Alcor A-3563

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 pronouncement of legal death, T-X represents occurrences before T-0, and T+X represents occurrences following T-0.

A-3563 was a 68-year-old member with whole-body cryopreservation arrangements who was a last-minute sign-up with membership being finalized just two days before cryoprotection. The death certificate shows the cause of death as septic shock, subsequent to acute respiratory failure with hypoxia, subsequent to cancer with metastasis to brain, bone, liver, and lungs. The member went into cardiac arrest at 00:18 hrs and was pronounced legally deceased in California at 00:19 hrs on T-0 days in 2022.

After stabilization and field washout, the patient was driven to Alcor for cryoprotectant perfusion and cryogenic cooldown. The patient arrived in the OR at Alcor on T-0 days at 15:00 hrs. The cryogenic cooldown was initiated on T-0 days at 19:02 hrs and terminated on T+6 days at 11:59 hrs. The patient was transferred to long-term care at liquid nitrogen temperature on T+15 days at 11:38 hrs.

2. Patient Assessment

T-1 days

The member had been in the hospital for the past month for cancer and had tumors growing on the spine that were causing issues with the right leg and left arm. The attending physician estimated a 1- to 2-day timeline before possible cardiac arrest. The member's vital signs were: heart rate (HR) 71/min, blood pressure (BP) 102/68, respiration rate (RR) 14/min, capillary oxygen saturation (SpO_2) 99% on 7L/min of oxygen.

3. Preparation and Deployment

The member's funding and paperwork were confirmed, and Alcor's Medical Advisor requested a Level-1 deployment to the member's location at 08:50 hrs. Suspended Animation, Inc. (SA), one of Alcor's strategic partners for providing standby, stabilization and transport (SST) as well as field washout, was immediately deployed.

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

SA alerted their contract surgeon and perfusionist and loaded their Mobile Operating Vehicle (MOV) and an additional van at their California facility. At 10:00 hrs three team members were enroute to the member's location.

4. Standby

At 12:19 hrs SA arrived at the member's hospital. Covid protocols were in place but not overly stringent. The charge nurse was reluctant to divulge any information until Risk Management and the Caseworker could be contacted for a meeting. At 14:08 SA had spoken with Risk Management, Decedent Affairs, Caseworker, Attending Physician, and the member's next of kin and Medical Power of Attorney (POA). The member's family wanted to do everything possible to prolong the life of the member. The attending physician stated that hospital policy, when life prolonging measures were requested with no chance of recovery, was that the physician had oversight to deny those measures.

At 14:34 hrs the member was alert and oriented with vitals of HR 76/min, BP 85/44, mean arterial pressure (MAP) 55 mmHg, RR 25/min, SpO_2 96% with a nasal cannula. The member was receiving Precedex, a short-term intravenous sedation, at 0.8ml/kg/hr, Levophed, an adjunct in the treatment of cardiac arrest and profound hypotension,27 mcg/min, and Vasopressin, to regulate blood pressure, at 0.3 IU/min. At 14:46 SA, Alcor's Medical Advisor, and the funeral director were placed on the hospital's approved list for medical information.

At 18:00 hrs the member was in a noticeable decline. Vitals taken at 17:58 were HR 79/min, BP 88/56, MAP 59 mmHg, RR 25/min, SpO_2 95% with high flow nasal cannula. The member was no longer alert and oriented. Medications being administered were Levophed 50 mcg/min, Vasopressin 0.03 IU/min, and Neo-Synephrine 45 mcg/min. The hospital authorized all stabilization measures to be done in the room, but the equipment would not be permitted on the floor until the member's cardiac arrest was more imminent.

By 19:25 SA had the MOV in place at the hospital's loading bay. Security was alerted and willing to assist with the member's extraction when needed. Permission was granted for the MOV to remain parked in the loading bay while the subsequent stabilization surgery was performed. At 20:20 SA began drawing up medications in proportion to the member's weight of 54.43 kg.

At 21:05 hrs the hospital began administering 125 ml/hr. of sodium bicarbonate for the member's lactic acidosis. The hospital granted permission for SA's equipment to be staged in an empty room next to the member.

Vital signs for the member at 22:03 hrs were HR 130/min, BP 76/43, RR not reading, SpO_2 at 95% with high nasal cannula. The member was receiving bicarbonate 125ml/hr., Neo-Synephrine 200 mcg/min, vasopressin 0.06 IU/min, and Levophed 50 mcg/min. At this time, the hospital also started the member on fentanyl 50 mcg/hr. for pain management and Ativan 0.5 mg/hr. for anxiety.

At 23:35 SA's surgeon and perfusionist were picked up at the airport and arrived at the MOV at 23:55. At the MOV the perfusionist began primming and precooling the MHP2 perfusate.

5. Stabilization

T-0 days

Cardiac arrest occurred at 00:18 hrs and the attending physician pronounced the member legally deceased at 00:19 hrs. The family took approximately one minute to leave the room and then the three SA team members began the stabilization procedures.

The patient was disconnected from the monitoring devices and placed into the portable ice bath (PIB) and at 00:22 hrs approximately 100 lbs. of water ice was placed around the patient's head and body. To circulate the medications and restore ventilation, mechanical chest compressions were initiated at 00:23 hrs with placement of the Autopulse device, but the device did not engage. Manual chest compression was started immediately. After one minute of unsuccessful troubleshooting of the Autopulse, it was decided to proceed with manual compressions while the other tasks for stabilization were completed.

At 00:26 hrs the patient was intubated, and placement was checked with an esophageal detection bulb, connected to the PCM-900 Capnograph to gather $EtCO_2$ data, and the SAVe Automedx ventilator was initiated. At 00:27 hrs an EZIO intraosseous device was placed in the tuberosity of the patient's right leg. Additionally, both nasopharyngeal temperature thermocouples were placed at about a 10 cm depth and secured with putty to prevent water from entering the nose and compromising temperature data. The thermocouples were secured with skin staples at 00:28 hrs. The medications protocol began at 00:29 hrs (see the below Table of Medications Administered for the names of the medications, the dosages, and the times of administration).

At 00:33 hrs attention was given to the Autopulse one more time. After about 10 seconds of paused manual compressions the Autopulse engaged and performed mechanical compressions. It was noticed at 00:36 hrs that the capnograph was not receiving data (see the Discussion section).

The cooling mask was placed on the patient at 00:38 hrs. The patient was covered with a privacy drape and moved from the room at 00:39 hrs and the endotracheal tube was secured with Tegaderm. The patient was loaded into the MOV at 00:43 hrs where the perfusionist was priming and cooling the patient circuit. Approximately 3 gallons of water were added to the PIB, and the surface conduction cooling (SCCD) pump was initiated at 00:45 hrs to improve external cooling.

Approximately 20 lbs. of additional water ice were added around the patient's head and body at 00:47 hrs. At 00:48 hrs the left nasopharyngeal temperature (NPT) was 28°C and the right NPT was 31°C. The SST team then waited for the patient's NPTs to reach 25°C. The patient circuit was kept primed and cooled while waiting, and the surgeon prepared for surgery. At 00:50 hrs an additional gallon of water was added to the PIB, and 20 lbs. of water ice were added around the patient's head at 01:05 hrs.

6. Field Surgery and Washout

The first Autopulse battery was depleted at 01:15 hrs with the patient's NPT was at 24°C in the left nare and 27°C in the right. Autopulse was removed from the patient. The decision was made to proceed with the thoracic access. The surgeon noticed the patient had undergone a prior medial sternotomy, but the decision to move forward stood.

The first incision was made at 01:20 hrs and sternal wires were uncovered by the surgeon. By 01:27 hrs the sternal wires had been removed and at 01:28 hrs the Stryker sternal saw was used to access the chest cavity. Scar tissue from the previous cardiac procedure was removed to access the heart vessels at 01:32 hrs. The surgeon noted the patient had a couple of grafts on his aorta. A 21 French (Fr) curved tip cannula was placed in the aorta through a pursestring at 01:42 hrs and a 29/32 dual stage venous cannula was placed the inferior vena cave through a pursestring at 01:45 hrs. The cannulae were sutured in place.

