

Alcor A-1197

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-1197 was an 89-year-old member with neuro cryopreservation arrangements. The member had an unattended cardiac arrest while at home. The cause of death shown on the death certificate was hypoxia, subsequent to atrial fibrillation, subsequent to coronary artery disease. Cardiac arrest was estimated to be between 11:30 hrs and 12:00 hrs on T-0 days. The member was pronounced legally deceased in California at 12:55 hrs on T-0 days in October of 2023.

This case was a neuro [field cryoprotection](#) (FCP). After stabilization and field cryoprotection, the patient was air transported to Alcor for cryogenic cooldown. The patient arrived at Alcor on T+1 days at 13:30. The cryogenic cooldown was initiated on T+1 days at 13:30 hrs and terminated on T+5 days at 13:34 hrs. The patient was transferred to long-term care at liquid nitrogen temperature on T+7 days at 14:41 hrs.

2. Patient Assessment and Deployment

T-0 days

The member had suffered a cardiac arrest while the family was at the grocery store. When they returned home the member was found not breathing. The family started manual chest compressions immediately and called 911. The member was transported to a community hospital and pronounced legally deceased at 12:55. Estimated time of cardiac arrest is between 11:00 hrs and 12:30 hrs. Alcor was notified of the situation at 12:41 hrs.

Alcor contracted with a local funeral home and instructed them to pick up the member at the hospital. The estimated time of arrival of the patient at the funeral home was between 18:30 hrs and 19:00 hrs which would give the DART team time to set up equipment and medications before the arrival of the patient. The funeral home was unable to source dry ice, therefore, the team needed to source dry ice from a local grocery store.

There would be no standby as this was a postmortem notification. The patient would be placed in the portable ice bath (PIB) when the DART team arrived, but no stabilization medications or cardiac compressions would be administered since it would be approximately 5 hours past cardiac arrest. The field cryoprotection would begin as soon as possible after the arrival of the team.

The DART team departed Arizona by air at 15:25 hrs and arrived in California at 17:15 hrs.

3. Stabilization

After arriving in California, picking up the equipment kits at the airline and driving to the funeral home, the DART team arrived at 18:27 hrs. The patient was surrounded by 50 lbs. of water ice, to start external cooling applied around the head and neck at 19:34 hrs. Because this was a postmortem notification, the portable ice bath was not used for external cooling. Instead, surgery was started as soon as possible.

4. Field Surgery

The field surgery began at 19:39 hrs. The right carotid artery was cannulated at 19:48 hrs with a 16 French (Fr), right-angle cannula. The left carotid artery was cannulated at 19:58 hrs with a 16 Fr, right angle cannula. The vertebral arteries could not be located and were not cannulated (see the Discussion section).

Using scalpels, the tissues of the neck were cleared away at 19:58 hrs in preparation for the cephalic isolation. Using an osteotome and mallet, the spinal cord was severed, and the cephalic isolation was completed at 20:19 hrs. Using a Codman perforator, the burr hole was drilled at 20:01 hrs. A thermocouple was placed into the burr hole to measure the patient's brain temperature. The first temperature reading was 22°C.

5. Field Cryoprotection (FCP)

The open circuit, gravity-induced cryoprotectant perfusion was initiated at 20:05 hrs using Bladder #1, which had a molarity of 0.47 and a calculated concentration needed to vitrify (CNV) of 0.05 Brix. See the below Table of Concentrations (Brix) of nM22 Solution, for the times the bladders were started, the precalculated concentrations of each bladder, and the refractive index of effluent samples taken.

By hanging two bladders with different cryoprotectant concentrations on a teeter-totter atop an elevated tripod, a smoother transition of increasing concentrations of cryoprotectant can be achieved (see the Discussion section for a more detailed explanation of the field equipment). The first bladder was hung and opened to flow, and the second bladder was opened when the first bladder was about half empty. The third bladder was hung when the first bladder was empty and opened when the second was about half empty, and so on.

