temperature on T+75 days at 12:55 hrs.

2. Patient Assessment

T-5 days

Alcor received notice from the emergency answering service at 18:26 hrs about a member in distress. A person claimed to be the patient's Medical Power of Attorney (MPOA) but was later determined not to have that qualification. This person will be referred to as the "not Medical Power of Attorney (nMPOA)" for an Alcor member. The nMPOA had reported that the member was in the Intensive Care Unit (ICU) of a local hospital and was on full respiratory support. Alcor's Medical Response Director (MRD) called the nMPOA to gather additional information.

Two days earlier the member had dialed 9-1-1 with a severe breathing problem. When EMS (Emergency Medical Services) arrived, the member was found unresponsive. The member was intubated and taken to the hospital. The member was at the time of admission on full ventilation support, showed no response to painful stimuli, but had a positive Babinski sign (which can indicate an underlying issue in the central nervous system).

The nMPOA was not sure if vasopressors were being used and was not aware of the corneal reflex status. The doctors had informed the nMPOA that the prognosis was poor and the outcome most likely to be fatal. The MRD asked about any advance directives of the member, to which the nMPOA replied that the member only wanted to be kept alive to allow Alcor to arrive and prepare for cryopreservation, after which care should be withdrawn to allow for cryopreservation. No vital signs were available.

3. Deployment

The Alcor Deployment Committee met and decided at 19:10 hrs to deploy Alcor's MRD, Social Services Director (SSD), and Suspended Animation (SA), one of Alcor's strategic partners for providing standby, stabilization, and transport (SST) as well as remote blood substitution. SA prepared for deployment and contacted their contract cardiothoracic surgeon and perfusionist, and a funeral home near the member, to assist with the transit permit and death certificate.

T-4 days

The SSD departed Phoenix in the Alcor transport vehicle at 09:30 hrs. The MRD left Phoenix by air at 10:50 hrs and was met by an SA team member at 12:15 hrs and was driven to the local hospital, arriving at 12:35 hrs. The other four SA team members had arrived at the hospital in their mobile operating vehicle (MOV) at about 11:30 hrs and arranged to park the vehicle in the main entrance loading bay. The Alcor team met with the member's nurse, the ICU charge nurse, the ICU unit manager, and the hospital social worker at 14:37 hrs. The member's advanced directives were discussed, and all medical personnel agreed to allow the ice bath and the attached equipment, along with all other stabilization equipment, to be placed in the patient's private room for standby readiness.

4. Standby

At about 15:00 hrs, SA contacted hospital security and was given authorization to park the MOV in the long-term ambulance parking lot and received permission to stay there while the stabilization procedure was performed. At 17:00 hrs the equipment was brought up to the member's room.

A nurse informed the Alcor team that the member had been in cardiac arrest upon arrival and required cardiopulmonary resuscitation (CPR) during transport to the hospital making this a potential Medical Examiner's (ME) case. The nurse also informed the Alcor team that the person Alcor thought was the MPOA was not, nor was the hospital treating him as such. Instead, they had been using a two physician consent procedure if decisions about care were needed. At 18:38 the nurse informed the Alcor team that the physicians had not made a decision regarding withdrawal of care and that they were waiting on their legal department to make a decision.

The member was hypertensive with a blood pressure (BP) of 210/100, heart rate (HR) 140 per minute, respiratory rate (RR) 20 per minute. The nurse reported no reaction to painful stimuli, decerebrate posturing in the bilateral lower extremities, flaccid bilateral upper extremities, sluggish pupillary response, no cough, and no gag reflex.

T-3 days

The patient remained unresponsive but stable. At 11:50 hrs, the hospital legal team made the decision to allow Alcor to proceed. However, one of the signing physicians had reservations about removing care. The nurse manager tried to take the decision up the chain of command but was unsuccessful. The attending physician wanted to perform an MRI for "brain activity", but the member had a spinal cord stimulator that might not be compatible with the MRI.

The member's Advance Directive did not mention brain death as a criteria to terminate care, but did state that an "imminent coma" would not be desirable. The Alcor team, the member's attorney, and an assistant were prepared to help carry out the member's wishes.

The ICU unit manager informed the Alcor team at 12:23 hrs that the physicians had decided to withdraw care earlier than originally agreed upon. Due to weekend transit permit acquisition obstacles, the team requested that the physicians wait until Monday to change to comfort care. The member's physicians did agree to wait until Monday to withdraw care.

At 13:48 hrs the member was on a 5 mcg/min drip of Cardene for the hypertension, was over breathing the vent at 24 (vent set to 20), and the member was being trickle fed. The vital signs were HR 130/min, BP 144/83, capillary oxygen saturation (SpO_2) 94%, temperature (T) 38°C, and RR 24/min. The member was in A-fib (a fast and irregular heartbeat), and was making extra urine, at >2L/12 hours.

It was decided that SA would remain with the member and that the MRD and the SSD would return to Arizona until needed again. At 19:00, the PIB and other equipment was removed from the member's room. The Alcor transport vehicle was left in SA's custody while the two Alcor representatives flew back to Phoenix. SA would be contacting the nursing staff twice a day for updates on the member's status.

T-2 days

The patient was checked both in the morning and late evening and the health status had not changed. The nurses were all fully briefed on the situation and agreed to let Alcor know if anything changed.

T-1 days

The MRD learned from the nurse at 10:57 hrs that the physician had spoken to a bioethics consultant who recommended withdrawing care, possibly immediately instead of on Monday as previously agreed, and ordered comfort care only. The member was still stable and on the ventilator. Vital signs and medications remained unchanged.

At 12:13 hrs the MRD spoke with the lead nurse, social worker, and attending nurse. The physician was set to remove care that afternoon. The MRD requested that care be removed as late as possible.

The team organized to be on site at 15:30 hrs including the MRD and SSD. The SA surgeon and perfusionist were scheduled to arrive by air at midnight. Stabilization medications were drawn at 17:40 hrs for the patient who weighed 77.3 kg. At 18:30 hrs the team staged the PIB and additional stabilization equipment. SA spoke with the attending physician at 19:30 hrs and arranged to have the removal of care order be placed when the surgeon and perfusionist arrive at the hospital.

5. Stabilization

T-0 days

The SA surgeon and perfusionist arrived at 01:15 hrs. Medical care had been removed from the member at 12:45 hrs. The PIB was primed with 20 lbs. of water ice and 1.5 gallons of water, and stabilization medications were placed in an ice chest beside the PIB. The member experienced cardiac arrest at 04:10 hrs, was pronounced legally deceased at 04:11 hrs, and access was given to the Alcor team to perform the initial stabilization in the patient's room. There were two SA team members and two Alcor team members available for the initial stabilization so many tasks were performed simultaneously.

The patient was transferred into the PIB at 04:12 hrs to start external cooling. Approximately 70 lbs. of water ice was placed on the patient's head and torso. The Autopulse chest compression bands were placed, and the device was activated to improve cooling but failed to initiate compressions. Manual compressions were implemented at 04:13 hrs. Troubleshooting the Autopulse was attempted and then abandoned at 04:14 hrs as there were four team members available to provide manual compressions and other stabilization tasks.

At 04:15 hrs an attempt was made to administer the stabilization medications through the patient's central line that had been left in place by the hospital, to minimize ischemic damage. The team member delivering the medications had difficulty attaching the syringes to the ports, some of the medications were delivered out of order and outside the guidelines of the administration protocol, and the central line access was flowing slower than optimal for delivering the larger quantities of medications (see the Discussion section regarding this issue and 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 04:15 hrs with a 37 French (Fr) Combi-tube airway to allow ventilation. The Ambu Tubechek esophageal intubation detector verified the placement was correct. At 04:16 hrs the AutoMedx SavII was initiated with a Zoll impedance threshold device to provide mechanical ventilation, and the CMI-900 capnograph was attached to measure the partial pressure of carbon dioxide in the exhaled breath expressed as CO_2 concentration over time.

The left and right nasopharyngeal probes were placed and secured. An additional 20 lbs. of water ice was applied to the patient's head, the surface conduction cooling device (SCCD) mask was applied, and Tegaderm was secured around the patient's mouth and nose to keep water from entering and interfering with correct temperature readings. An additional gallon of water was added to the PIB, and the recirculating pump began to flow. An additional 14 lbs. of water ice was added to the patient's head. A last attempt to troubleshoot the Autopulse was performed and then abandoned in favor of giving attention to other procedures.

