Alcor A-2408
Case Report

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Alcor A-2408 Case Report Contents:

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-2408 was a 52-year-old male with whole-body cryopreservation arrangements. He had stage IV lung cancer. He was pronounced clinically deceased in November of 2020 in New Jersey at 07:29 hrs on T-0 days. He was flown to Alcor on water ice for cryoprotection and entered cryogenic cooldown at 05:50 hrs on T+1 days. Cooldown was terminated on T+10 days and he was transferred into long-term maintenance on T+11 days.

2. Patient Assessment

T-0 days

Alcor received an alert from their medical answering service at 08:17 hrs that the member was deceased following last-minute lung cancer surgery. Alcor had not previously been notified that the member had cancer and since he was only 52 years old, he was not on the Watch List.

The patient's right lung had been removed and his physician was initially optimistic that the tumor had been entirely removed but his blood pressure never recovered. The patient had been pronounced clinically deceased at 07:29 hrs. According to the member's brother, he was resuscitated once after he went into cardiac arrest but coded again shortly thereafter.

Alcor documentation was faxed to the hospital and the Emergency Instructions document was texted to the patient's brother who was still in the intensive care unit (ICU) and wanted to help carry out his brother's arrangements for cryopreservation.

3. Stabilization and Transport

Alcor's Readiness Coordinator (RC) began calling funeral homes near the patient for logistics support. After receiving the documentation and Emergency Instructions, the hospital called Alcor and agreed to administer 50,000 IU of heparin, to apply manual chest compressions for 10 minutes after heparin administration, pack the patient in as much ice as possible and have him moved to a refrigerated room in the morgue (the temperature of the room was not recorded).

The assistance of members from the Alcor New York group was requested to make sure the patient was properly packed in a sufficient amount of water ice, not dry ice, and to assist with moving the patient onto the plane. Three volunteers responded and drove to the patient's location.

There was a temporary concern that this might become a Medical Examiner's (ME) case that could require an autopsy, but that did not transpire. The patient was released by the ME at 11:49 hrs. The use of a private jet was arranged.

When the cryonics first responders arrived at the funeral home, the patient had already been prepared for shipping and was in a sealed Ziegler case, but the first responders had it opened and found almost no ice on the patient. One of the first responders left to purchase 120 lbs. of ice and sealable plastic bags. This was placed on the patient and the first responder left again to purchase additional ice.

Alcor called the funeral home in New Jersey to help finalize paperwork and called the Arizona funeral director to alert him about this case. At 17:47 hrs the patient was packed and ready to be taken to the airport. At 18:57 hrs the patient was loaded into the plane in an improvised carrier.

Four staff members from Alcor and two additional helpers would meet the plane in Scottsdale to off-load the patient and transport him to Alcor. The private flight left New Jersey at 19:22 hrs on T-0 days and arrived in Scottsdale at 00:18 hrs on T+1days. The patient was moved into the Alcor response vehicle at 00:36 hrs and driven to Alcor.

4. Cryoprotectant Perfusion Surgery

T+1 days

The Alcor operating room had been prepared in advance of the arrival of the patient. The patient arrived at the back door to Alcor at 00:48 hrs and a MegaMover was placed under the whole-body patient. Using a hoist, the patient was brought into the operating room (OR) at 01:03 hrs. The patient's nasopharyngeal temperature (NPT) was 7.3°C. The patient was moved to the OR table and ice bags were placed around his head.

The recent surgical closure was cut open and the patient was draped and prepped for the cannulation surgery. A Finochietto retractor was used at 01:19 hrs to open the thoracic cavity. The entire right lung had been removed. A purse-string was placed in the atrial appendage at 01:26 hrs in preparation for venous cannulation. A 32 French (Fr) venous cannula was attached to the system tubing. At 01:37 hrs the venous cannula was placed and ligated and tied to the retractor to optimize the tubing position.

A purse-string was placed in the aortic arch at 01:45 hrs. A 22 Fr arterial cannula was attached to the tubing and bubbles were removed. At 01:59 hrs the cannula was placed and ligated. A Keck clamp was slowly opened to start perfusion flow and the bypass line was closed. Air was cleared from the lines, and open-circuit washout was initiated at 02:01hrs.

To stay ahead of potential edema, the washout procedure was initiated with 20 liters of 5% M22 5% M22 cryoprotectant solution (instead of a washout solution without cryoprotectant). 250,000 IU of streptokinase, a blood clot dissolver, was added to the first batch of washout solution. The washout was started at an arterial refractive index of 12.7 Brix and an accelerated ramp rate of approximately twice the normal ramp rate.