The cannulae were connected to the perfusion circuit and purged of air at 01:48 hrs. The circuit included a room air pump set to 5L/min. After zeroing the pressure transducer and purging the air from the tubing and cannulae, the patient was placed on open circuit bypass washout at 01:54 hrs.

There was a leak near the placement of the aortic cannula. Perfusion was halted while the area was sutured. This happened twice before the leak was stopped. Bypass was again started at 02:01 hrs with a flow rate of 2.3 L/min and a cannula head pressure of 87 mm/Hg. 250,000 IU of streptokinase, a thrombolytic used to break up existing blood clots, was added to the perfusion circuit at 02:04 hrs. A thoracic thermocouple was placed at 02:09 hrs at the same time the patient was switched to closed circuit bypass using MHP2 perfusate.

At 02:26 hrs a reduction in the flow from the heat exchanger was noticed. After five minutes of troubleshooting the cause of the flow reduction was found to be a filter on the head of the heat exchanger diffuser. The diffuser was removed, and the flow returned to normal. At 03:06 the patient temperatures were: thoracic 2°C, left NPT 4°C, right NPT 5°C, delivering perfusate at 0°C, and returning perfusate at 2°C. The patient was taken off bypass at 03:07 hrs. The highest arterial line pressure during washout was 100 mmHg.

The surgeon closed the patient with the heads of the canulae exposed for easy re-connection at Alcor. An additional 60 lbs. of water ice was added to the PIB at 03:45 hrs.

7. Patient Transport

The patient was transported in the MOV from the hospital to El Centro, CA, at 04:45 hrs to refuel and add an additional 40 lbs. of water ice. The MOV was then moved to a rest area, arriving at 09:30 hrs to wait for the transit permit to be issued. An additional 40 lbs. of water ice was added to the PIB at 10:45 hrs. The permit was issued at 11:25 hrs and transport of the patient to Alcor commenced.

8. Cryoprotectant Perfusion Surgery at Alcor

The patient arrived in the operating room (OR) at 15:00 hrs. The initial nasopharyngeal temperatures (NPT) were left 0.6°C and right 1.0°C. Ice bags were removed from around patient, who was still in PIB, to facilitate moving the patient to the OR table. The data acquisition system was hooked up to the patient at 15:17 hrs. The NPT thermocouple placed in left nare read 0.8°C. Ice bags were placed around the patient's head and thorax.

The cannulae were still in place from the washout; the surgical team began connecting the cannulae to the OR tubing circuit at 15:24 hrs. The arterial pressure at 15:25 hrs was 30.28 mmHg; venous line connected first. The arterial line was connected at 15:27 hrs.

9. Cryoprotectant Perfusion at Alcor

Computer controlled open circuit perfusion started at 15:27 hrs. 14 liters of B1 had been added to the mixing reservoir prior to the arrival of the patient. To start cryoprotectant perfusion and stay ahead of edema, approximately 400 mL of M22 were then added until the refractive index (RI) reached approximately 11 Brix. Arterial pressure was 34 mmHg. The thoracic cavity was suctioned at 15:28 hrs; minor leaking had occurred due to scar tissue around the previous thoracic surgery. The cryoprotectant ramp was started at 15:29 hrs with a target arterial pressure of 80 mmHg.

Incisions were made in the patient's scalp for two burr holes at 15:30 hrs. The left burr hole was started at 15:31 hrs, using a Codman perforator and distilled water to cool the perforator and the skull. The right burr hole was similarly drilled at 15:32 hrs and both burr holes were cleaned of debris. A thermocouple was placed in the left burr hole, sutured to scalp, and plugged into the data acquisition system. The initial reading was 2.5°C.

The laser, brain-retraction, detection device (BRDD) was placed in the right burr hole at 15:40 hrs and connected to the data acquisition system. The initial reading was 77 Alcor units (still an arbitrary unit system).

Ice bags were removed from the patient at 15:45 hrs and the patient and OR table then covered with plastic wrap prior to starting to cool the patient with flowing nitrogen gas. At 16:04 hrs the patient's face showed dramatic tanning, a typical response to exposure to the M22 cryoprotectant.

Computer control failed at 16:17 hrs. Perfusion control was manual and there would be no data to use for graphing temperature, perfusion concentrates, etc., until this was fixed. Computer control was reacquired at 16:28 hrs (see Discussion section).

The 30-minute ramp pause was started at 17:02 hrs. The patient enclosure and the chiller temperatures were set to -3°C. The venous refractive index (RI) readings on whole body patients are taken from a port in the venous return line. The arterial RI is taken from the mixing

reservoir. The RI readings had already converged at 17:13 hrs, with 30.20 Brix venous and 30.58 Brix arterial.

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. When the bladder system is used, bladders 6 & 7 represent the pause. 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.

As the patient had already come to osmotic equilibrium, the pause was discontinued at 17:16 hrs and the ramp pump was started at full speed. A large number of clots of diverse sizes were observed in the effluent line at 17:44 hrs.

Because the RI had been over 51.5 Brix for 30 minutes, the cryoprotectant perfusion ramp was terminated 18:32 hrs. The final RI readings were: Venous RI: 52.08 Brix, Arterial RI: 53.94 Brix. The patient's face was very tanned, but the corneas had not collapsed.

10. Cooling to Liquid Nitrogen Temperature

All lines and equipment were removed from the patient at 18:36 hrs and the patient was moved into the patient care bay for cryogenic cooldown.

The appropriate computer program was used to initiate cryogenic cooldown at 19:02 hrs on T-0 days, plunging to -110°C and descending thereafter at -1°C/hour to liquid nitrogen temperature. On T+6 days, an uneventful cooldown was terminated at 11:59 hrs. On T+15 days at 11:38 hrs, the patient was transferred to long-term maintenance at liquid nitrogen temperature (see Discussion section).

11. Timeline and Time Summaries

Timeline

T-0	00:18	Cardiac arrest
T-0	00:19	Pronouncement of legal death
T-0	00:22	Start of ice bath cooling
T-0	00:23	Start of chest compressions
T-0	00:26	Placement of airway
T-0	00:27	Placement of IV and/or intraosseous device
T-0	00:29	Administration of first medication (propofol)
T-0	00:39	Transport patient to MOV for surgery
T-0	01:15	Termination of CPS (LNPT=24°C, RNPT=27°C)
T-0	01:20	Start of field surgery
T-0	01:53	End of field surgery
T-0	01:54	Start of open circuit washout
T-0	02:04	Administration of final medication (streptokinase)
T-0	02:08	End open circuit washout (estimated)
T-0	02:09	Start of closed circuit perfusion
T-0	03:07	Completion of closed circuit perfusion
T-0	04:45	Departure of transport vehicle to Alcor
T-0	15:00	Arrival of patient at Alcor (LNPT=0.6°C, RNPT=1°C)
T-0	15:17	NPT probes attached to data acquisition system (0.8°C)
T-0	15:17	Start of surgery at Alcor (cannulae connected to circuit)
T-0	15:19	End of surgery at Alcor (cannulae connected to circuit)
T-0	15:27	Start of open-circuit washout
T-0	15:28	Completion of open-circuit washout
T-0	15:29	Start of cryoprotection
T-0	15:30	Start of burr hole surgery
T-0	15:32	Completion of burr hole surgery
T-0	16:17	Computer control failed
T-0	16:28	Computer control restored
T-0	17:02	Pause at 50% of concentration necessary for vitrification (CNV) achieved
T-0	17:16	Start of sub-zero terminal concentration ramp (off pause)
T-0	18:32	End of cryoprotection (final RI: V=52.08 Brix, R=53.94 Brix)
T-0	19:02	Start of cryogenic cooldown
T+6	11:59	Completion of cryogenic cooldown
T+15	11:38	Transfer of patient to long-term care at LN2 temperature