The height of the bladders on the teeter totter was 39 inches which is (39 x 2.054 mmHg per inch of height =) 80 mmHg, the maximum arterial pressure at the infusion site. The goal is to have the pressure between 70 and 80 mmHg and the bladders can be raised or lowered as needed to optimize flow and protect the vasculature.

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 5 & 6 represent the pause. 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.

Ethylene glycol antifreeze at 50/50 concentration was added to the water in the heat exchanger at 20:55 hrs, when Bladder #5 was hung, to produce temperatures below 0°C, and the 30-minute pause for equilibration was initiated.

The bladder system cryoprotectant perfusion (FCP) was terminated at 22:58 hrs. The terminal refractive index (RI) reading was 52.45%, with a molarity of 1.06. The 3-hour limit for perfusion (to prevent toxicity) had been reached.

The patient was moved into the dry ice shipper at 23:10 hrs, and covered with approximately 30 lbs. of dry ice.

6. Patient Transport to Alcor

T+1 days

The DART team checked the dry ice in the shipper and added 10 lbs. of dry ice before departing from the funeral home at 10:50 hrs. The cephalon had approximately 30 lbs. of dry ice in the neuro shipper container. The patient left the funeral home at 10:50m hrs to be transported to the cargo department of the local airport.

7. Cooling to Liquid Nitrogen Temperature

The patient arrived at Alcor at 13:30 hrs. The burr hole temperature was -77°C .

Computer-controlled cryogenic cooldown was initiated at 13:44 hrs on T+1 days, plunging to -110°C and descending thereafter at $-1^{\circ}\text{C}/\text{hour}$ to liquid nitrogen temperature. On T+5 day at 06:02 hrs, an uneventful cooldown was terminated. On T+7 days at 14:41 hrs, the patient was transferred to long-term care at liquid nitrogen temperature.

8. Timeline and Time Summaries

Timeline

T-0	11:30	Estimated time of cardiac arrest
T-0	12:55	Pronouncement of legal death
T-0	19:34	Start of ice bath cooling
T-0	19:39	Start of field surgery
T-0	19:58	Start of cephalic isolation
T-0	20:01	Drill burr hole and place thermocouple
T-0	20:05	Start of field cryoprotection (FCP)
T-0	20:19	Complete cephalic isolation
T-0	22:58	End of FCP (final RI = 52.45 Brix)
T-0	23:10	Start of dry ice cooling
T+1	10:50	Patient departed funeral home for the airport
T+1	13:30	Arrival of patient at Alcor (-77°C)
T+1	13:44	Start of patient cryogenic cooldown at Alcor
T+5	06:02	End of cooldown
T+7	14:41	Transfer of patient to long-term maint.at LN2 temperature

Time Summaries

Event Duration hr:min		days	time	
01:25	From: Till:	T-0 T-0	11:30 12:55	Estimated time of cardiac arrest Pronouncement of legal death
08:04	From: Till:	T-0 T-0	11:30 19:34	Estimated time of cardiac arrest Start of ice bath cooling
08:09	From: Till:	T-0 T-0	11:30 19:39	Estimated time of cardiac arrest Start of field surgery
00:22	From: Till:	T-0 T-0	19:39 20:01	Start of field surgery Drill burr hole and place thermocouple
08:35	From: Till:	T-0 T-0	11:30 20:05	Estimated time of cardiac arrest Start of field cryoprotection (FCP)
02:53	From: Till:	T-0 T-0	20:05 22:58	Start of field cryoprotection (FCP) End of FCP (final RI = 52.45 Brix)
11:28	From: Till:	T-0 T-0	11:30 22:58	Estimated time of cardiac arrest End of FCP (final RI = 52.45 Brix)
00:40	From: Till:	T-0 T-0	19:39 20:19	Start of field surgery Complete cephalic isolation
00:26	From: Till:	T-0 T-0	19:39 20:05	Start of field surgery Start of field cryoprotection (FCP)
03:19	From: Till:	T-0 T-0	19:39 22:58	Start of field surgery End of FCP (final RI = 52.45 Brix)
00:12	From: Till:	T-0 T-0	22:58 23:10	End of FCP (final RI = 52.45 Brix) Start of dry ice cooling
11:40	From: Till:	T-0 T-0	11:30 23:10	Estimated time of cardiac arrest Start of dry ice cooling
26:00	From: Till:	T-0 T+1	11:30 13:30	Estimated time of cardiac arrest Arrival of patient at Alcor (-77°C)
00:14	From: Till:	T+1 T+1	13:30 13:44	Arrival of patient at Alcor (-77°C) Start of patient cryogenic cooldown at Alcor