There were no visible blood clots; the patient had received heparin at the hospital and streptokinase had been added to the washout solution. The arterial pressure was 80 mmHg. The washout of the patient was unusually fast; the first batch of washout solution was drained in about 3 minutes without the venous effluent running clear. A second batch of solution needed to be prepared. The CT scanner was warmed up for the pre-cryoprotection CT scans at 02:06 hrs.

The ice bags were removed from the top of the patient's head and at 02:09 hrs incisions were made on the scalp for the burr holes.The left burr hole was drilled at 02:13 hrs using chilled saline to cool the Codman perforator bit and the scalp. There were no blood clots observed. The same procedure was performed on the right burr hole at 02:17 hrs. The temperature thermocouple probe was placed in the left burr hole.

5. Cryoprotectant Perfusion

At 02:10 hrs 1100 mL of 10% M22 cryoprotectant (based on the field neuro ratio of 1 L M22 x 1.25 in approximately 20 L B1 base solution, resulting in a Brix concentration of 12.7 Brix) was added to 20 L of B1 solution for the second washout pass. At 02:22 hrs the second batch of washout solution was perfused. The arterial refractive index was 13.7 Brix and the venous refractive index was 12.8 Brix.

A thermocouple probe was ligated to the patient's forehead at 02:23 hrs and connected to the data acquisition system. The initial burr hole temperature (BHT) was 5.9°C. The brain retraction detection device (BRDD) was placed in the right burr hole at 02:25 hrs. The initial retraction distance was 4.17 mm.

The cryoprotectant ramp was started at 02:27 hrs. The arterial refractive index was 13.4 Brix and the venous refractive index was 13.1 Brix. Ice bags were removed from the patient's head in preparation for the pre-cryoprotection CT scan. The ramp pump speed was set to 4 (5.3 mL/min) and recirculation was initiated at 02:35 hrs. The mixing reservoir volume was 9 L. The patient's corneas were becoming concave from dehydration resulting from exposure to the cryoprotectant solution. Abdominal bloating was apparent at 02:38 hrs. The ramp pump speed was set to 5 (6.6 mL/min).

At 02:41 hrs the CT scanner was moved to the head of the OR table and centered. Effluent from the burr holes was seen as a possible problem for taking the CT scans. A 2-gallon Ziploc bag was placed over the patient's head to contain the effluent. The pre-cryoprotection CT scan was taken at 02:45 hrs. The scanner was then moved away from the patient's head.

The patient and the OR table were covered at 02:52 hrs to improve external cooling. The ramp pump was set to full speed (13.14 mL/min at 03:01 hrs because of the increase in edema and bloating. Because of the edema, there was no pause at 30 Brix (50% of the desired terminal concentration) to allow the patient to come to osmotic equilibrium. The arterial input and the OR table enclosure were set to -3°C.

Sidebar:
Per the cryoprotection protocol, the ramp is to be paused at 30 Brix (50% of the desired terminal concentration) to allow the patient to come to osmotic equilibrium. The cephalic 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 corneas continued to become more concave. A second bladder of M22 cryoprotectant was initiated at 03:27 hrs after the first bladder was depleted. There was no visible brain volume reduction observed at the burr hole and the BRDD retraction distance had declined from 23 to 18 at 03:40 hrs, indicating increased edema in the brain.

The 30-minute countdown to termination of perfusion was not initiated because the concentration needed to vitrify (CNV) could not be reached (see the below graph on Brain Shrink Distance) without exposing the patient to the toxicity of the cryoprotectant for more than 3 hours, resulting in excessive cryoprotectant toxicity. At 03:56 hrs the arterial refractive index was 52.7 Brix. At 04:27 hrs the arterial pressure was fluctuating due to the low pump speed. The cryoprotective ramp was terminated at 04:56 hrs because the arterial refractive index was 53.6 Brix, the venous refractive index was 37.2 Brix and rising so slowly that terminal concentration could not be obtained within the 3-hour limit to cryoprotectant perfusion.

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

Warmup of the CT scanner was started at 04:46 hrs for the post-cryoprotection scans which were taken at 04:51 hrs. The 2-gallon Ziplock bag was again placed over the patient's head to contain the effluent and protect the scanner from effluent. After the scan was taken the scanner was again moved away from the patient's head. The NPT was 5.1°C and the BHT was 0.7°C.