Time Summaries

Event Duration hr:min		days	time	
FIELD STABILIZATION				
00:01	From:	T-0	00:18	Cardiac arrest
	Till:	T-0	00:19	Pronouncement of legal death
00:04	From:	T-0	00:18	Cardiac arrest
	Till:	T-0	00:22	Start of ice bath cooling
00:05	From:	T-0	00:18	Cardiac arrest
	Till:	T-0	00:23	Start of chest compressions
00:11	From:	T-0	00:18	Cardiac arrest
	Till:	T-0	00:29	Administration of first medication (propofol)
01:35	From:	T-0	00:29	Administration of first medication (propofol)
	Till:	T-0	02:04	Administration of final medication (streptokinase)
FIELD SURGERY AND WASHOUT				
01:02	From:	T-0	00:18	Cardiac arrest
	Till:	T-0	01:20	Start of field surgery
00:33	From:	T-0	01:20	Start of field surgery
	Till:	T-0	01:53	End of field surgery
01:36	From:	T-0	00:18	Cardiac arrest
	Till:	T-0	01:54	Start of open circuit washout
00:14	From:	T-0	01:54	Start of open circuit washout
	Till:	T-0	02:08	End open circuit washout (estimated)
01:50	From:	T-0	00:18	Cardiac arrest
	Till:	T-0	02:08	End open circuit washout (estimated)
CRYOPROTECTANT SURGERY AT ALCOR				
14:42	From:	T-0	00:18	Cardiac arrest
	Till:	T-0	15:00	Arrival of patient at Alcor (LNPT=0.6°C, RNPT=1°C)
00:17	From:	T-0	15:00	Arrival of patient at Alcor (LNPT=0.6°C, RNPT=1°C)
	Till:	T-0	15:17	NPT probes attached to data acquisition system (0.8°C)
00:02	From:	T-0	15:17	Start of surgery at Alcor (cannulae connected to circuit)
	Till:	T-0	15:19	End of surgery at Alcor (cannulae connected to circuit)

CRYOPROTECTANT PERFUSION AT ALCOR				
15:11	From: Till:	T-0 T-0	00:18 15:29	Cardiac arrest Start of cryoprotection
00:29	From: Till:	T-0 T-0	15:00 15:29	Arrival of patient at Alcor (LNPT=0.6°C, RNPT=1°C) Start of cryoprotection
00:12	From: Till:	T-0 T-0	15:17 15:29	Start of surgery at Alcor (cannulae connected to circuit) Start of cryoprotection
03:15	From: Till:	T-0 T-0	15:17 18:32	Start of surgery at Alcor (cannulae connected to circuit) End of cryoprotection (final RI: V=52.08 Brix, R=53.94 Brix)
00:11	From: Till:	T-0 T-0	16:17 16:28	Computer control failed Computer control restored
03:03	From: Till:	T-0 T-0	15:29 18:32	Start of cryoprotection End of cryoprotection (final RI: V=52.08 Brix, R=53.94 Brix)
CRYOGENIC COOLDOWN AT ALCOR				
00:30	From: Till:	T-0 T-0	18:32 19:02	End of cryoprotection (final RI: V=52.08 Brix, R=53.94 Brix) Start of cryogenic cooldown
18:44	From: Till:	T-0 T-0	00:18 19:02	Cardiac arrest Start of cryogenic cooldown
04:02	From: Till:	T-0 T-0	15:00 19:02	Arrival of patient at Alcor (LNPT=0.6°C, RNPT=1°C) Start of cryogenic cooldown

12. Table of Medications Administered

T-0 days

TIME	MEDICATION	DOSE	PURPOSE
00:29 hrs	Propofol	200 mg	Anesthetic; reduces cerebral metabolic demand; reduces the theoretic possibility of increased awareness during aggressive CPS.
00:29 hrs	Sodium citrate	50 cc Note 1	Anticoagulant; prevents blood clot formation.
00:30 hrs	Sodium citrate	50 cc Note 1	Anticoagulant; prevents blood clot formation.
00:30 hrs	Heparin	50,000 IU	Anticoagulant; prevents blood clot formation.
00:30 hrs	Vasopressin	80 IU Total (1st dose 40 IU) Note 2	Vasopressor; increases blood pressure during CPS.
00:30 hrs	Minocycline	200 mg	Antibiotic and neuroprotectant
00:31 hrs	SMT (S-methyl-isothiourea)	400 mg Note 3	Neuroprotectant (iNOS inhibitor); protects the brain from ischemic injury; raises blood pressure.
00:31 hrs	Decaglycerol/THAM	400 cc total (1st dose 20 cc) Note 4	Decaglycerol inhibits cerebral edema.

00:32 hrs	Decaglycerol/THAM	400 cc total (2nd dose 60 cc) Note 4	Decaglycerol inhibits cerebral edema.
00:33 hrs	Decaglycerol/THAM	400 cc total (3rd dose 60 cc) Note 4	Decaglycerol inhibits cerebral edema.
00:34 hrs	Decaglycerol/THAM	400 cc total (4th dose 60 cc) Note 4	Decaglycerol inhibits cerebral edema.
00:34 hrs	Vital Oxy (w/ saline)	70 cc total Note 5	Antioxidants: melatonin, vitamin E (D-alpha tocopherol), PBN (alpha Phenyl t-Butyl Nitrone) and anti-inflammatory carprofen.
00:35 hrs	Antacid	250 cc total (1st dose 50 cc) Note 6	A buffer used to protect the stomach from acid erosion.
00:35 hrs	Antacid	251 cc total (2nd dose 60 cc) Note 6	A buffer used to protect the stomach from acid erosion.
00:35 hrs	Antacid	252 cc total (3rd dose 60 cc) Note 6	A buffer used to protect the stomach from acid erosion.
00:36 hrs	Antacid	253 cc total (4th dose 40 cc) Note 6	A buffer used to protect the stomach from acid erosion.
00:36 hrs	Antacid	254 cc total (5th dose 40 cc) Note 6	A buffer used to protect the stomach from acid erosion.
00:36 hrs	Decaglycerol/THAM	400 cc total (5th dose 60 cc) Note 4	Decaglycerol inhibits cerebral edema.
00:36 hrs	Decaglycerol/THAM	400 cc total (6th dose 60 cc) Note 4	Decaglycerol inhibits cerebral edema.
00:37 hrs	Decaglycerol/THAM	400 cc total (7th dose 60 cc) Note 4	Decaglycerol inhibits cerebral edema.
00:38 hrs	Decaglycerol/THAM	400 cc total (8th dose 20 cc) Note 4	Decaglycerol inhibits cerebral edema.
00:53 hrs	Vasopressin	80 IU Total (2nd dose 40 IU) Note 2	Vasopressor; increases blood pressure during CPS.
02:04 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 received 20 grams of sodium citrate because the patient weighed 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.

3. SMT (S-methyl isothiourea) is a fixed-dose and 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 useful 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).

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

7. Streptokinase is not administered with the stabilization medications but is put in the first batch of washout solution. The standard administration of streptokinase is 250,000 IU dissolved in 5 mL of 9% sodium chloride. 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 logistical planning for this case, the member's Medical Power of Attorney incorrectly relayed the member's location, resulting in confusion and delays. Confirmation of the member's location with a physical address rather than only the name of the hospital would help in the future, as well as corroboration with the care staff.

The Autopulse failed to engage when initially turned on because the patient's arm was not positioned correctly. Two SST personnel positioned the patient in the ice bath and prepared for the Autopulse initiation. Going forward only one SST member will oversee the implementation of the Autopulse as it is better for one operator to observe, and troubleshoot any potential issues with its deployment.