The patient's central line was flowing too slowly for adequate medication administration, and the decision was made to establish an intraosseous device (IO) in the patient's right tuberosity. At 04:21 hrs the IO was established, and the subsequent medications were administered through both the IO and the central line. During this time manual compressions were being given by rotating team members and an additional 2 gallons of water were added to the PIB for the recirculation pump.

At 04:28 hrs the patient was covered with a privacy drape while still in the PIB. The patient was removed from the hospital while manual compressions continued, with team members alternating. At 04:33, the patient was loaded into the MOV. An additional 35 lbs. of water ice was added to the patient's head and body.

The MOV was not parked on level ground and the head of the PIB was lower than the foot. Therefore, the water in the PIB was not flowing back to the recirculation pump. Additional ice was added to the PIB to increase the volume and to displace water and improve the recirculation pump flow. At 04:46 hrs, the PIB was lifted and an MHP2 pelican case was positioned under the head of the bath to allow water to return to the recirculation pump. The Ice bath slipped off the pelican case at 04:47 and was then repositioned more centrally onto the pelican case at 04:48 hrs.

The perfusion circuit was connected to the SCPC (superior cavopulmonary connection) centrifugal heart lung machine, and to the 5L/min air pump, and was primed and chilling during the loading procedure. At 04:45 hrs the surgeon had begun preparing for surgery. The ice bath was rotated diagonally to give room for the surgeon on the patient's right side. At 04:51 hrs, the patient was rolled to allow ice under the back to level out the body. At 04:57 hrs, manual compressions were halted to allow surgery to begin.

6. Field Surgery and Washout

Alcor's MRD took the role of assistant to the thoracic surgeon. The SA team lead assisted with the delivery of equipment and miscellaneous assistance for the duration of the perfusion.

The perfusion procedure was performed with the patient in the PIB. Surface cooling continued until the patient's nasopharyngeal temperature (NPT) was 25°C. The chest was prepped, and sterile drapes were placed. At 04:58 hrs a standard median sternotomy incision was made, and it was noted that the patient had had a prior sternotomy. The sternal wires were removed, and the sternum was divided at 05:04 hrs with a standard non-oscillating saw.

The underlying structures did not appear to have been injured, but when the sternal retractor was inserted, there was a sudden brisk hemorrhage from the anterior right ventricle. The bleeding was too voluminous to define the source, much less to repair the injured structure. Thus, the wound was forcibly packed with multiple laparotomy pads, slowing the bleeding somewhat. The surgeon decided at 05:06 hrs to convert to femoral cannulation and perfusion.

The patient drapes were shifted, and a longitudinal incision was made at 05:07 hrs over the right groin vessels, which were exposed and found to be of good quality. A total of four 2-0 silk sutures were placed proximally and distally around both the femoral artery and femoral vein.

A 21 French (Fr) venous cannula was placed and secured at 05:27 hrs. At 05:28 hrs a 21 Fr arterial cannula was placed and secured. At 05:30 hrs the arterial cannula was connected to the perfusion circuit, and at 05:31 hrs the venous cannula was connected. Open circuit blood substitution was initiated at 05:32 hrs using MHP2 perfusate in bladders hung from the ceiling of the MOV.

After the start of open circuit perfusion, leakage in the sternal opening was noticed. At 05:34 hrs the surgeon began to investigate the cause of the leakage in the chest, and at 05:35 hrs the

perfusion flow rate was reduced from 2 L/min to 1.5 L/min. The surgeon noticed an anterior right ventricle tear that was causing the massive leakage. The surgeon applied laparotomy pads in an attempt to tamponade the ventricle leakage. At 05:45 hrs closed circuit perfusion was reinitiated at 96 mm/Hg of pressure. The NPT was 8°C. The remaining full concentration of Vital Oxy was administered through the patient circuit at 05:46 hrs.

At 05:54 hrs the surgeon secured the femoral cannula with an additional suture. At 05:57 hrs perfusion was stopped to allow the surgeon to attempt further repair of the anterior right ventricle tear. The suturing concluded at 06:09 hrs and the perfusion was restarted. The leak was mitigated substantially for the remainder of the procedure (see the Discussion section). Because of the ongoing bleeding from the chest and loss of perfusate, the perfusion time had to be limited. Some discharge persisted from several sites, which could not be repaired because of the poor quality of the tissues.

At 06:14 hrs closed circuit perfusion was terminated and the patient was disconnected from the perfusion circuit. The highest flow rate during the procedure was 2 L/min and the highest line pressure was 96 mmHg. The surgeon proceeded to close the sternum with #6 sternal wire. At 06:29 hrs the surgeon and surgical assistant secured the femoral canulae and closure. At Alcor's request, the cannulae were left in place, and brought out through the bottom of the groin incision. The surgeon proceeded to close the skin over the thoracic sight with Vicryl sutures.

7. Patient Transport

At approximately 06:55 hrs the patient was transferred into two body bags on the Alcor transport gurney. The patient was packed with approximately 200 lbs. of double bagged water ice. The patient was secured in the Alcor transport vehicle at 07:20 hrs.

The two Alcor representatives began the ground transport back to Alcor, waiting at the Arizona border until the transit permit could be obtained. The SA team lead went back to the patient's floor at the hospital to wait for the attending physician to obtain cause of death and a signature for the death certificate. At 08:29 hrs the SA team lead was still waiting on the physician to sign the official cause of death so a transit permit could be obtained.

The funeral director sent the SA team lead a working copy of the death certificate and the application for a transit permit at 09:53 hrs. At 10:30 hrs the SA team lead went to the coroner's office to receive a transit permit signoff in person. At 10:50 hrs the coroner signed the transit permit, and it was transmitted to the transport team who were then able to cross the border and complete the patient transport to Alcor.

8. Cryoprotectant Perfusion Surgery

The patient arrived at Alcor at 14:54 hrs and was moved into the operating room (OR) at 14:59 hrs with a right nasopharyngeal temperature (NPT) of 5.5°C and a left NPT of 6.1°C. The cryoprotection circuit had been prepped in advance of the arrival of the patient. Ice bags were removed from the PIB, and the patient was moved to the OR table at 15:28 hrs. The data acquisition system was connected to the patient at 15:29 hrs. A nasopharyngeal thermocouple was placed in the patient's left nare. The initial temperature reading at 15:29 hrs was 5.9°C.

Ice bags were placed back around the patient's head and thorax. The right femoral artery and vein cannulae were still in place from the washout; the surgical team began connecting the cannulae to the perfusion circuit tubing at 15:31 hrs. The right femoral vein cannula was connected to the tubing containing M22 cryoprotectant solution at 15:35 hrs. The right femoral artery cannula was connected to the tubing at 15:37 hrs. The arterial pressure was 41.71 mmHg, the venous refractive index (RI) was 10.63 Brix (2% of perfusate concentration needed to vitrify (CNV), and the arterial RI was 10.55 Brix (2% of CNV).

9. Cryoprotectant Perfusion

At 15:42 hrs open-circuit perfusion was initiated when the left arterial cannula was connected to the perfusion tubing. The arterial pressure was 62 mmHg and gradually increasing. The left burr hole was made at 15:46 hrs and the right burr hole was made at 15:47 hrs. A thermocouple was placed in the left burr hole and secured with sutures at 15:48 hrs. The perfusion circuit was switched to closed circuit on computer control at 15:52 hrs with the target arterial pressure set to 80 mmHg.

The perfusion pressure dropped abruptly at 15:55 hrs and the pump speed went to maximum. The problem was corrected (see Discussion section). Perfusion was again started at 15:59 hrs. The arterial pressure was 55 mmHg.

The cryoprotectant ramp was started at 16:02 hrs. Bubbles were noted in the venous return but not in the arterial input. By 16:07 hrs the venous return was flowing well in spite of the arterial pressure being at 44 mmHg. The vasculature likely had very few occlusions. The OR table with patient was wrapped with plastic wrap at 16:09 hrs to keep nitrogen gas circulating around patient for cooling. At 16:23 hrs the right eye appeared to be swelling more than left eye and there was tanning of the skin. At 17:00 hrs the right eye was starting to collapse but the left eye was not.

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 started at 17:19 hrs. The venous refractive index (RI) was 30.32 Brix (49% CNV), and the arterial RI was 32.11 Brix (54% of CNV). The cryoprotectant-addition pump speed was manually turned up and down in small increments to make the RI curve smoother. The temperature of the patient enclosure was changed from +3°C to -3°C at 17:20 hrs. At 17:42 hrs perfusate was observed to be draining from the burr holes, but there was no noticeable retraction of the brain.