The patient's face was very tanned, an indication of some degree of perfusion. Some areas of the face and head were a reddish color instead of tanned, but the chest was only slightly mottled and only the skin on the knees was tanned. The brain surface was touching the skull but had not yet extruded from the burr hole.

At 05:04 hrs, to move the patient into the patient care bay (PCB) for cryogenic cooldown, the instruments and system tubing were removed from the patient, the hoist straps were placed on the OR table and the thoracic cavity was suctioned. Straps were placed under the patient's shoulders and legs.

6. Cooling to Liquid Nitrogen Temperature

At 05:21 hrs the entire OR table, with the patient, was rolled into the PCB. Using the hoist, the patient was raised and the MegaMover was retrieved; the patient was then lowered back onto the table tray and the patient was hoisted in the tray into the cooldown box. The lid was placed on the cooldown box and the nitrogen source was connected. The probes were connected to the cooldown computer.

The fan was noisy and needed to be adjusted. The lid was removed, an adjustment was made, and the lid was put back in place. The problem had not been corrected; further efforts were made to correct the problem. At 05:49 hrs the problem was corrected, the lid was placed back on the cooldown box, and the nitrogen source was again connected.

The appropriate computer program was used to initiate cryogenic cooldown at 05:50 hrs on T+1 days, plunging to -80°C and holding for 125 hours. On T+6 days at 11:16 hrs, the patient was transferred to the TallBoy dewar and the appropriate computer program was used to resume cryogenic cooldown, plunging to -110°C and descending thereafter at -1°C/hour to liquid nitrogen temperature. On T+10 days, the cooldown was terminated. On T+11 days, the patient was transferred to long-term maintenance at liquid nitrogen temperature.

7. Timeline and Time Summaries

Timeline

T-0 days

07:29 Pronouncement of legal death
09:53 (estimated) Administration of 50,000 IU heparin by hospital staff
19:22 Departure of the patient via air ambulance to Alcor

T+1 days

00:48 Arrival of the patient at Alcor (7.3°C)
01:19 Start of thoracic surgery
02:01 Start of open-circuit washout
02:13 Start of burr hole surgery
02:17 Completion of burr hole surgery
02:23 NPT probes attached to the data acquisition system (5.9°C)
02:27 Completion of open-circuit washout
02:27 Start of cryoprotection
02:45 CT scans made pre-cryoprotection
04:51 CT scans made post-cryoprotection (NPT = 5.1°C, BHT = 0.7°C)
04:56 Termination of cryoprotection (53.6 Brix arterial and 37.2 Brix venous)
05:50 Start of cryogenic cooldown

T+10 days

Completion of cryogenic cooldown at LN_2 temperature

T+11 days

Transfer of patient to long-term maintenance at LN_2 temperature

Time Summaries

Stabilization and Transport

hrs: mins

02:24 From pronouncement of legal death to heparin administration at the hospital: 07:29 hrs to 09:53 hrs (estimate) on T-0 days.

17:19 From pronouncement of legal death to patient arrival at Alcor: 07:29 hrs on T-0 days to 00:48 hrs on T+1 days

Surgery

hrs: mins

17:50 From pronouncement of legal death to start of surgery: 07:29 hrs on T-0 days to 01:19 hrs on T+1 days

00:31 From arrival at Alcor to the start of surgery: 00:48 hrs to 01:19 hrs

00:42 From the start of surgery to end of surgery: 01:19 hrs to 02:01 hrs

Cryoprotectant Perfusion

hrs: mins

18:32 From pronouncement of legal death to start of washout: 07:29 hrs on T-0 days to 02:01 hrs on T+1 days

00:26 From the start of washout to the end of washout: 02:01 hrs to 02:27 hrs

18:58 From pronouncement of legal death to end of washout: 07:29 hrs on T-0 days to 02:27 hrs on T+1 days

01:08 From the start of surgery to the start of the cryoprotection: 01:19 hrs to 02:27 hrs

03:37 From the start of surgery to the end of the cryoprotection: 01:19 hrs to 04:56 hrs

18:58 From pronouncement of legal death to start of cryoprotection: 07:29 hrs on T-0 days to 02:27 hrs on T+1 days

01:39 From arrival at Alcor to the start of cryoprotection: 00:48 hrs to 02:27 hrs