9. Table of Concentrations (Brix) of nM22 Solution

A-1197 step-ramp, nM22								
Preferred endpoint is over 49.9 Brix from both jugulars for 1/2hr								
2L Bag label number	[nM22], CNV	Molarity of penetrating CPAs*	Brix (calc)	Bag start hh:mm, MST	hrs post pronouncement	Bag avg. flow rate, mL/min	Sample time hh:mm, MST	Effluent Conc., Brix
1	0.05	0.47	11.81	20:05	7.17	200.0	21:11	31.4
2	0.08	0.78	13.14	20:15	7.33	133.3	21:29	51.25
3	0.14	1.29	15.35	20:30	7.58	133.3	21:54	52.45
4	0.23	2.15	19.03	20:45	7.83	200.0	22:15	52.45
5	0.50	4.67	29.85	20:55	8.00	500.0	22:44	52.45
6	0.50	4.67	29.85	20:59	8.07	166.7	22:58	52.45
7	1.06	9.91	52.306	21:11	8.27	142.9		
8	1.06	9.91	52.306	21:25	8.50	133.3		
9	1.06	9.91	52.306	21:40	8.75	142.9		
10	1.06	9.91	52.306	21:54	8.98	111.1		
11	1.06	9.91	52.306	22:12	9.28	117.6		
12	1.06	9.91	52.306	22:29	9.57	133.3		
13	1.06	9.91	52.306	22:44	9.82	142.9		
END				22:58	10.05			

* does not account for concentration of non-penetrating CPAs

10. Discussion

Standby, Stabilization and Recovery

The stabilization kits did not contain the pipettes and the refractometer device. This made it difficult to obtain the refractive index readings required to determine the cryoprotectant concentration in the effluent samples. The team used sterile syringes to obtain effluent samples and saved them in contact lens cases to be read upon return to Alcor. The kits must always be checked prior to deployment. Extensive training, meetings, and redundancies have been put into place to ensure these problems do not happen again.

Field Surgery and Cryoprotection (FCP)

The vertebral arteries could not be located and were not cannulated. The DART team has received additional surgical training with emphasis on the importance of isolating and cannulating the vertebral arteries. The team members have been given additional training on how to isolate and cannulate all arteries.

The team suspects that samples taken during the perfusion were composed primarily of perfusate leaking past the cannulas rather than only being effluent. The measured values are nearly identical to the step ramp bag concentrations. A planned CT scan of the patient will be used to analyze the extent of perfusion.

The statement in the field report that the patient was perfusing at full concentration for 30 minutes longer than needed was based on these refractometer readings, however it is likely they

do not accurately reflect the concentration of effluent from the patient. In cases where refractometer readings are compromised, falling back on the 3-hour perfusion time limit gives the patient the best chance of reaching full CNV.