The 30-minute pause was terminated at 17:50 hrs. The venous RI was 44.25 Brix (83% of perfusate (CNV), and the arterial RI was 44.58 Brix (83% of CNV). The main pump was increased to full speed, and the target perfusion pressure was increased to 80 mmHg at 18:05 hrs.

The RI readings were observed at 18:22 hrs to be going flat instead of increasing. The refractometers were checked and were working correctly. At 18:42 hrs the RI readings were again rising (see the Discussion section).

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.

A one-hour countdown to termination of the cryoprotectant ramp was started at 18:48 hrs (see the Discussion section). At 19:05 hrs the left eye had still not collapsed as is usual. The cryoprotectant ramp was terminated at 19:44 hrs. The arterial perfusate temperature was -4.6°C, the venous effluent temperature was -1.4°C, and the patient's NPT was -2.1°C. The venous RI was 51.96 Brix (101% of perfusate concentration needed to vitrify (CNV),
and the arterial RI was 53.04 Brix (104% of CNV).

All ice, lines, and equipment were removed from the patient at 19:50 hrs in preparation for moving the patient into the Patient Care Bay for cryogenic cooldown. At 19:54 hrs no shrinkage of the brain was observed at the right burr hole. The patient was moved into the Patient Care Bay at 20:01 hrs. The patient was moved to the cooldown enclosure at 20:03 hrs and all thermocouples and other lines were connected to the cooldown computer at 20:07 hrs. Cryogenic cooldown was initiated at 20:08 hrs.

10. Cooling to Liquid Nitrogen Temperature

Computer controlled cryogenic cooldown was initiated at 20:08 hrs on T-0 days, plunging to -110°C and descending thereafter at -1°C/hour to liquid nitrogen temperature. On T+5, an uneventful cooldown was terminated. On T+75 days at 12:55 hrs the patient was transferred to long-term maintenance at liquid nitrogen temperature. The delay in transferring this patient to permanent storage was due to the high case load at that time.

11. Timeline and Time Summaries

Timeline

T-0	04:10	Time of cardiac arrest
T-0	04:11	Time of pronouncement of legal death
T-0	04:12	Start of ice bath cooling
T-0	04:13	Start of manual chest compressions (CPS)
T-0	04:21	Placement of intraosseous device (IO)
T-0	04:15	Placement of airway
T-0	04:16	Start ventilation and capnograph logger
T-0	04:15	Administration of first medication (propofol)
T-0	05:46	Administration of final medication (Vital-Oxy)
T-0	04:33	Transport patient to MOV for surgery
T-0	04:57	Termination of CPS (LNPT = 23°C, RNPT = 19°C)
T-0	04:58	Start of field surgery (median sternotomy)
T-0	05:07	Switch to femoral cannulation
T-0	05:30	End of field surgery
T-0	05:32	Start of open circuit blood substitution
T-0	05:42	Completion of open circuit
T-0	05:45	Start of closed circuit perfusion
T-0	06:14	Completion of closed circuit perfusion
T-0	07:20	Departure of transport vehicle to Alcor
T-0	14:59	Arrival of patient at Alcor OR (LNPT = 6°C, RNPT = 6°C)
T-0	15:29	NPT probes attached/data acquisition system (NPT = 6°C)
T-0	15:31	Start surgery (connecting cannulae) at Alcor
T-0	15:37	Completion of cannulation
T-0	15:42	Start of open-circuit perfusion at Alcor
T-0	15:52	Completion of open-circuit perfusion
T-0	15:46	Start of burr hole surgery
T-0	15:47	Completion of field (burr hole) surgery
T-0	16:02	Start of cryoprotectant ramp
T-0	17:19	Pause at 50% CNV commenced
T-0	17:50	Start of terminal concentration ramp (off pause)
T-0	18:48	Start 1-hour countdown to end of cryoprotectant ramp
T-0	19:44	Termination of cryoprotection (Brix: venous 51.96, arterial 53.04)
T-0	20:08	Start of cryogenic cooldown
T+5	02:12	Completion of cryogenic cooldown
T+75	12:55	Transfer of patient to long-term maintenance at LN2

Time Summaries

Event Duration hr:min		days	time	
Field Stabilization				
00:01	From:	T-0	04:10	Time of cardiac arrest
	Till:	T-0	04:11	Time of pronouncement of legal death
00:02	From:	T-0	04:10	Time of cardiac arrest
	Till:	T-0	04:12	Start of ice bath cooling
00:03	From:	T-0	04:10	Time of cardiac arrest
	Till:	T-0	04:13	Start of manual chest compressions (CPS)
00:05	From:	T-0	04:10	Time of cardiac arrest
	Till:	T-0	04:15	Administration of first medication (propofol)
01:31	From:	T-0	04:15	Administration of first medication (propofol)
	Till:	T-0	05:46	Administration of final medication (Vital-Oxy)
Field Surgery and Blood Substitution				
00:48	From:	T-0	04:10	Time of cardiac arrest
	Till:	T-0	04:58	Start of field surgery (median sternotomy)
00:32	From:	T-0	04:58	Start of field surgery (median sternotomy)
	Till:	T-0	05:30	End of field surgery
01:22	From:	T-0	04:10	Time of cardiac arrest
	Till:	T-0	05:32	Start of open circuit blood substitution
00:10	From:	T-0	05:32	Start of open circuit blood substitution
	Till:	T-0	05:42	Completion of open circuit
01:32	From:	T-0	04:10	Time of cardiac arrest
	Till:	T-0	05:42	Completion of open circuit
Cannulation and Surgery at Alcor				
10:49	From:	T-0	04:10	Time of cardiac arrest
	Till:	T-0	14:59	Arrival of patient at Alcor OR (LNPT = 6°C, RNPT = 6°C)
00:32	From:	T-0	14:59	Arrival of patient at Alcor OR (LNPT = 6°C, RNPT = 6°C)
	Till:	T-0	15:31	Start surgery (connecting cannulae) at Alcor
00:16	From:	T-0	15:31	Start surgery (connecting cannulae) at Alcor
	Till:	T-0	15:47	Completion of field (burr hole) surgery
Cryoprotectant Perfusion at Alcor				
11:52	From:	T-0	04:10	Time of cardiac arrest
	Till:	T-0	16:02	Start of cryoprotectant ramp
01:03	From:	T-0	14:59	Arrival of patient at Alcor OR (LNPT = 6°C, RNPT = 6°C)
	Till:	T-0	16:02	Start of cryoprotectant ramp
00:31	From:	T-0	15:31	Start surgery (connecting cannulae) at Alcor
	Till:	T-0	16:02	Start of cryoprotectant ramp
04:13	From:	T-0	15:31	Start surgery (connecting cannulae) at Alcor
	Till:	T-0	19:44	Termination of cryoprotection (BRIX: venous 51.96, arterial 53.04)
03:42	From:	T-0	16:02	Start of cryoprotectant ramp
	Till:	T-0	19:44	Termination of cryoprotection (BRIX: venous 51.96, arterial 53.04)

Cryogenic Cooldown at Alcor				
00:24	From: Till:	T-0 T-0	19:44 20:08	Termination of cryoprotection (BRIX: venous 51.96, arterial 53.04) Start of cryogenic cooldown
15:35	From: Till:	T-0 T-0	04:33 20:08	Transport patient to MOV for surgery Start of cryogenic cooldown
05:09	From: Till:	T-0 T-0	14:59 20:08	Arrival of patient at Alcor OR (LNPT = 6°C, RNPT = 6°C) Start of cryogenic cooldown

12. Table of Medications Administered

T-0 days

TIME	MEDICATION	DOSE	PURPOSE
04:15 hrs	Propofol	200 mg	Anesthetic; reduces cerebral metabolic demand; reduces the theoretic possibility of increased awareness during aggressive CPS.
04:16 hrs	Sodium citrate	100 mg total (1st dose 50 mg) Note 2	Anticoagulant; prevents blood clot formation.
04:18 hrs	Vasopressin	80 IU Note 3	Vasopressor; increases blood pressure during CPS.
04:18 hrs	SMT (S-methyl-isothiourea)	400 mg Note 4	Neuroprotectant (iNOS inhibitor); protects the brain from ischemic injury; raises blood pressure.
04:18 hrs	Minocycline	200 mg total (1st dose 100 mg) Note 5	Antibiotic and neuroprotectant
04:20 hrs	Decaglycerol/THAM	400 cc total (1st dose 60 cc) Note 6	Decaglycerol inhibits cerebral edema.
04:21 hrs	Decaglycerol/THAM	400 cc total (2nd dose 60 cc) Note 6	Decaglycerol inhibits cerebral edema.
04:21 hrs	Antacid	250 cc total (1st dose 70 cc) Note 7	A buffer used to protect the stomach from acid erosion.
04:21 hrs	Antacid	250 cc total (2nd dose 70 cc) Note 7	A buffer used to protect the stomach from acid erosion.
04:22 hrs	Antacid	250 cc total (3rd dose 70 cc) Note 7	A buffer used to protect the stomach from acid erosion.
04:22 hrs	Decaglycerol/THAM	400 cc total (3rd dose 60 cc) Note 6	Decaglycerol inhibits cerebral edema.