02:29 From the start to the end of cryoprotection: 02:27 hrs to 04:56 hrs

Cryogenic Cooldown

hrs: mins

00:54 From the end of cryoprotection to the start of cooldown: 04:56 hrs to 05:50 hrs

22:21 From pronouncement of legal death to start of cooldown: 07:29 hrs on T-0 days to 05:50 hrs on T+1 days

05:02 From arrival at Alcor to the start of cooldown: 00:48 hrs to 05:50 on T+1 days

8. Discussion

This patient had not informed Alcor that he had cancer or even that he was having surgery; the notification was post-arrest. As this member was only 52 years old he was not on the Watch List. The Watch List needs to be expanded to the whole membership when possible. Part of this could be working with new members to get their paperwork in order, HIPAA, Advanced Directive, etc. This could be something like "caseworkers" that follow-up with the members periodically. Since the patient went into cardiac arrest the day after a surgical procedure was performed for lung cancer, the family would have had time to notify Alcor of his critical condition. Extra effort, such as articles in the *Alcor News*, needs to be given to raise member awareness of the importance of letting Alcor know about pending health conditions and surgeries.

There was extensive discussion on Alcor's internal communication system (ICS) about how to best respond as several challenges were being faced. First, this was a post-mortem case where there was insufficient time to send a standby, stabilization and transport (SST) team to the East Coast. Second, the potential problems with obtaining a transit permit on the weekend. Third, how long it would take to have the patient shipped to Alcor on a commercial flight since there was no extra funding for an air ambulance. Since Alcor's strategic partners for providing SST would not be used on this post-mortem case, it was determined that there would be sufficient funding for an air ambulance and this would greatly reduce the transport time and resulting ischemic damage to the patient. Because the patient was on the east coast, the plane would also have to be on the East Coast to prevent a time loss from flying a plane from another location. All these issues raised the question of whether the potential ischemic time would allow for good perfusion when the patient did arrive at Alcor.

Because of previous experience with funeral homes that had not followed Alcor's instructions on how to pack the patient for shipment, it was decided to ask for the assistance of one or more members of the Alcor New York group to make sure the patient was properly packed in a sufficient amount of water ice, not dry ice, and to assist with getting the patient on the plane.

The first response team made up of Alcor members in the New York area was invaluable for this case. They stayed in close communication with the Alcor staff on Alcor's internal communication system (ICS) while they worked to make sure the patient was properly packed in ice, various supplies were purchased and the patient was delivered to the plane. Due to the size and configuration of the private plane, the patient could not be shipped in the standard Ziegler case or a casket as these would not fit through the side door and make a tight turn. The first responders used good judgment and ingenuity in packing the patient in sealable bags of ice.

The funeral home had only one body bag and it was torn. No other body bags could be found on short notice from other funeral homes in the area or even from the fire department. The first responders used a tarp to wrap the patient and ice so that the patient could be loaded and off-loaded again in Scottsdale without leakage in the plane. The first responders did not have a temperature logger with them to monitor the patient's temperature during transport and it could not be found locally on short notice. A list of items for a first response kit is being developed.

Even with good documentation, remote morticians do not always follow directions or even do what they agree to do. The airport in Philadelphia, which was the nearest airport to the location of the patient in New Jersey, was some distance from New York, but the first responders still got there in a couple of hours.It was decided that one of the first responders should accompany the patient on the flight to Arizona to ensure the maintenance of ice packing and assist with logistics.

Because ischemic delays caused by both time and temperature can result in damage to the vasculature and potentially compromise perfusability, Alcor still hoped that the transport time would be short enough that the patient could be adequately cryoprotected.

Local groups need to be encouraged to develop a list of members who are willing to be trained as first responders. That list should also show which first responders will agree to fly to other locations in addition to their home location, to assist the medically trained Alcor team. Several first responders will usually be needed in any case because there are a lot of logistics to be handled, and strong backs are needed to move a patient in the field without a hoist.

The surgical approach used on this case was a departure from previous cannulation procedures, doing the venous cannulation before the arterial cannulation, and this resulted in less leakage into the thoracic cavity.

The first bladder of the washout solution only took three minutes to expend. Long washouts with normal osmolality may be detrimental as they may promote edema. Perfusion after long ischemic times should probably begin with some cryoprotectant to open blood vessels to release blood clots, and potentially reduce early edema."