The capnograph had recorded three hours of data but stopped recording about 10 minutes after placement. The device was restarted, but still no data was retrieved. All ventilator connections were checked, the Capnograph was power cycled, and the lumens for the endotracheal tube were confirmed to be inflated. The device will be sent to the manufacturer for inspection, service, and hopefully a diagnosis of the issue.

Field Surgery and Washout

The patient circuit heat exchanger pump was producing a lower flow than normal during the bypass cooldown. The heat exchanger recirculation circuit was dismantled. A debris filter at the diffuser head was found to be clogged. The filter was seen as superfluous and removed. This solved the issue of low flow.

Cryoprotectant Surgery and Perfusion at Alcor

The laser, brain-retraction, detection device (BRDD) was placed in the right burr hole at 15:40 hrs and connected to the data acquisition system. The initial reading was 77 Alcor units (still an arbitrary unit system). On this case, the BRDD input signal was plagued with spurious spike signals. The underlying BRDD data was still present in the signal, if all the 'spikes' could be filtered from the data being used for graphing. It is believed that the spikes were caused by a faulty power supply and that has been replaced for the next case.

The cryoprotection computer control failed at 16:17 hrs. The reason was and still is unknown but was resolved with a reboot. Alcor engineering staff are working on a perfusion system design that does not require computer control. This is called back-pressure regulated perfusion and will be used for local neuro cases and later for whole body patients as well.

Cryogenic Cooldown

Upon reviewing the cooldown data for this case, a trend of rapid cooling was observed from dry ice temperature (-79°C) to approximately -119°C. Rewarming over a period of 20 hours then brought the patient temperature to -124°C, at which point cooling resumed. The result is that the patient temperature often differed significantly from the gas control temperature used by the PID (pump control algorithm) loop.

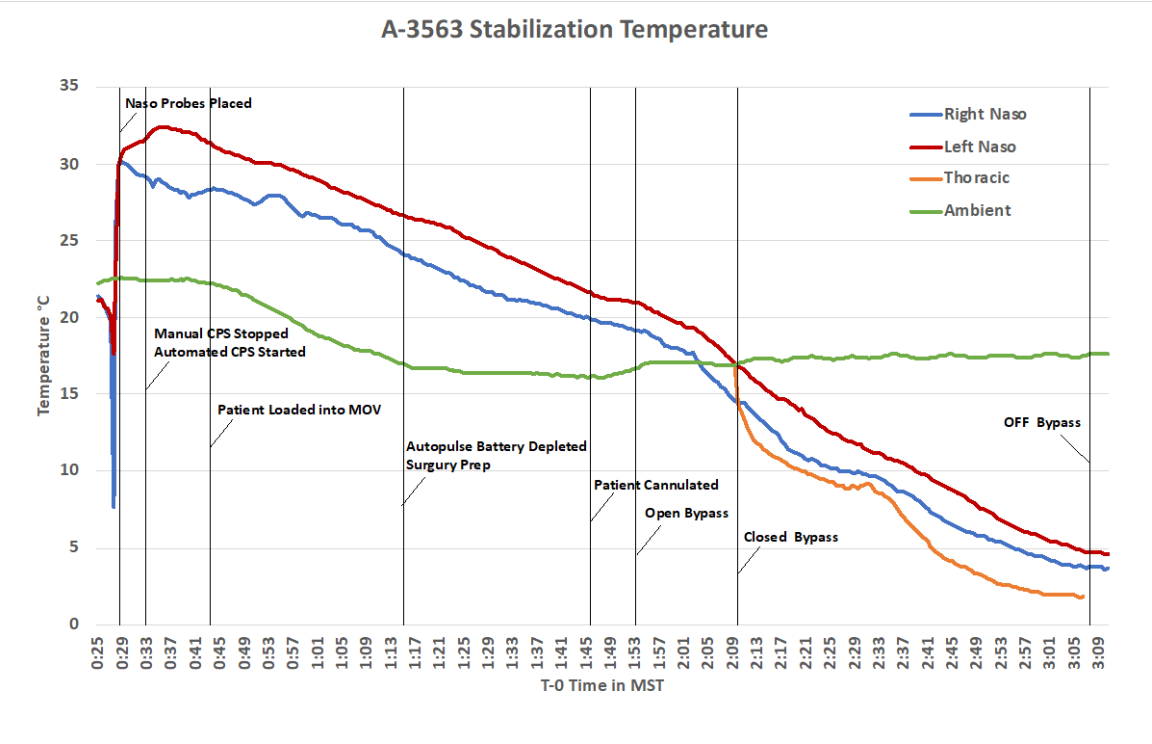
The cause of this trend is possibly due to improper placement of the gas control thermocouple. If the thermocouple was in good contact with the wall of the vessel, the low responsiveness of the thermal mass could have caused the system to inject significantly more liquid nitrogen than necessary. However, one confounding factor in this situation is the presence of a powerful mechanical stirring fan penetrating the cooldown chamber lid. This stirrer was engaged for the entire cooldown, so the temperature within the chamber should have been approximately equalized, even if the thermocouple was contacting something inside the chamber. Therefore, the discrepancy in temperature between patient and gas probe cannot be attributed with certainty to this cause.

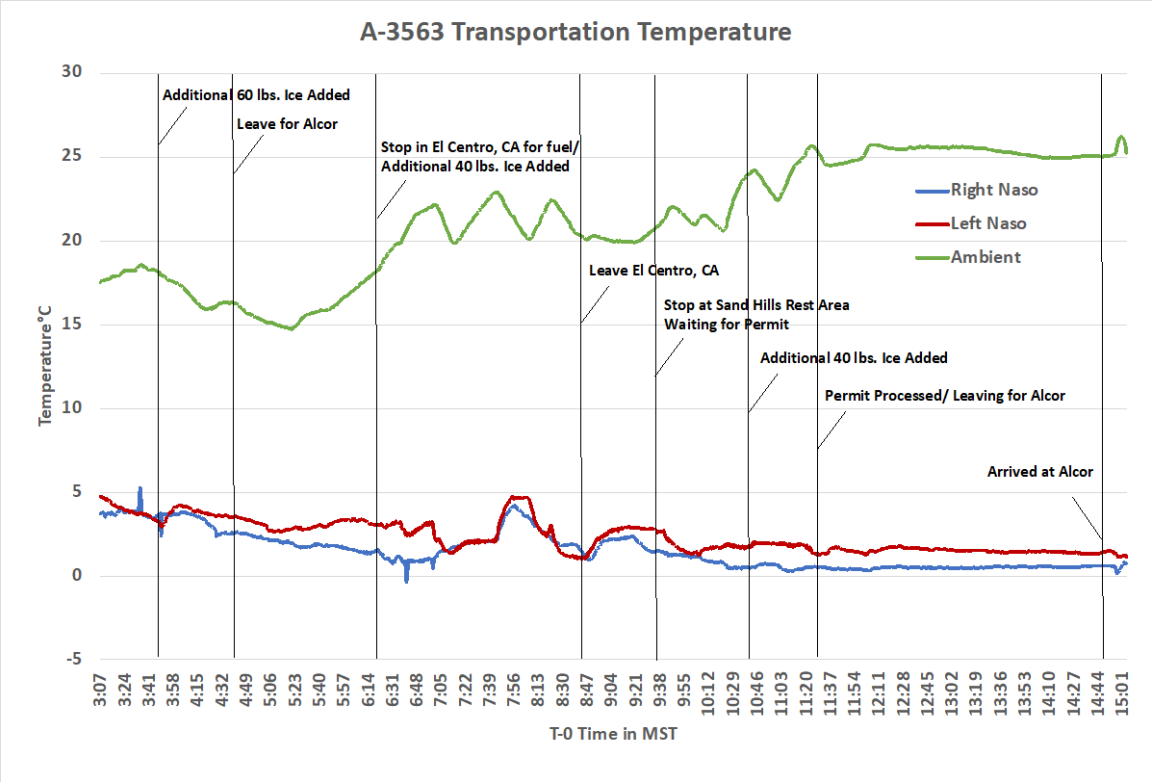
Furthermore, this might not account for the later trend in the data which can be seen where the patient temperature rises nearly 10°C above the gas control temperature. If the gas control probe was thermally connected to the outside of the vessel, the patient reading would be expected to be consistently lower than the gas control reading.