04:22 hrs	Decaglycerol/THAM	400 cc total (4th dose 20 cc) Note 6	Decaglycerol inhibits cerebral edema.
04:23 hrs	Antacid	250 cc total (4th dose 40 cc) Note 7	A buffer used to protect the stomach from acid erosion.
04:23 hrs	Vital Oxy (w/ saline)	54 cc total Note 8	Antioxidants: melatonin, vitamin E (D-alpha tocopherol), PBN (alpha Phenyl t-Butyl Nitrone) and anti-inflammatory carprofen.
04:25 hrs	Decaglycerol/THAM	400 cc total (5th dose 60 cc) Note 6	Decaglycerol inhibits cerebral edema.
04:26 hrs	Decaglycerol/THAM	400 cc total (6th dose 20 cc) Note 6	Decaglycerol inhibits cerebral edema.
04:26 hrs	Decaglycerol/THAM	400 cc total (7th dose 60 cc) Note 6	Decaglycerol inhibits cerebral edema.
04:26 hrs	Minocycline	200 mg total 2nd dose 100mg Note 5	Antibiotic and neuroprotectant
04:27 hrs	Sodium citrate	100 mg total (2nd dose 50 mg) Note 2	Anticoagulant; prevents blood clot formation.
04:27 hrs	Decaglycerol/THAM	400 cc total (8th dose 60 cc) Note 6	Decaglycerol inhibits cerebral edema.
04:27 hrs	Heparin	50,000 IU	Anticoagulant; prevents blood clot formation.
05:32 hrs	Streptokinase	250,000 IU Note 8	A thrombolytic used to break up existing blood clots.

Notes:

1. During the initial stabilization, due to inadequate training provided to the SA team member delivering the medications, they were delivered out of order. The second 50cc sodium citrate was skipped and delivered in the middle of the second dose of Decaglycerol/THAM, the 50K IU heparin was also skipped and given last, the 80 IU vasopressin was administered in one dose, and half the minocycline was given then the second was given 8 min. later.

2. 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. See note 1 above.

3. 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. See note 1 above.

4. 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.

5. See note 1 above.

6. 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). See note 1 above.

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

8. 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.

13. Discussion

Standby and Stabilization

During the initial stabilization, the Autopulse failed to initiate. Only minimal time was taken to troubleshoot the device as there was an abundance of personnel to trade off on manual chest compressions. The device was inspected after the deployment to reveal the compression band key was inserted correctly but was not applying enough pressure to the key sensor to allow the device to initiate. The device was tested with a new band and worked properly. It will be tested in advance of each case.

The medications protocol was delivered out of order. The second 50 cc of sodium citrate was skipped and delivered in the middle of the second dose of Decaglycerol/THAM, the 50K IU heparin was also skipped and given last, the 80 IU vasopressin was administered in one dose, and half the minocycline was given, and the second dose was given 8 min. later. This issue was due to inadequate training provided to the SA team member delivering the medications protocol. Additional training has been provided.

Field Surgery and Washout

During the field blood substitution sternotomy access, a large tear in the patient's anterior right ventricle occurred. According to the surgeon, this must have happened due to scar tissue adhering to the patient's heart and sternum. When the chest was spread apart with the sternal retractor, a tear occurred. The surgeon had never experienced a situation like this and with the minimal equipment available found it difficult to repair. This patient had prior open-heart surgeries which was the cause for the scarring and sternal wire found in the chest. Chest cannulation was abandoned for femoral access. The surgeon sutured the heart back together as well as possible, and blood substitution was completed. Going forward surgical access will need to be determined on a case-by-case basis.

Due to the leak in the chest cavity, there was significant loss of perfusate. With a finite supply of perfusate the duration of cooling was forced to be cut short of the optimal temperature. Additionally, the leakage made intravenous cooling less effective and resulted in a higher body temperature than desired. This was not a normal situation. It could happen again, but the probability is not high enough to make changes in the protocol.

Cryoprotectant Surgery and Perfusion at Alcor

During cryoprotectant surgery at Alcor, using the femoral cannulae left in the patient, the standard procedure following open circuit perfusion with B1 perfusate is to lower the mixing reservoir level to 4 liters of B1 perfusate, and then to initiate closed circuit perfusion, set the arterial pump pressure with automated control to 80 mmHg, and start the addition ramp using M22 perfusate.

A sudden drop in vascular resistance at 15:55 hrs, initially believed to be due to the failure of sutures around the cannula, resulted in the pump speed rapidly increasing to maintain the target pressure. The increasing flow primarily leaked into the chest cavity past the cannula rather than returning to the mixing reservoir, resulting in a large loss to the table dump. The main perfusion pump was immediately put into manual mode and the pump speed was lowered almost to zero while the team addressed the leak. A large hematoma was noted to be forming directly forward of (toward the patient's head) the previously sutured sternotomy site. The reservoir level was raised by adding more B1 carrier solution to bring it back above the minimum operating volume. Manually repositioning the cannula by pushing it further into the opening appeared successful, and the operation continued at a lowered pressure for approximately 45 minutes out of cautious intent not to induce another leak. It is likely that the initial leak was caused by displacement of the cannula as it was connected to the perfusion system, and not by suture failure, as the pressure was gradually increased to nominal levels and the leak did not reoccur.

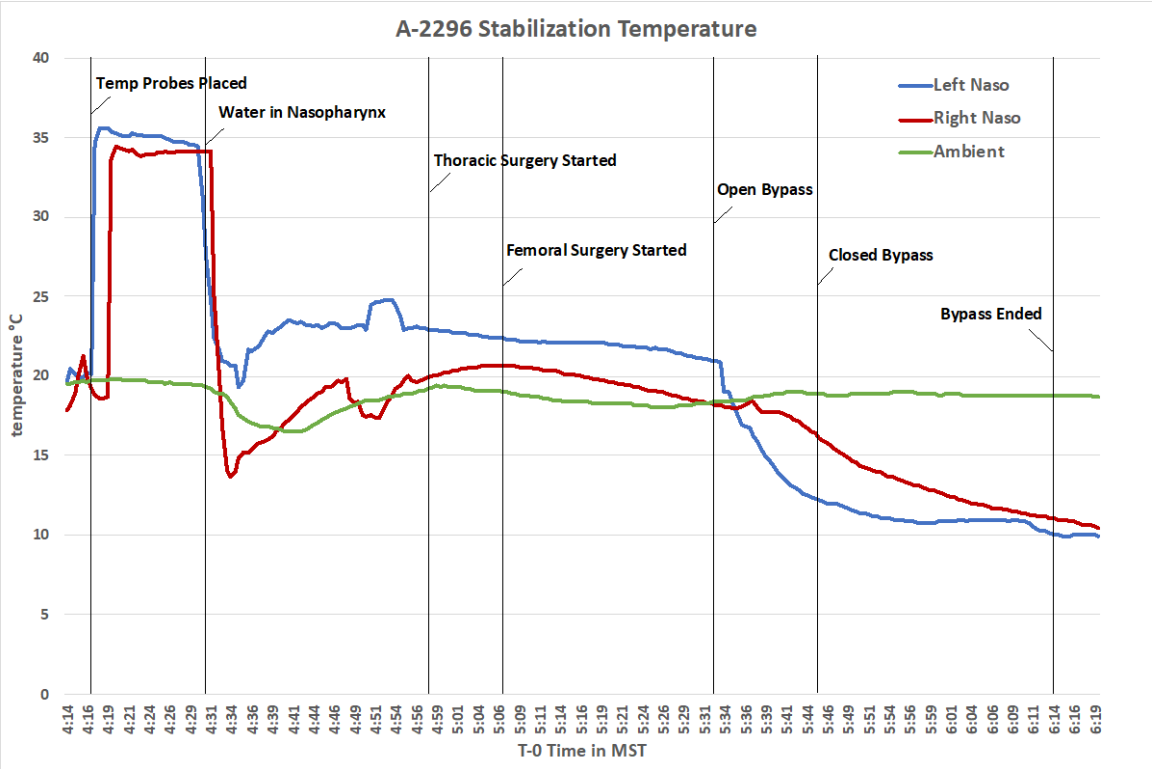
The above event lowered the mixing reservoir level to approximately 1 liter. Alcor's engineering staff will make a reservoir low-level alarm to avoid draining the main reservoir dry during times when attentions are elsewhere. At the time this report was written the sensor was not yet available for use, but the perfusionists are aware of the need to carefully monitor the reservoir level until the new equipment is in use.