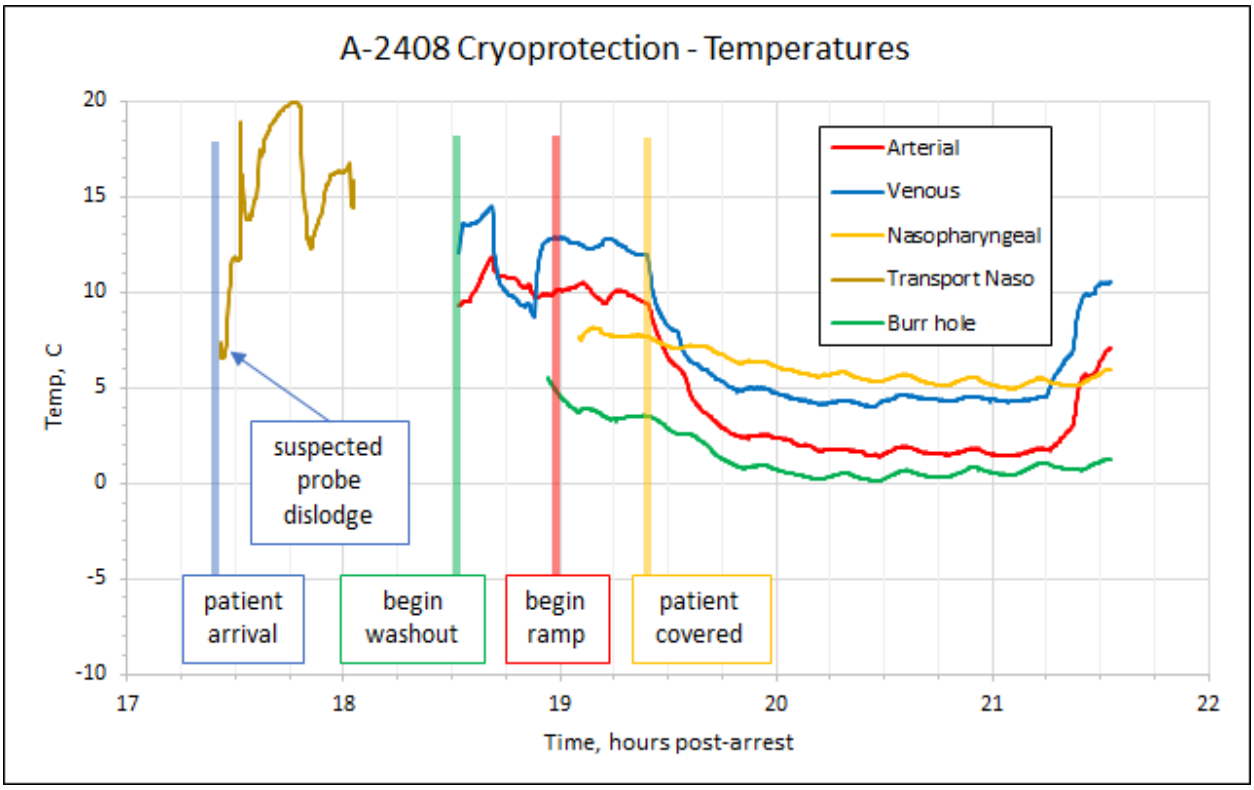
In one sense the response of this patient to extensive periods of warm ischemia was typical; he had lower body edema and little brain dehydration (size decrease) during cryoprotective perfusion. In another sense, it was quite a-typical: there was very little leaking from the patient despite a compromised circulatory system and organs. During the second batch of washout solution the venous effluent was slower.