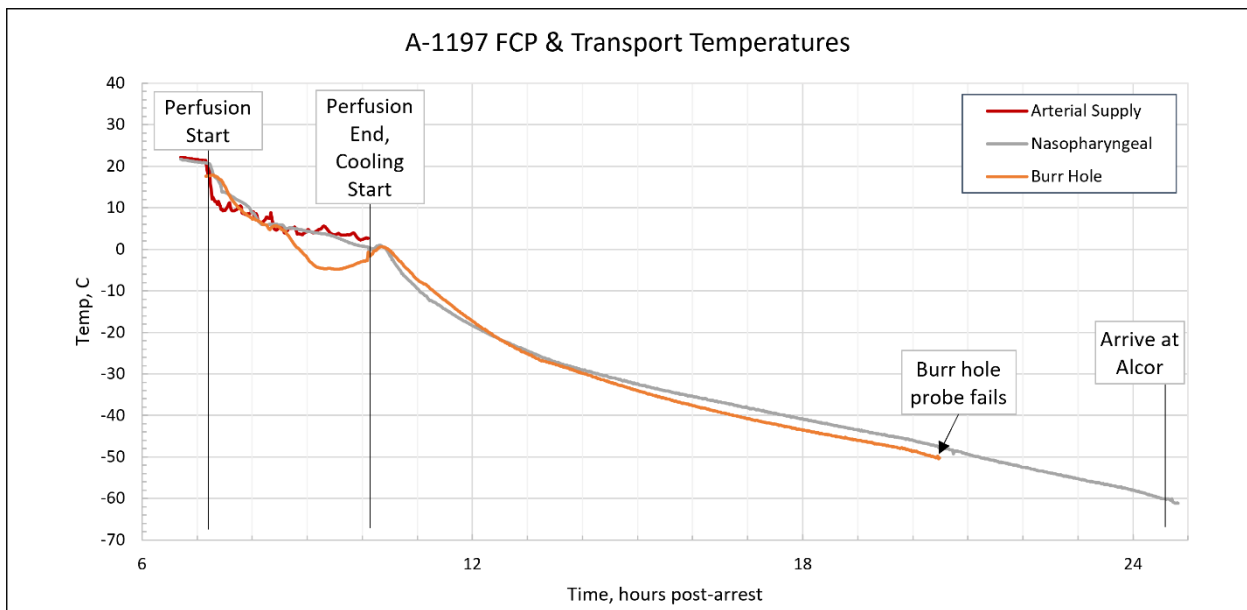
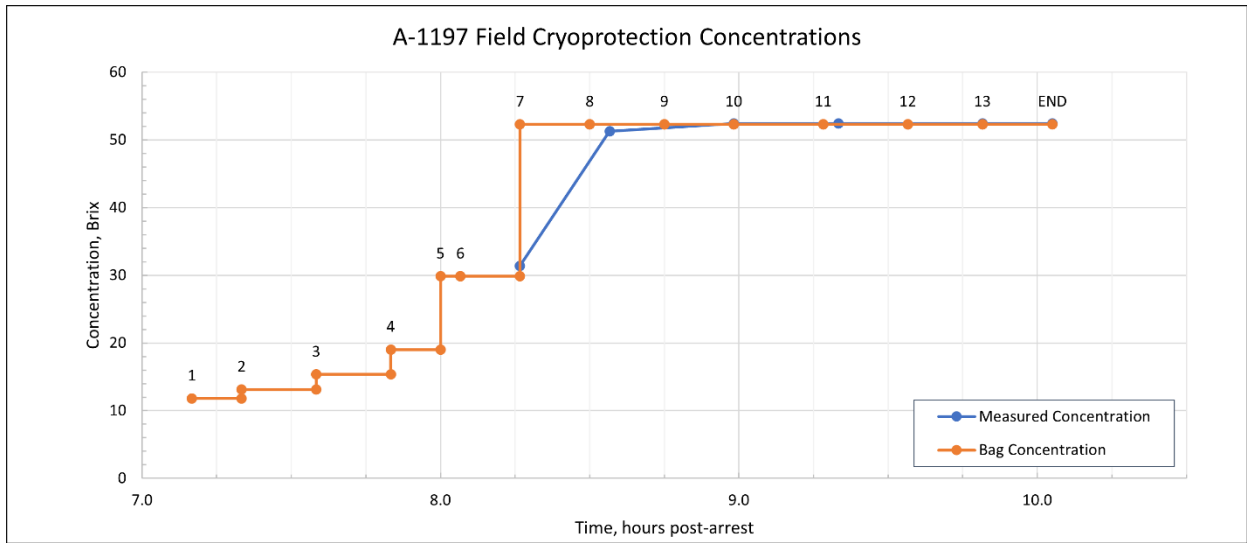
Cryoprotectant Surgery and Perfusion at Alcor