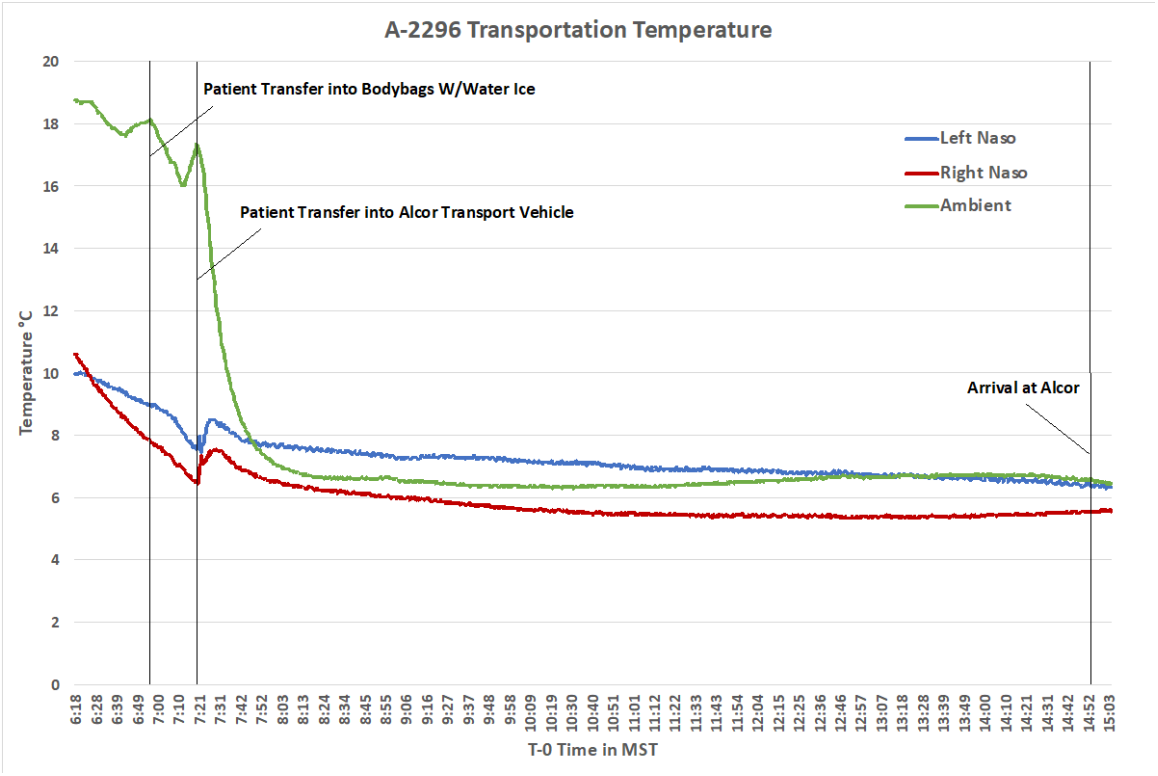
Following the 30-minute pause for equilibration, the refractive index (RI) readings were observed at 18:22 hrs to be flat instead of increasing, but were working correctly again at 18:42 hrs. The refractometers were checked and were working properly. The current conclusion is that when the arterial pressure was increased from 70 mmHg to 80 mmHg at 18:05 hrs, it may have opened up more vasculature. A large number of particulates were suddenly observed in the effluent line.

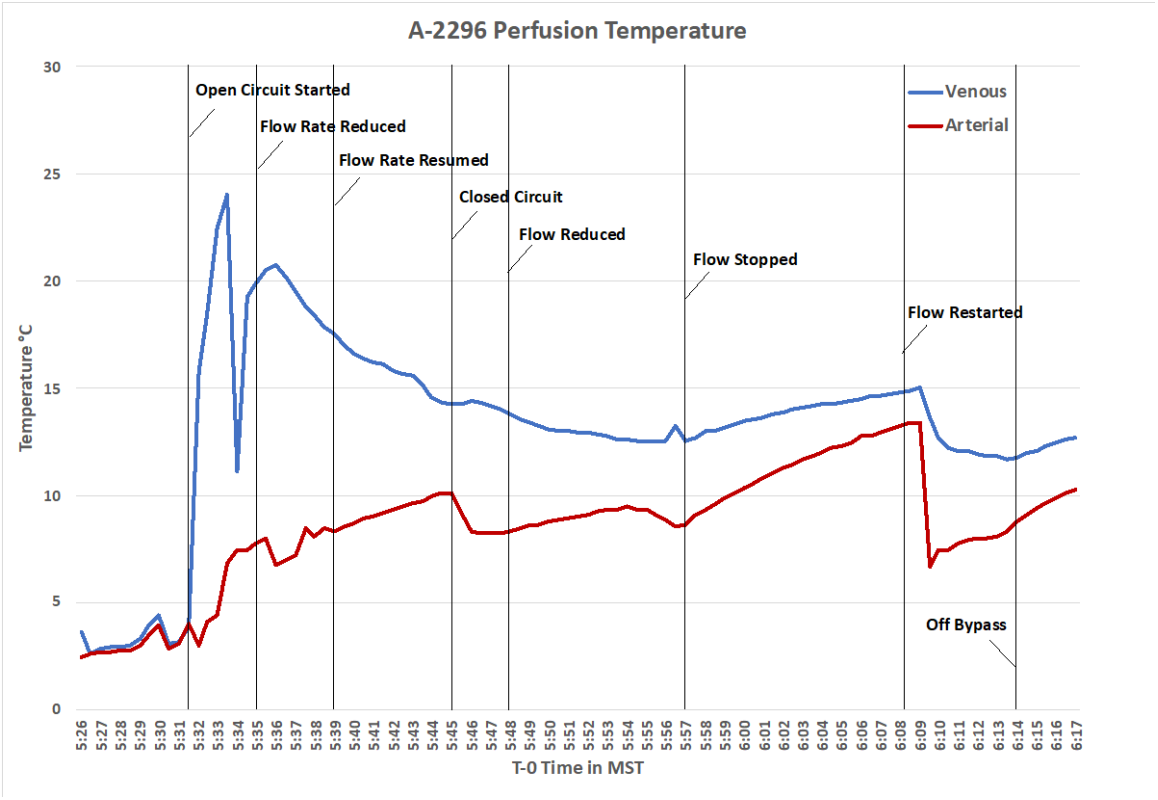
The standard 30-minute countdown to termination of the cryoprotectant ramp was extended on this case because the normal endpoint criterion for whole body patients (over 100% of perfusate concentration needed to vitrify (CNV) for over 30 minutes from the venous return) had not yet been met. When the cryoprotectant ramp was terminated, the venous RI was 51.96 Brix (101% of CNV and the arterial RI was 53.04 Brix (104% of CNV).