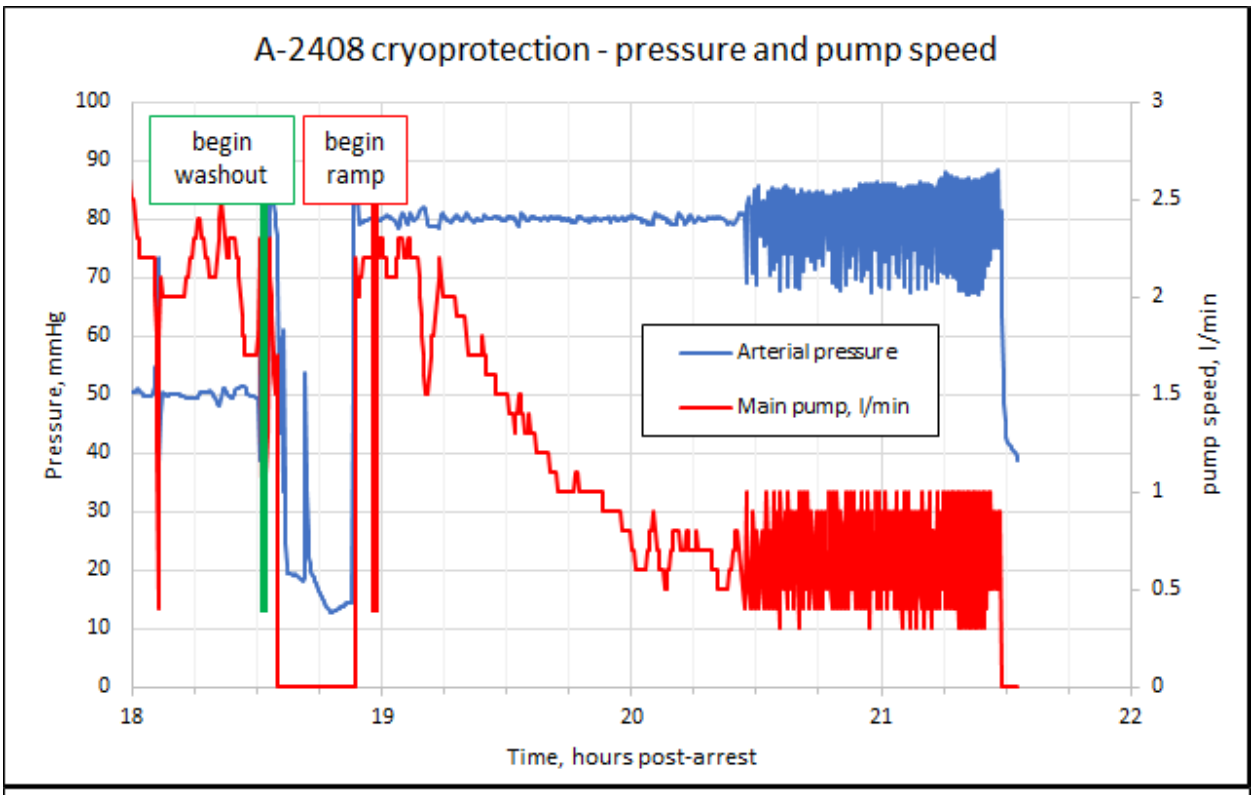
The perfusionists discussed how to decide when to terminate cryoprotection. It was decided that when the arterial refractive index reached 52.7 Brix, or 106% concentration needed to vitrify (CNV), perfusion would be continued for an additional hour before termination unless brain edema was observed at the burr hole. Readings from the BRDD had been fluctuating; probably due to effluent from the burr hole affecting the laser reading. Observation of the brain surface at the burr holes did not reflect imminent danger.