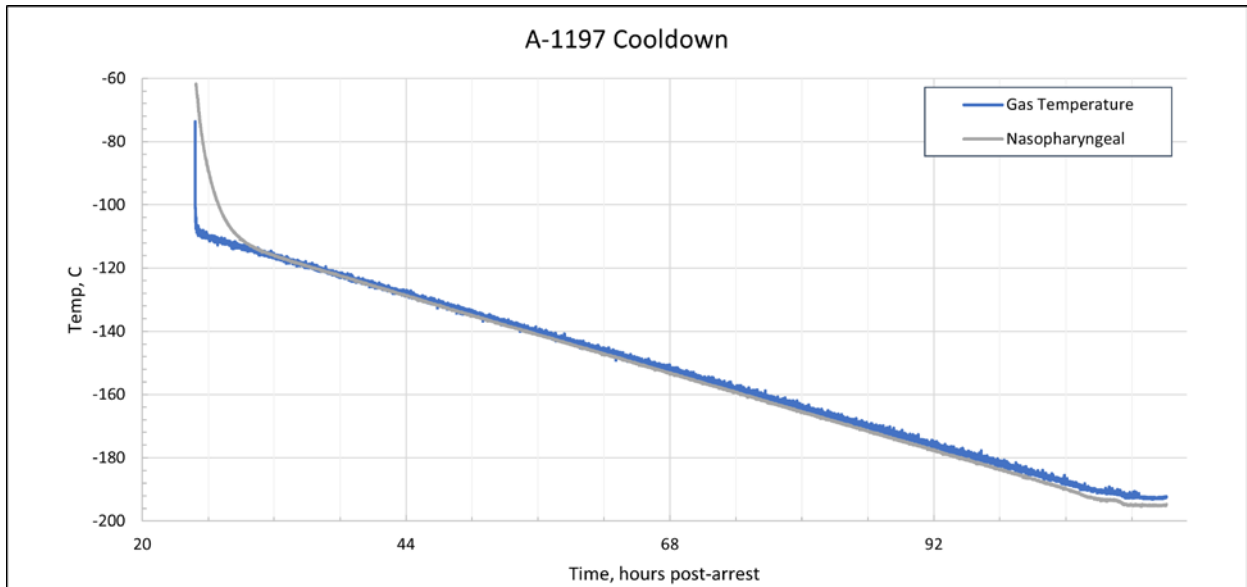
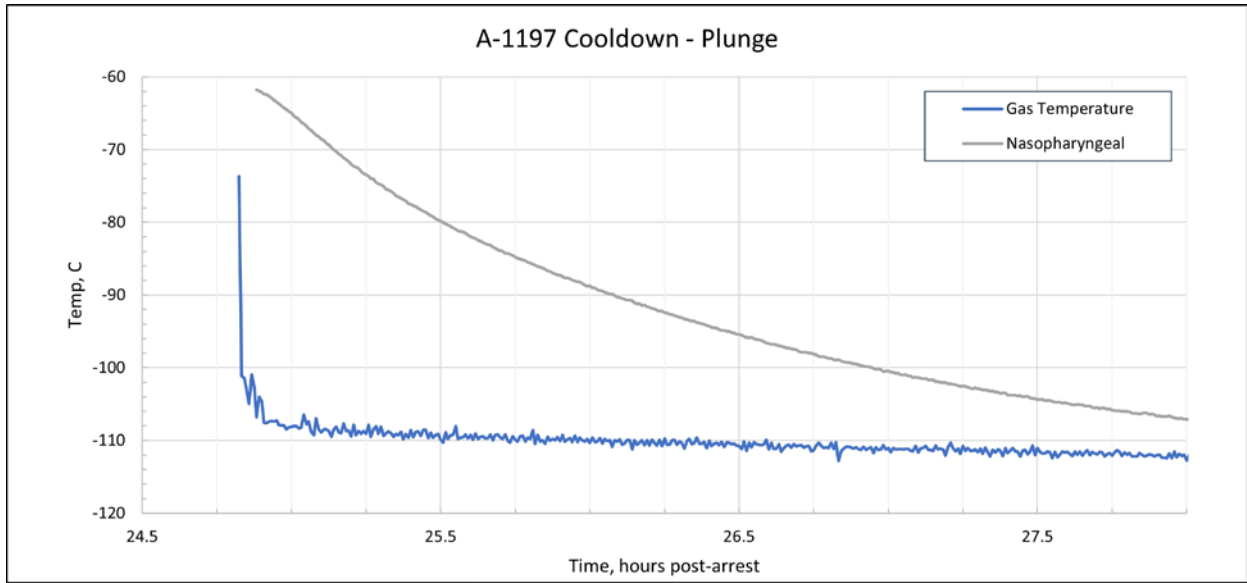
Due to an error in packing the kits, the pipettes for taking refractive index (RI) readings were not packed. The Brix concentrations of the effluent samples were sampled by syringe and placed into sterile contact lens containers upon return to Alcor.