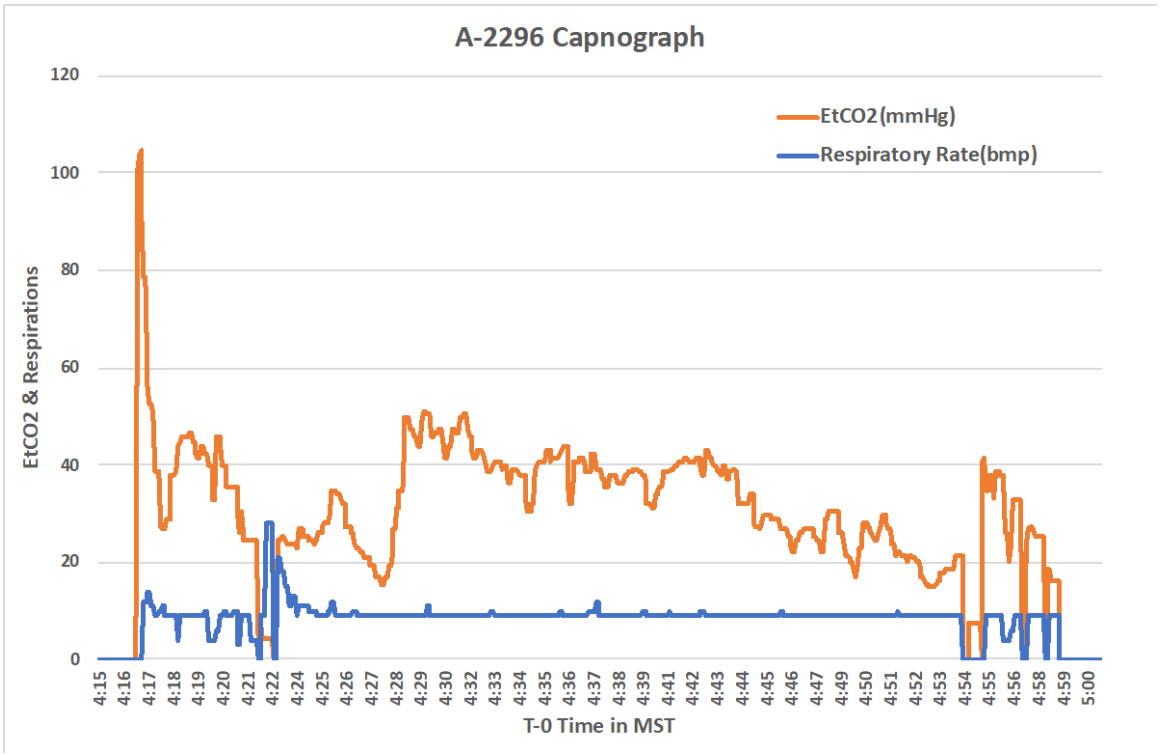
14. 5 Cryoprotection and Temperature Graphs

Graphs from SA:

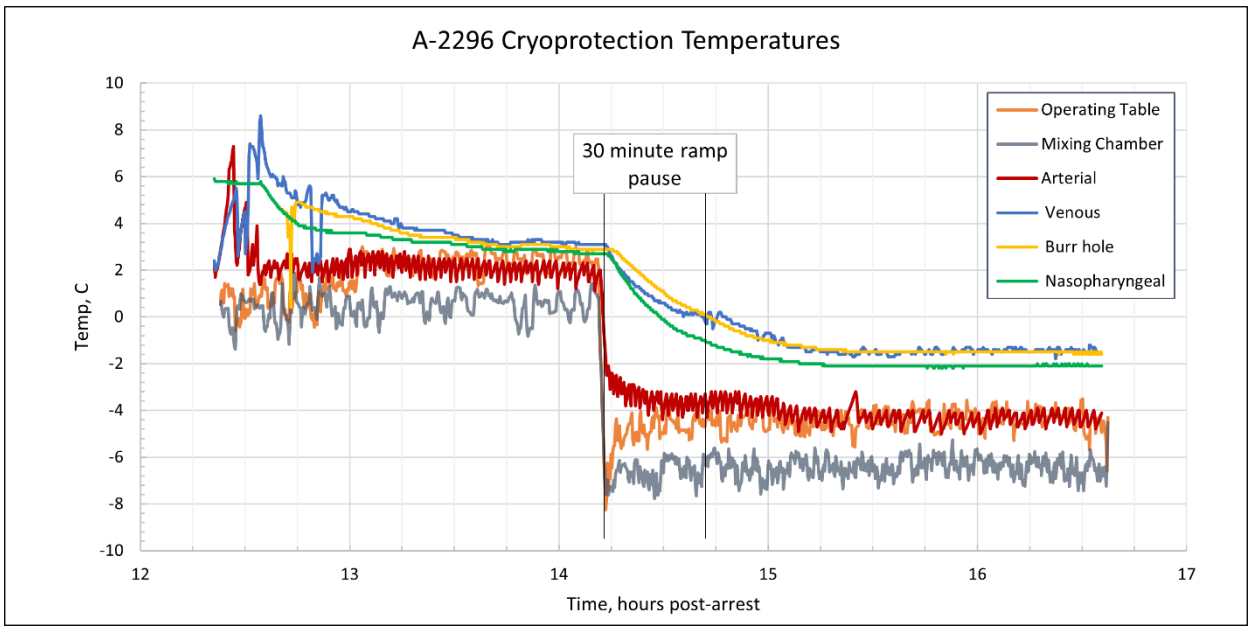


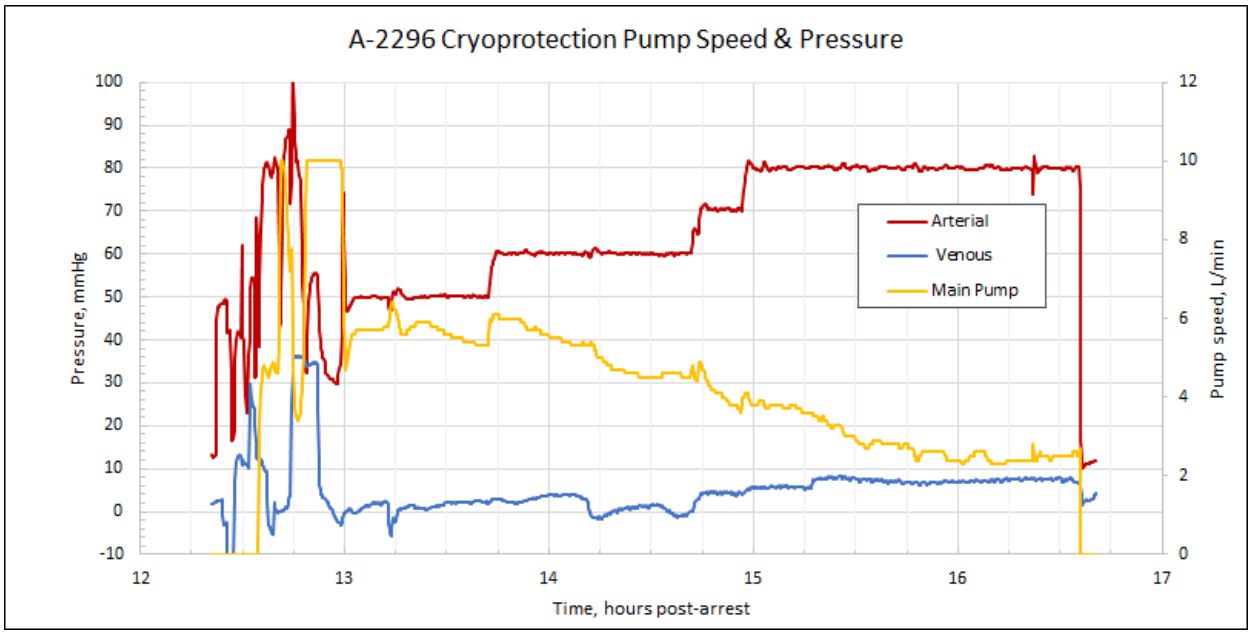

A-2296 Transportation Temperature
Patient Transfer into Bodybags W/Water Ice
Patient Transfer into Alcor Transport Vehicle
Arrival at Alcor
Left Naso
Right Naso
Ambient
Temperature °C
T-0 Time in MST

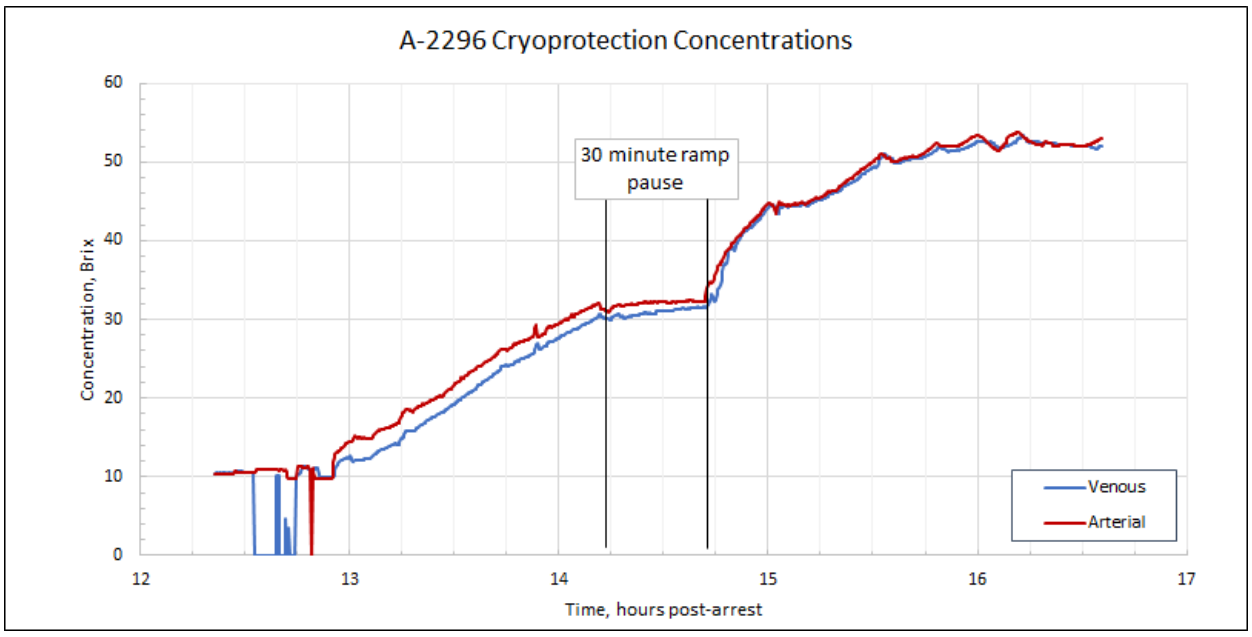

A-2296 Perfusion Temperature
Open Circuit Started
Flow Rate Reduced
Flow Rate Resumed
Closed Circuit
Flow Reduced
Flow Stopped
Flow Restarted
Off Bypass
Venous
Arterial
Temperature °C
T-0 Time in MST