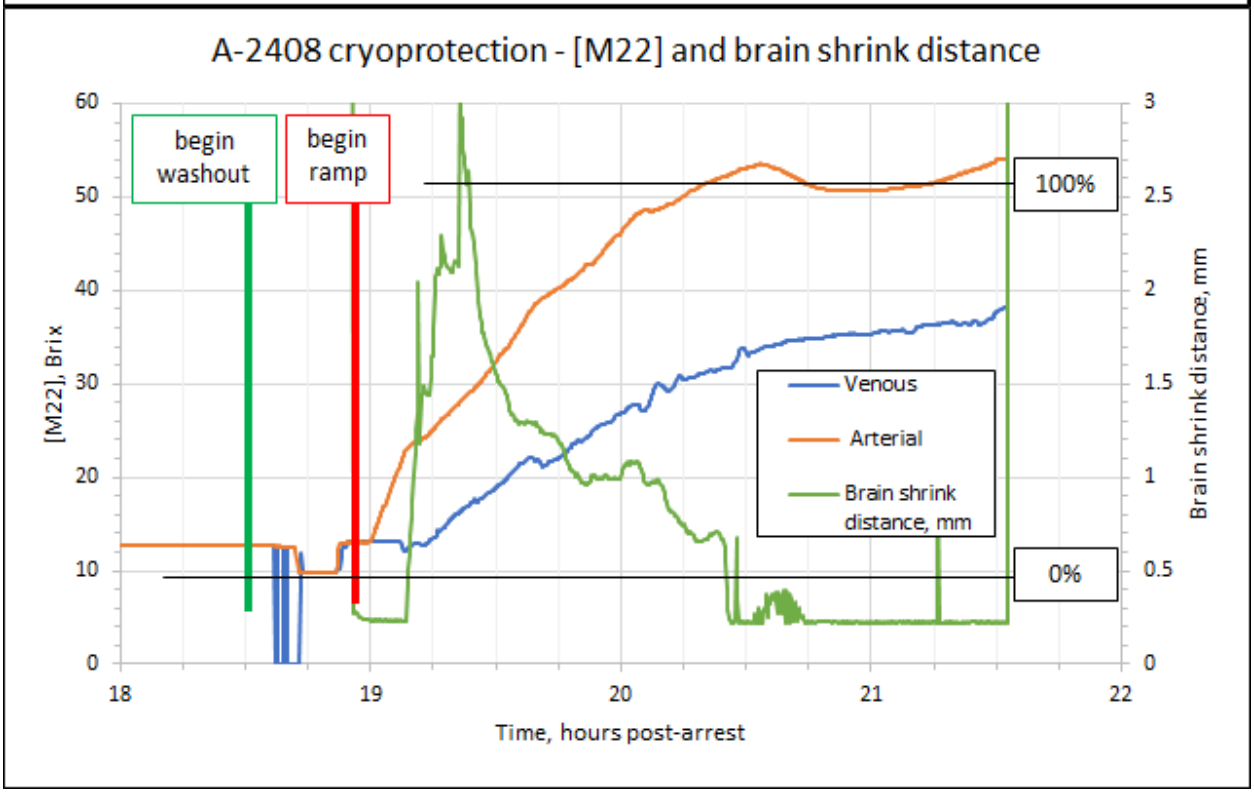
Per the cryoprotection protocol, the ramp is to be paused at 30 Brix (50% of the desired terminal concentration) to allow the patient to come to osmotic equilibrium. The whole-body enclosure and the chiller are switched from +3°C to -3°C operation. At the end of the 30-minute pause, the ramp is resumed 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. However, due to the edema that was developing, the pause at 50% concentration needed to vitrify (CNV) was not used.

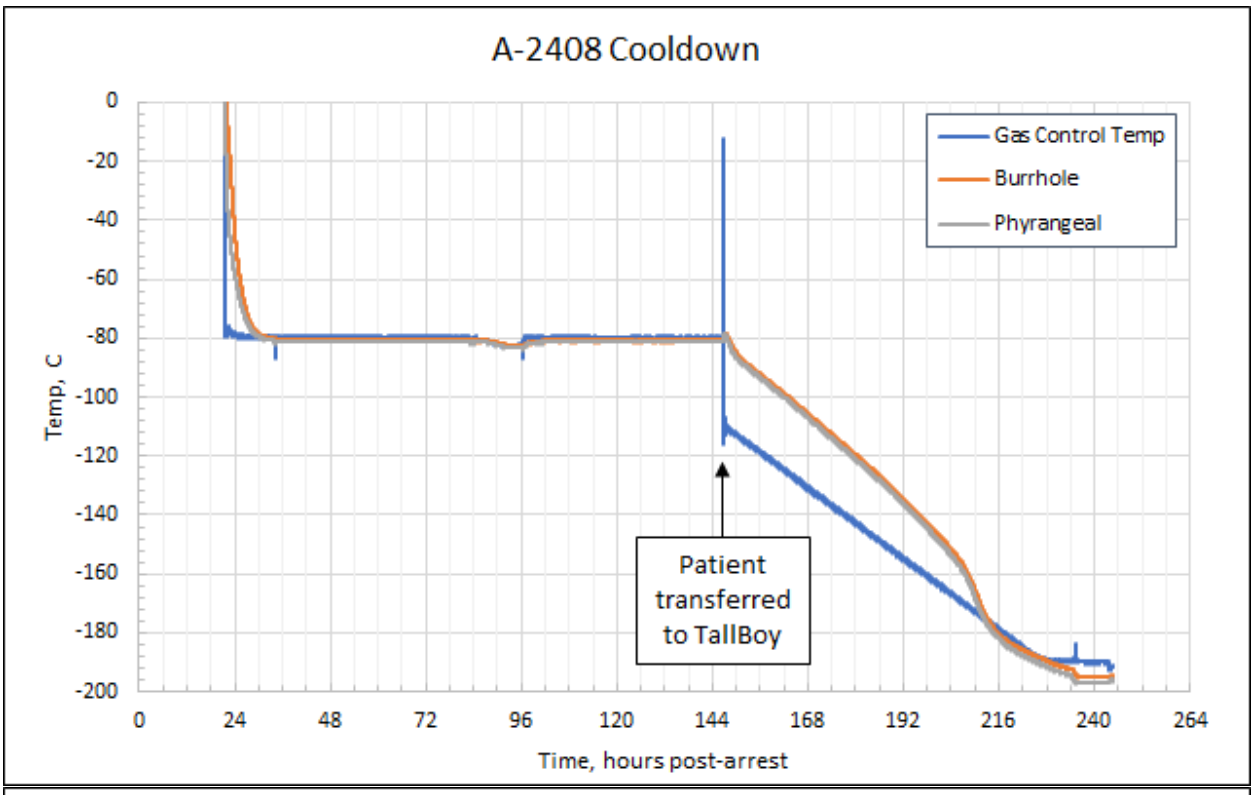
Effluent from the burr holes was a possible problem for taking the CT scans as it could damage the scanner. A 2-gallon plastic bag was placed over the patient's head to contain the effluent. This worked well and the scanner was not compromised with effluent.