Patient Transport

The burr hole thermocouple disconnected abruptly during transport. The thermocouple wire was cut, and a new plug attached after cooldown initiated, but this did not reestablish the signal, indicating damage somewhere further along the wire.

11. Cryoprotection and Temperature Graphs



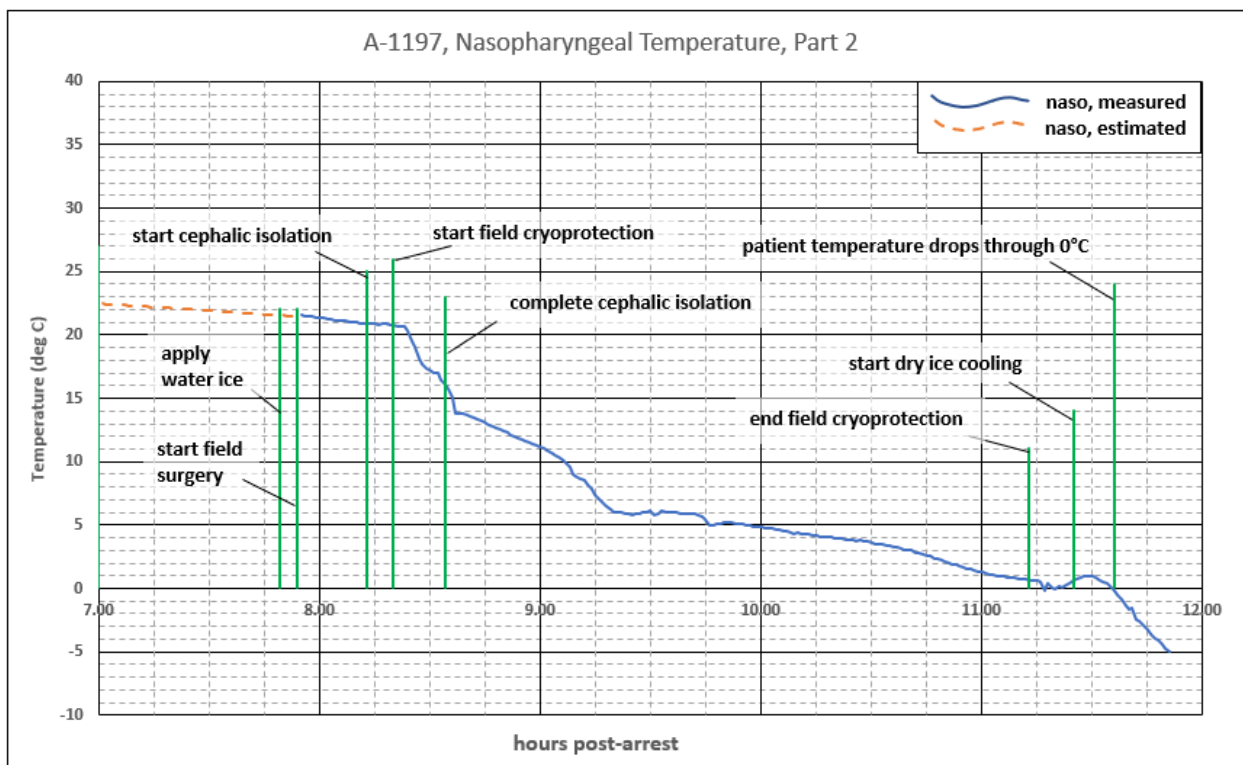
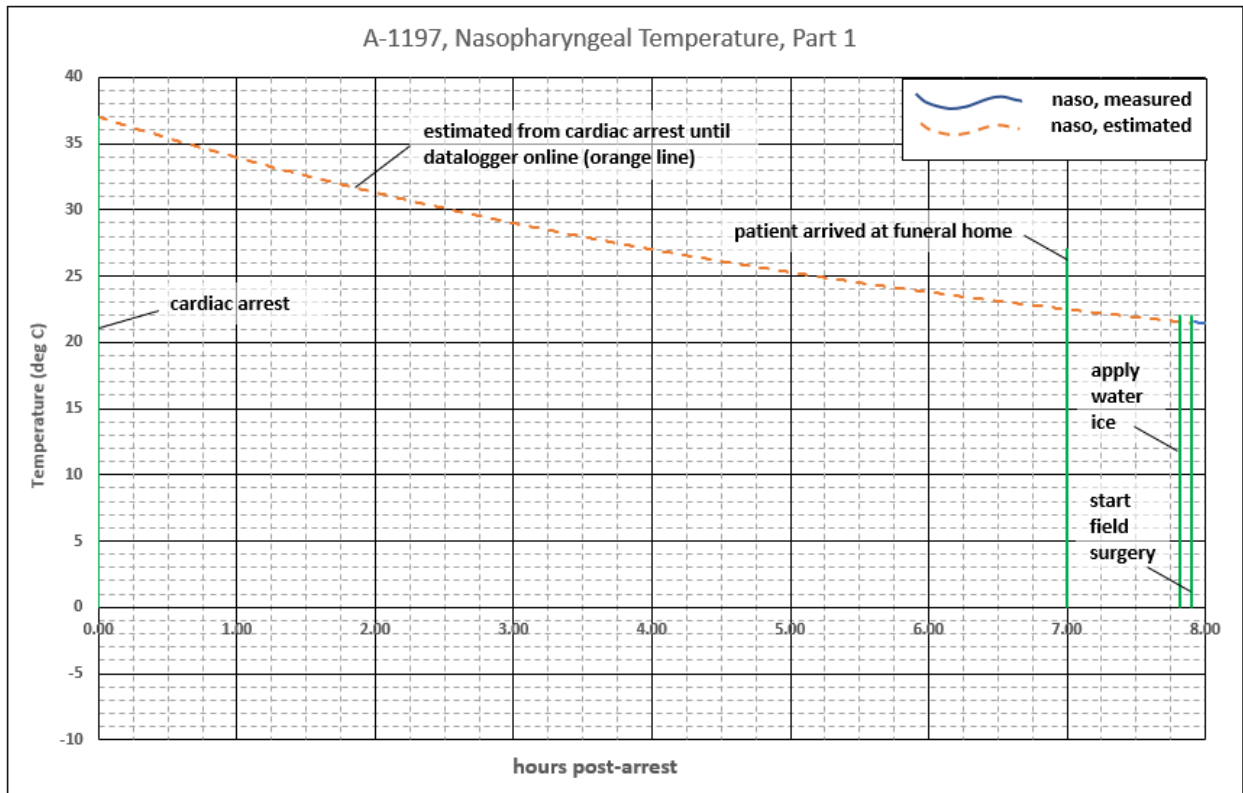