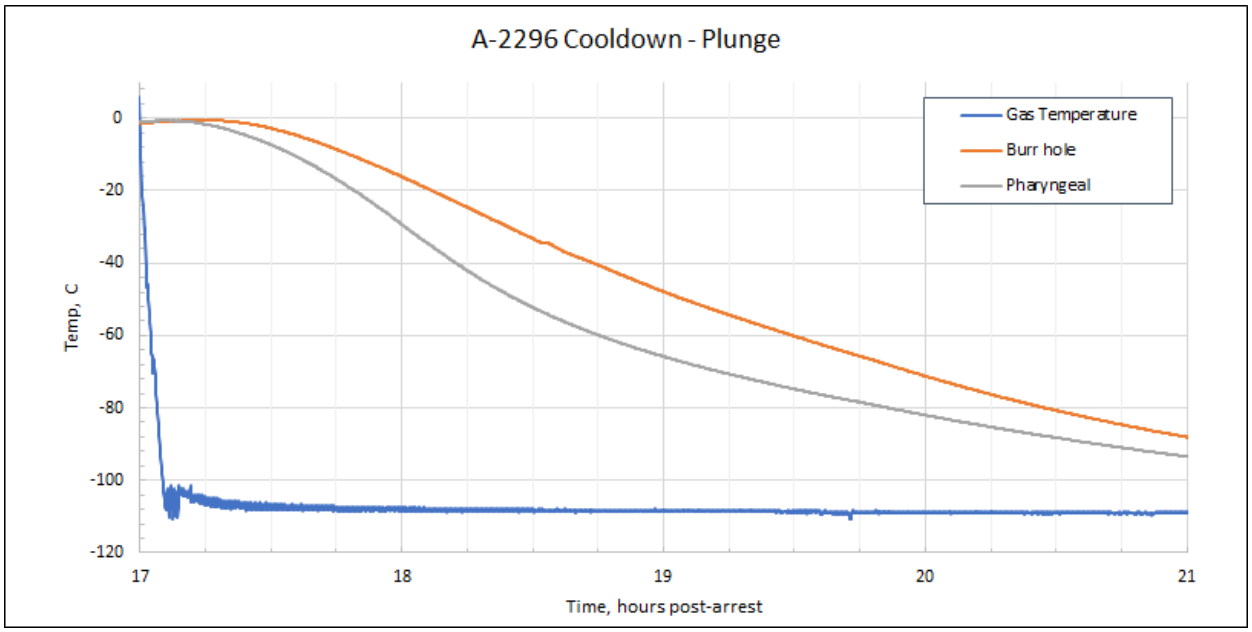
Graphs by Alcor:




A-2296 Cryoprotection Pump Speed & Pressure
Pressure, mmHg
Pump speed, L/min
Time, hours post-arrest
Arterial
Venous
Main Pump
100
90
80
70
60
50
40
30
20
10
0
-10
12
10
8
6
4
2
0
12
13
14
15
16
17


A-2296 Cryoprotection Concentrations
Concentration, Brix
Time, hours post-arrest
30 minute ramp pause
Venous
Arterial
60
50
40
30
20
10
0
12
13
14
15
16
17


A-2296 Cooldown
Transfer to vertical dewar
Gas Temperature
Burr hole
Pharyngeal
Temp, C
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
15
39
63
87
111
Time, hours post-arrest

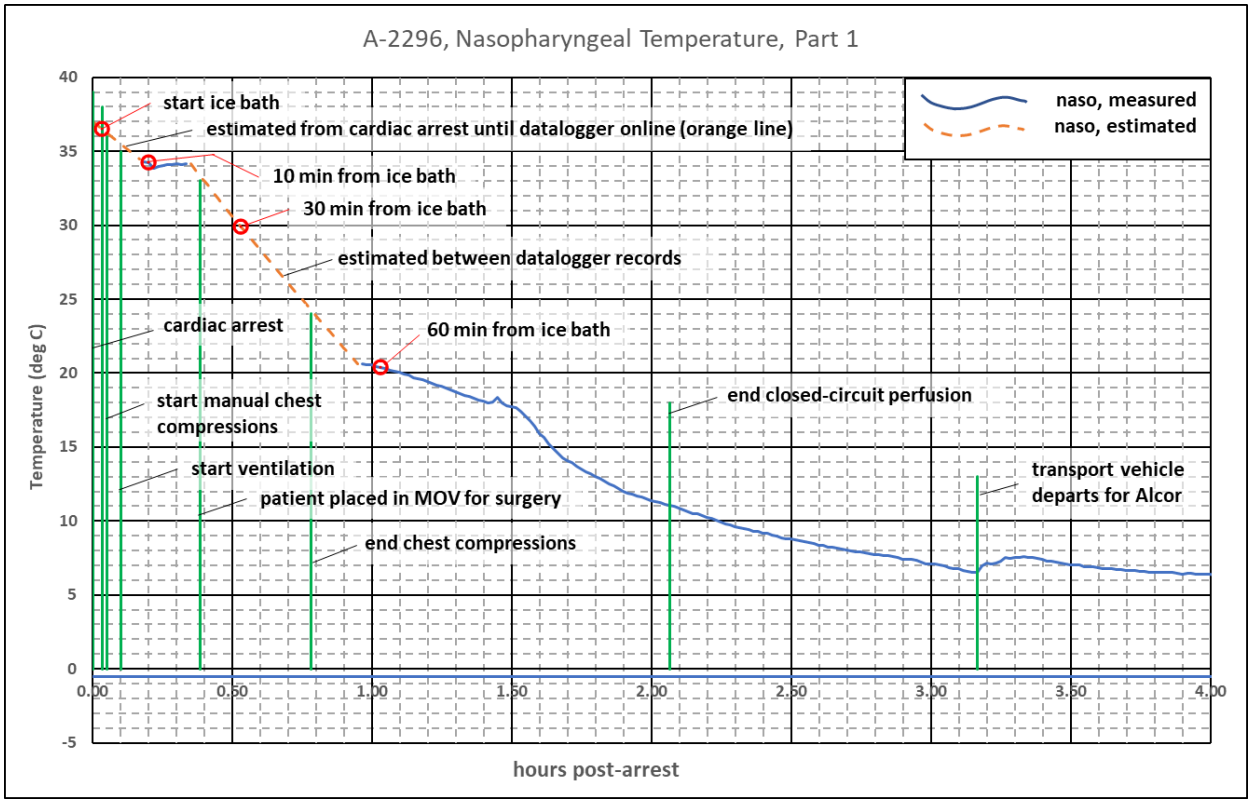

A-2296 Cooldown - Plunge
Gas Temperature
Burr hole
Pharyngeal
Temp, C
0
-20
-40
-60
-80
-100
-120
17
18
19
20
21
Time, hours post-arrest