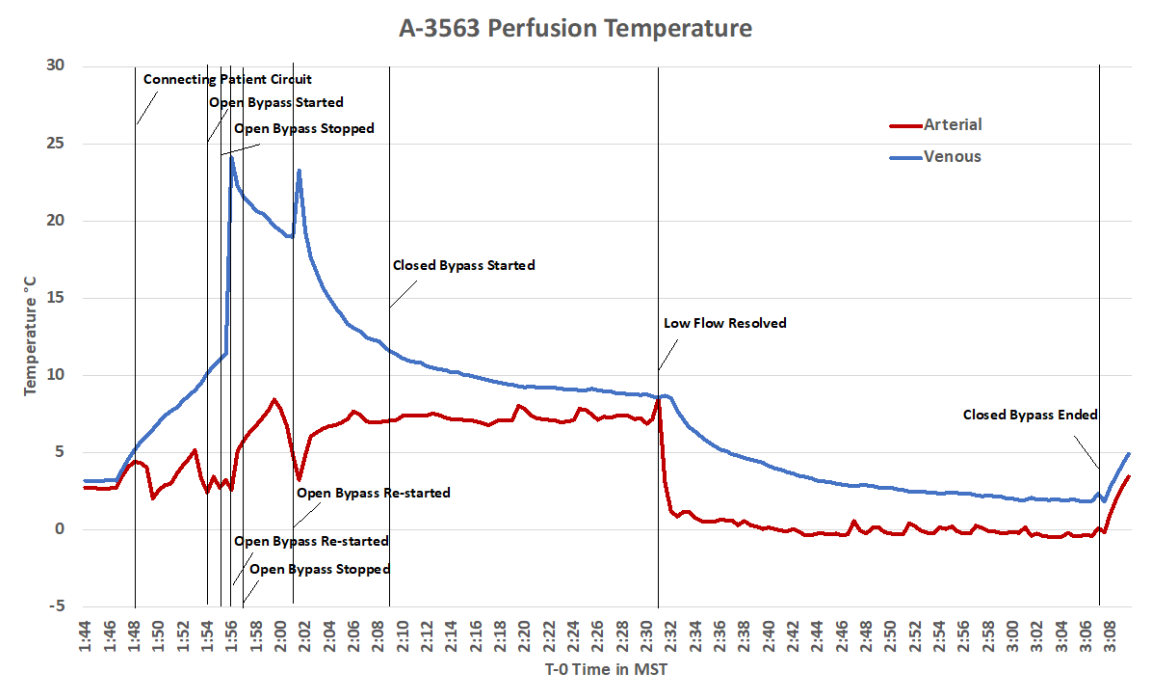
Another possibility might be the procedure used to precool the dewar by adding a small quantity of liquid nitrogen. If the vessel was significantly overcooled, the thermal mass of the vessel could have rapidly cooled the patient. Again, this should have been prevented by the aggressive stirring inside the dewar, so the cause is not certain.

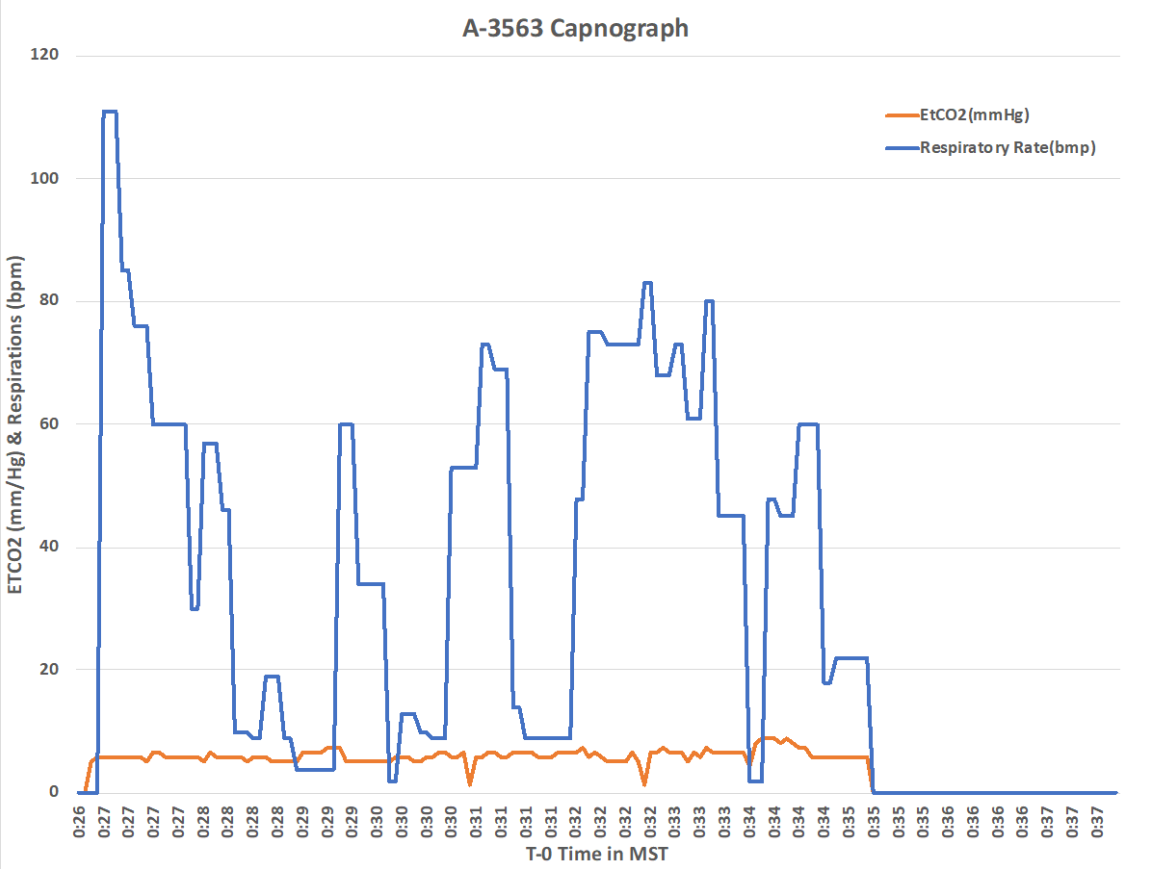
14. Cryoprotection and Temperature Graphs

Graphs from SA:

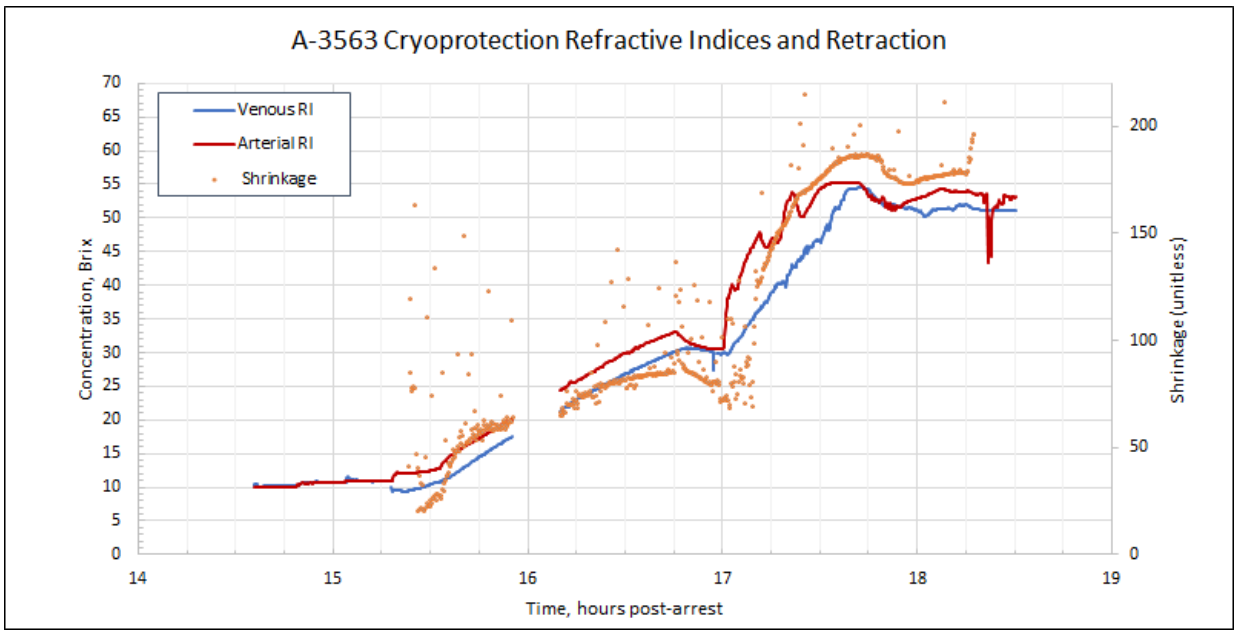


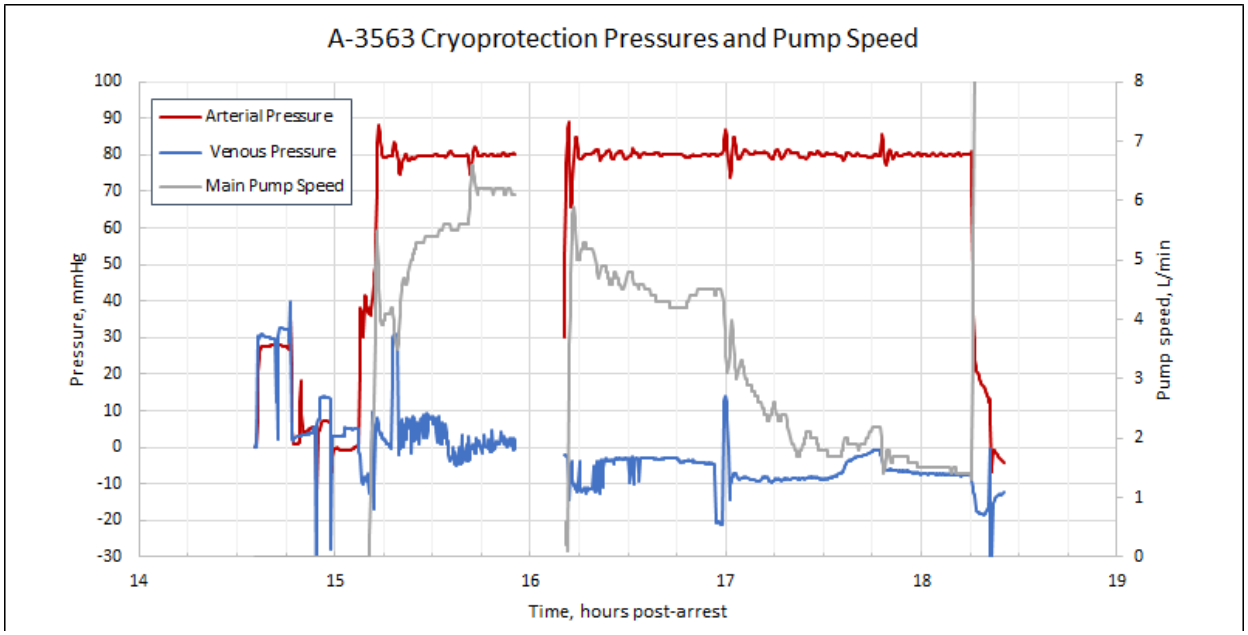

A-3563 Transportation Temperature
Additional 60 lbs. Ice Added
Leave for Alcor
Stop in El Centro, CA for fuel/
Additional 40 lbs. Ice Added
Leave El Centro, CA
Stop at Sand Hills Rest Area
Waiting for Permit
Additional 40 lbs. Ice Added
Permit Processed/ Leaving for Alcor
Arrived at Alcor
Right Naso
Left Naso
Ambient
Temperature °C
T-0 Time in MST

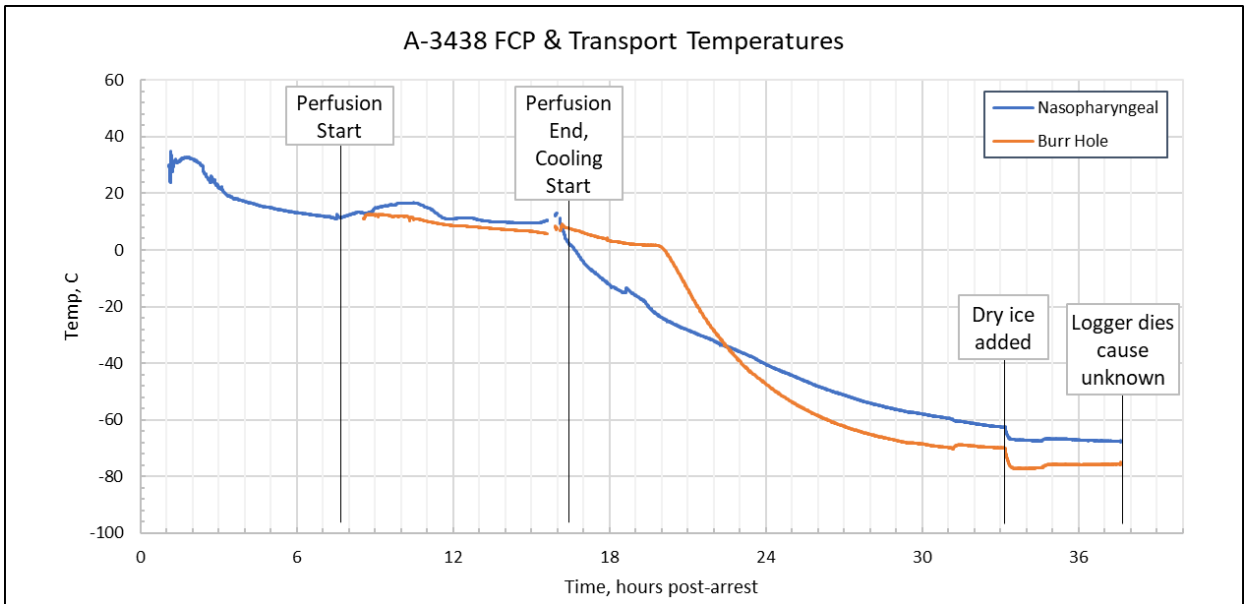

A-3563 Perfusion Temperature
Connecting Patient Circuit
Open Bypass Started
Open Bypass Stopped
Closed Bypass Started
Low Flow Resolved
Closed Bypass Ended
Open Bypass Re-started
Open Bypass Re-started
Open Bypass Stopped
Arterial
Venous
Temperature °C
T-0 Time in MST