12. S-MIX

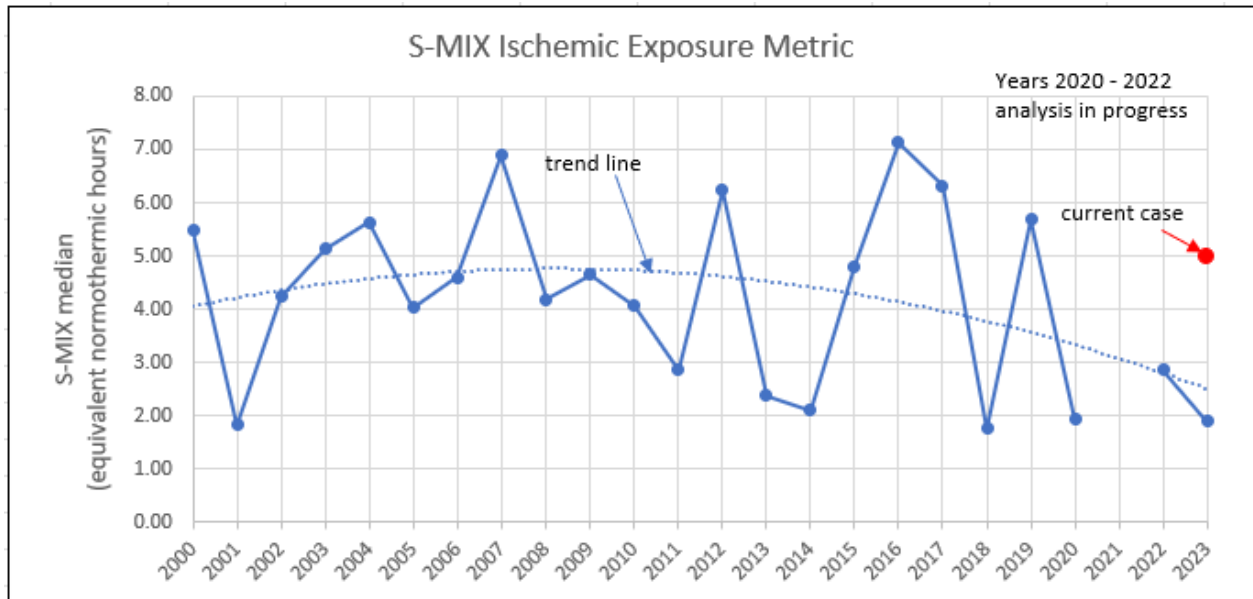
The [Standardized Measure of Ischemic Exposure](#) (S-MIX) expresses the total ischemic exposure prior to the start of cryogenic cooling as the equivalent duration of normothermic ischemia. An S-MIX of 00:00 (hh:mm) is the ideal case of no ischemic damage. The higher the S-MIX time, the more damage. 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 11:36. As shown below, and due to lowering of the body temperature, S-MIX duration is shorter, at 04:57.

event	seg- ment #	days (T+X)	time (MST)	post- arrest	Tnaso (deg C)	CPS w/ ventil.	washout oxygen.	S-MIX (hh:mm)
			duration					
Estimated time of cardiac arrest		T-0	11:45	00:00	37.0			
	seg 1		06:60	06:60	-14.5	no	no	04:04
Patient arrived at funeral home		T-0	18:45	06:60	22.5			
	seg 2		00:49	00:49	-0.9	no	no	00:17
Start of water ice cooling		T-0	19:34	07:49	21.6			
	seg 3		00:05	00:05	-0.1	no	no	00:02
Start of field surgery		T-0	19:39	07:54	21.5			
	seg 4		00:19	00:19	-0.6	no	no	00:06
Start of cephalic isolation		T-0	19:58	08:13	20.9			
	seg 5		00:07	00:07	-0.2	no	no	00:02
Start of field cryoprotection (FCP)		T-0	20:05	08:20	20.7			
	seg 6		00:14	00:14	-4.6	no	no	00:04
Complete cephalic isolation		T-0	20:19	08:34	16.1			
	seg 7		02:39	02:39	-15.5	no	no	00:19
End of FCP (final RI = 52.45 Brix)		T-0	22:58	11:13	0.7			
	seg 8		00:12	00:12	-0.1	no	no	00:01
Start of dry ice cooling		T-0	23:10	11:25	0.6			
	seg 9		00:11	00:11	-0.8	no	no	00:01
Estimated temperature thru 0°C		T-0	23:21	11:36	-0.2			
totals:			11:36	11:36	-37.2			04:57

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



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



13. CT Scans

Cryoprotectant Distribution (Post-cryopreservation CT scan)

When the in-house scanner is functional additional information will be added to this report.