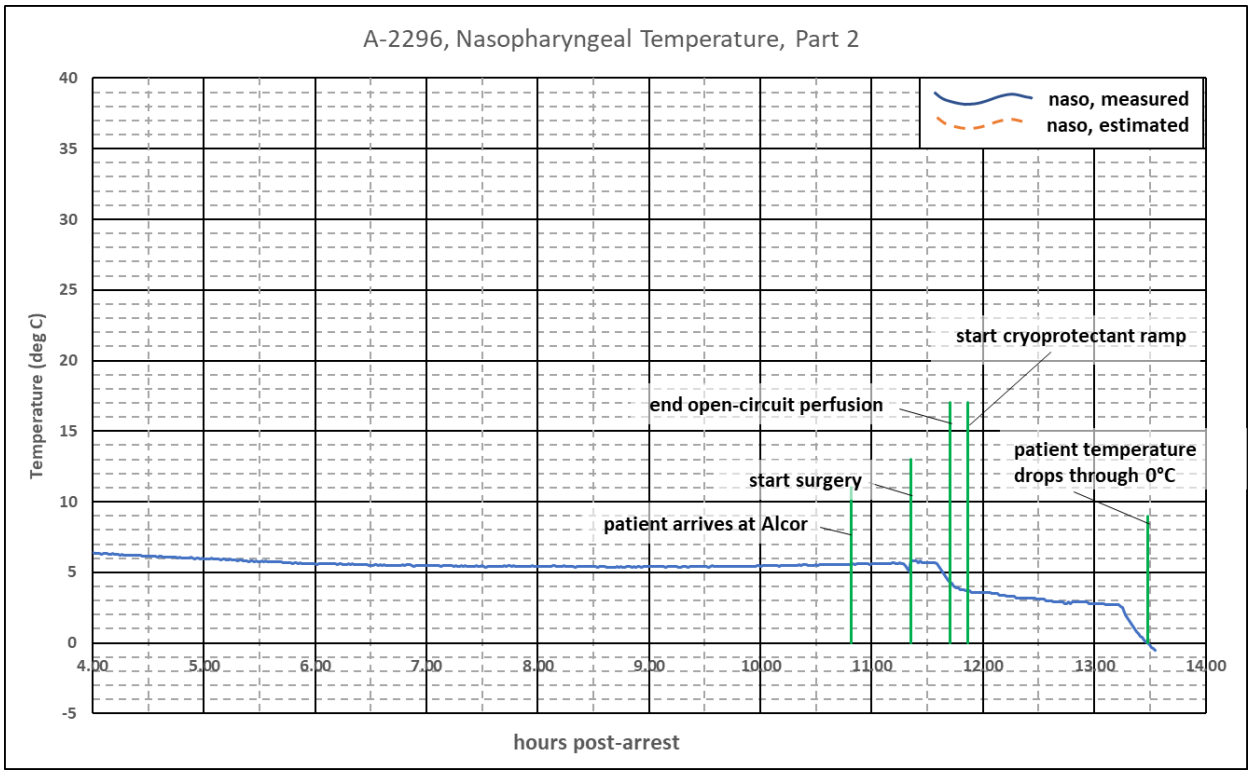
15. S-MIX

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 13:29. As shown below, and due to lowering of the body temperature, S-MIX duration is shorter, at 01:49.

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	04:10	00:00	37.0			
	seg 1		00:02	00:02	-0.5	no	no	00:02
Start of ice bath cooling		T-0	04:12	00:02	36.5			
	seg 2		00:01	00:01	-0.3	no	no	00:01
Start of manual chest compressions (CPS)		T-0	04:13	00:03	36.2			
	seg 3		00:03	00:03	-0.8	no	no	00:03
Start ventilation		T-0	04:16	00:06	35.5			
	seg 4		00:17	00:17	-2.1	yes	no	00:07
Transport patient to MOV for surgery		T-0	04:33	00:23	33.3			
	seg 5		00:24	00:24	-9.1	yes	no	00:07
End CPS; start field surgery		T-0	04:57	00:47	24.3			
	seg 6		00:35	00:35	-6.0	no	no	00:11
Start of open circuit blood substitution		T-0	05:32	01:22	18.3			
	seg 7		00:42	00:42	-7.2	no	yes	00:00
Completion of closed circuit perfusion		T-0	06:14	02:04	11.1			
	seg 8		01:06	01:06	-4.5	no	no	00:09
Departure of transport vehicle to Alcor		T-0	07:20	03:10	6.6			
	seg 9		07:39	07:39	-1.0	no	no	00:53
Arrival of patient at Alcor OR		T-0	14:59	10:49	5.6			
	seg 10		00:32	00:32	0.3	no	no	00:04
Start surgery at Alcor		T-0	15:31	11:21	5.9			
	seg 11		00:21	00:21	-1.6	no	no	00:02
Completion of open-circuit perfusion		T-0	15:52	11:42	4.3			
	seg 12		00:10	00:10	-0.6	no	no	00:01
Start of cryoprotectant ramp		T-0	16:02	11:52	3.7			
	seg 13		01:37	01:37	-3.7	no	no	00:09
Patient temperature drops through 0°C		T-0	17:39	13:29	0.0			
totals:			13:29	13:29	-37.0			01:49

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.

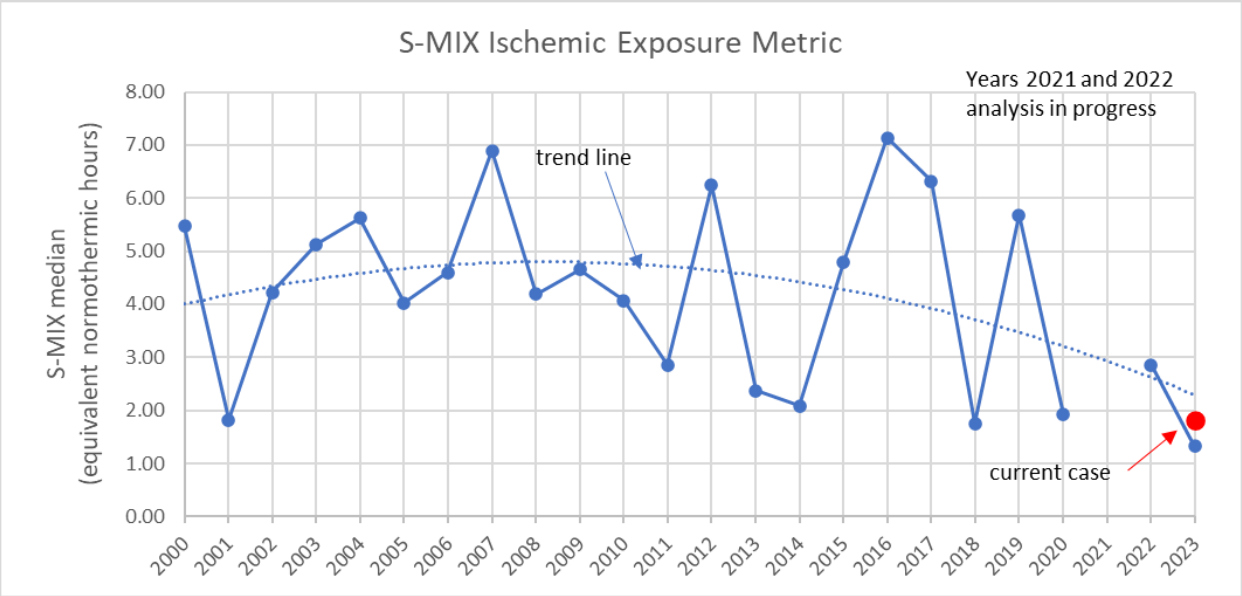

A-2296, Nasopharyngeal Temperature, Part 1
Temperature (deg C)
hours post-arrest
naso, measured
naso, estimated
start ice bath
estimated from cardiac arrest until datalogger online (orange line)
10 min from ice bath
30 min from ice bath
estimated between datalogger records
cardiac arrest
60 min from ice bath
start manual chest compressions
end closed-circuit perfusion
start ventilation
patient placed in MOV for surgery
transport vehicle departs for Alcor
end chest compressions


A-2296, Nasopharyngeal Temperature, Part 2
Temperature (deg C)
hours post-arrest
naso, measured
naso, estimated
start cryoprotectant ramp
end open-circuit perfusion
patient temperature drops through 0°C
start surgery
patient arrives at Alcor

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

Patient Cooling Rate			(patient weight 77.3 kg; 170 lb)	
Note: time = 0 at start of ice bath	0 min elapsed	10 min elapsed	30 min elapsed	60 min elapsed
Naso temperature (°C)	36.5	34.2	29.9	20.4
Temperature drop (°C) from t = 0	0.0	-2.3	-6.6	-16.1
Cooling rate (°C/min) from t = 0	N/A	-0.23	-0.22	-0.27

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



16. CT Scans

As this was a whole-body cryopreservation, no post-cryopreservation CT scans were obtained. When Alcor's new CT scanner is operational, all cryoprotected patients not previously scanned will be scanned and scans will be added to this report.