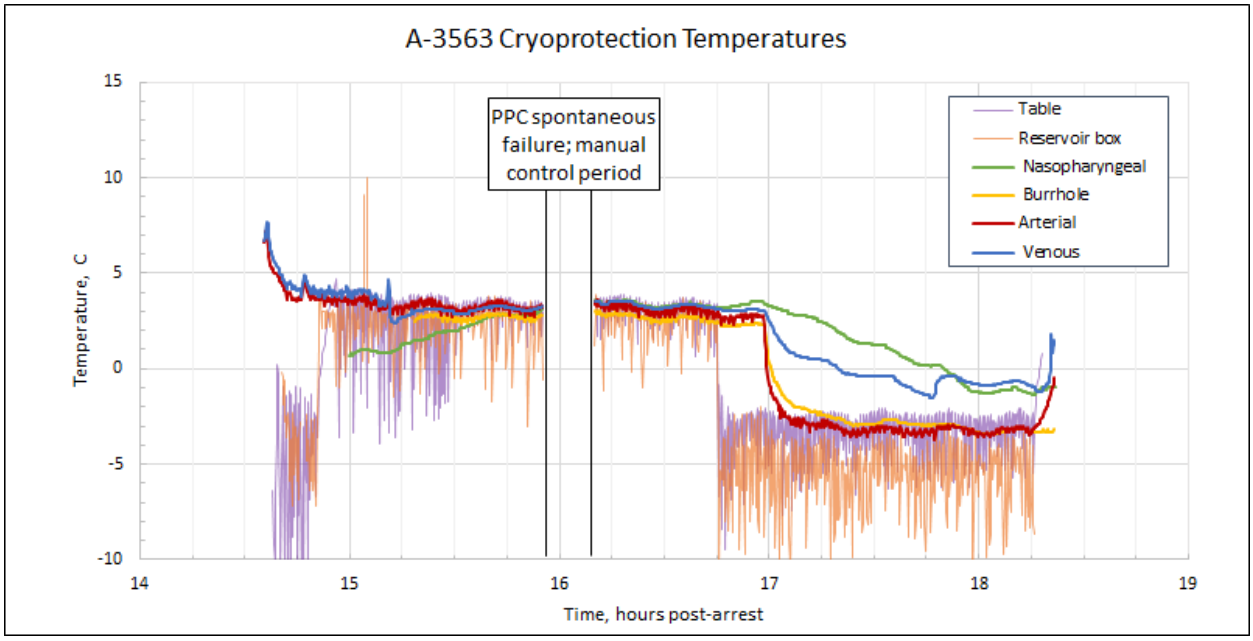


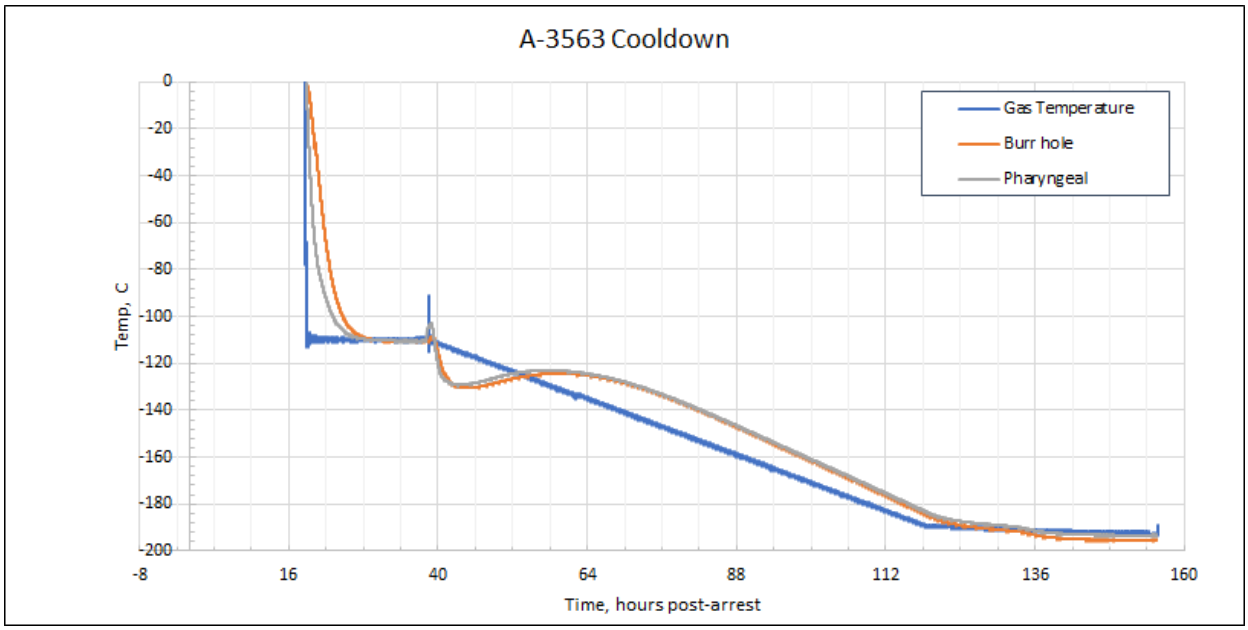
Graphs provided by Alcor:

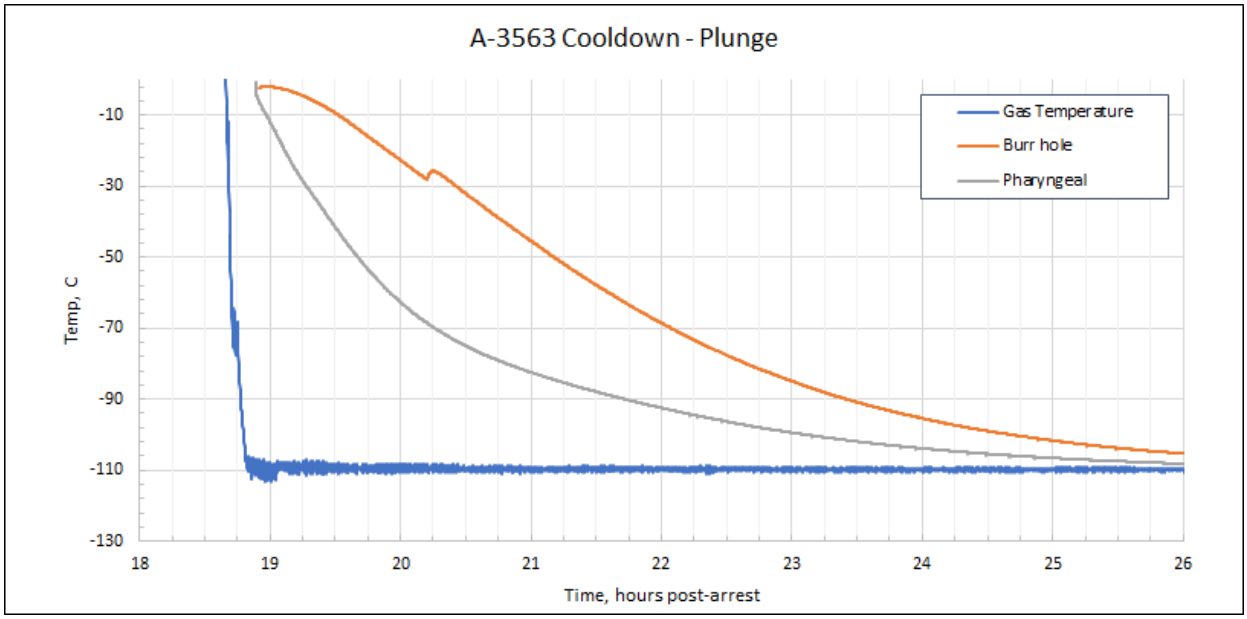



A-3563 Cryoprotection Pressures and Pump Speed
Arterial Pressure
Venous Pressure
Main Pump Speed
Pressure, mmHg
Pump speed, L/min
Time, hours post-arrest


A-3438 FCP & Transport Temperatures
Perfusion Start
Perfusion End, Cooling Start
Dry ice added
Logger dies cause unknown
Nasopharyngeal
Burr Hole
Temp, C
Time, hours post-arrest


A-3563 Cryoprotection Temperatures
PPC spontaneous failure; manual control period
Table
Reservoir box
Nasopharyngeal
Burrhole
Arterial
Venous
Temperature, C
Time, hours post-arrest
15
10
5
0
-5
-10
14
15
16
17
18
19


A-3563 Cooldown
Gas Temperature
Burr hole
Pharyngeal
Temp, C
Time, hours post-arrest
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-8
16
40
64
88
112
136
160

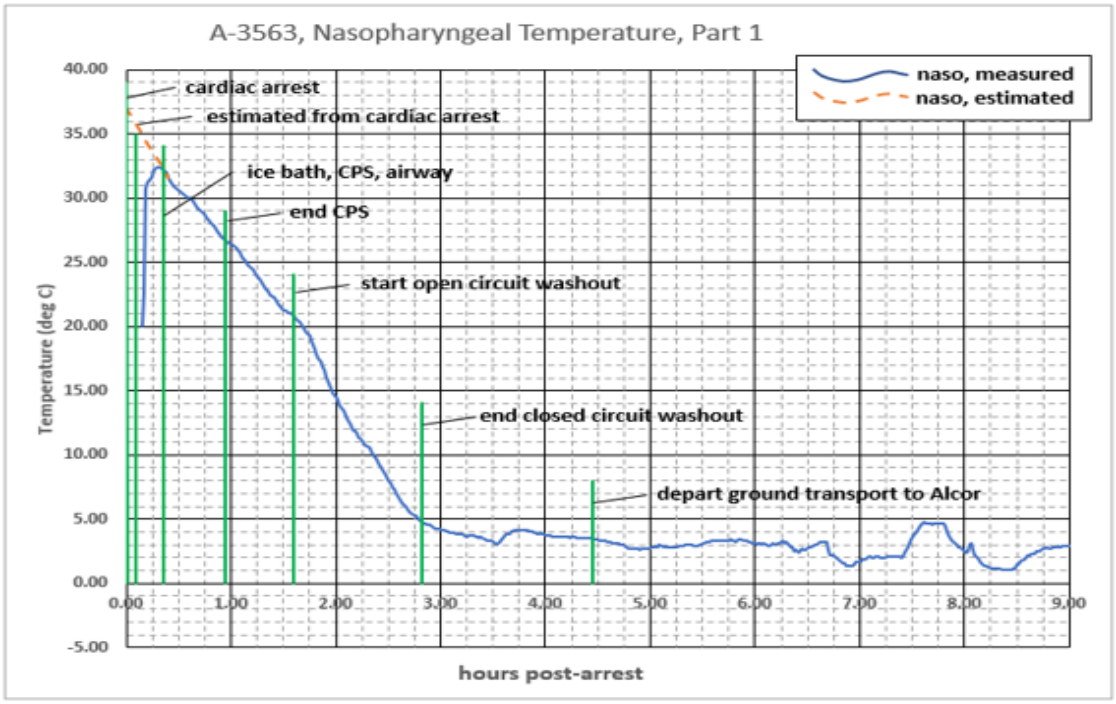

A-3563 Cooldown - Plunge
Gas Temperature
Burr hole
Pharyngeal
Temp, C
-10
-30
-50
-70
-90
-110
-130
18
19
20
21
22
23
24
25
26
Time, hours post-arrest

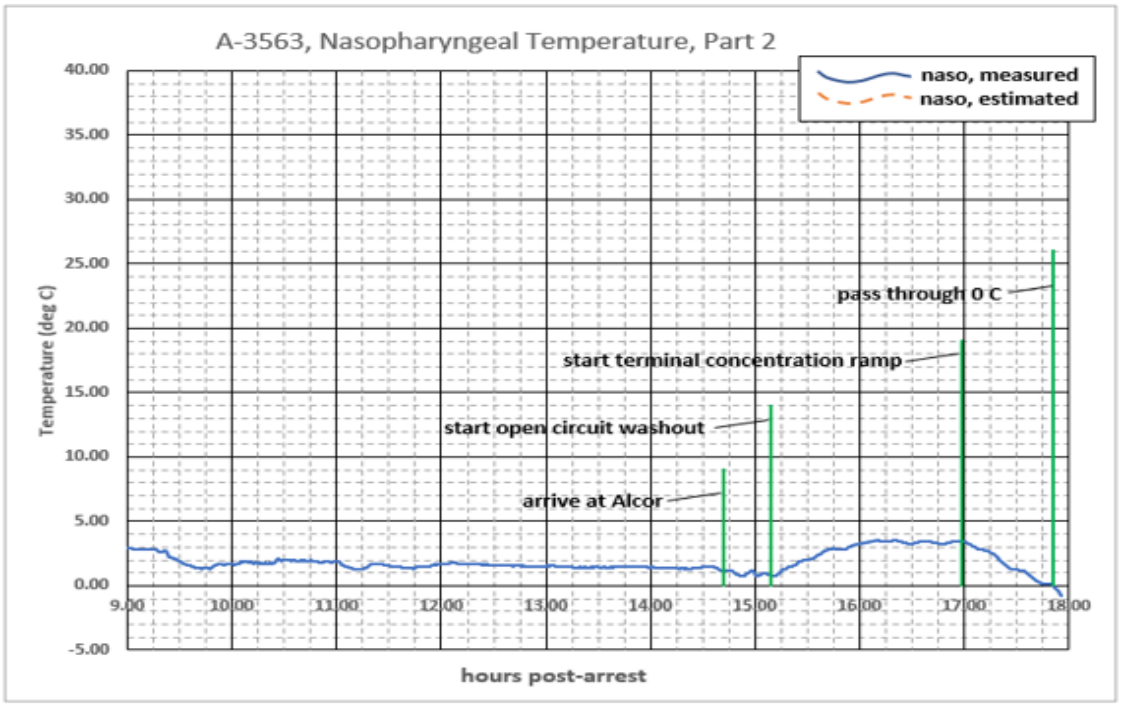
15. S-MIX

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. As calculated below, S-MIX duration for this case is 01:46.

Segments 6 – 10 all occur below 5 C. Even so, these segments account for most of the calculated ischemic damage, S-MIX. Segments 6 – 10 subtotals 01:09 out of a total 01:46 hours, or 65%. It is seen that S-MIX can be very significant at low temperatures when the low-temperature duration is several hours.

event	segment #	days (T+X)	time (MST) duration	post-arrest	Tnaso (deg C)	CPS w/ ventil.	washout oxygen.	S-MIX (hh:mm)
Cardiac arrest		T-0	00:18	00:00	37.0			
	seg 1		00:05	00:05	-1.1	no	no	00:05
ice bath, CPS, airway		T-0	00:23	00:05	35.9			
	seg 2		00:16	00:16	-3.6	yes	no	00:07
Transport patient to MOV for surgery		T-0	00:39	00:21	32.3			
	seg 3		00:36	00:36	-5.6	yes	no	00:11
Termination of CPS (LNPT=24°C, RNPT=27°C)		T-0	01:15	00:57	26.7			
	seg 4		00:39	00:39	-5.7	no	no	00:16
Start of open circuit washout		T-0	01:54	01:36	20.9			
	seg 5		01:13	01:13	-16.2	no	yes	00:00
Completion of closed circuit washout		T-0	03:07	02:49	4.8			
	seg 6		01:38	01:38	-1.3	no	no	00:09
Departure of transport vehicle to Alcor		T-0	04:45	04:27	3.5			
	seg 7		10:15	10:15	-2.3	no	no	00:50
Arrival of patient at Alcor (LNPT=0.6°C,		T-0	15:00	14:42	1.1			
	seg 8		00:27	00:27	-0.3	no	no	00:02
Start of open-circuit washout		T-0	15:27	15:09	0.8			
	seg 9		01:49	01:49	2.7	no	no	00:05
Start of sub-zero terminal concentration ramp		T-0	17:16	16:58	3.5			
	seg 10		00:53	00:53	-3.5	no	no	00:03
Temperature thru 0C		T-0	18:09	17:51	0.0			
totals:			17:51	17:51	-37.0			01:46





16. 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 operational, this patient will be scanned and added to this report.