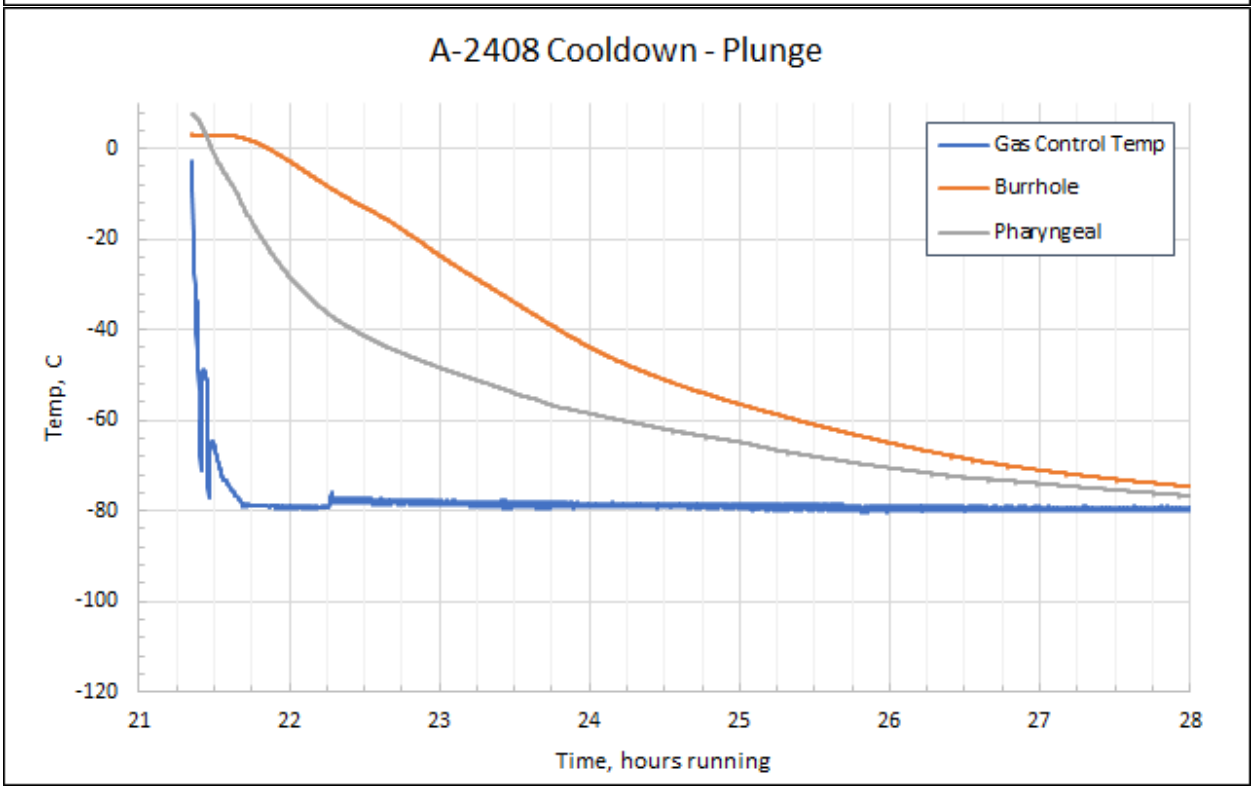
10.Graphs and CT Scans

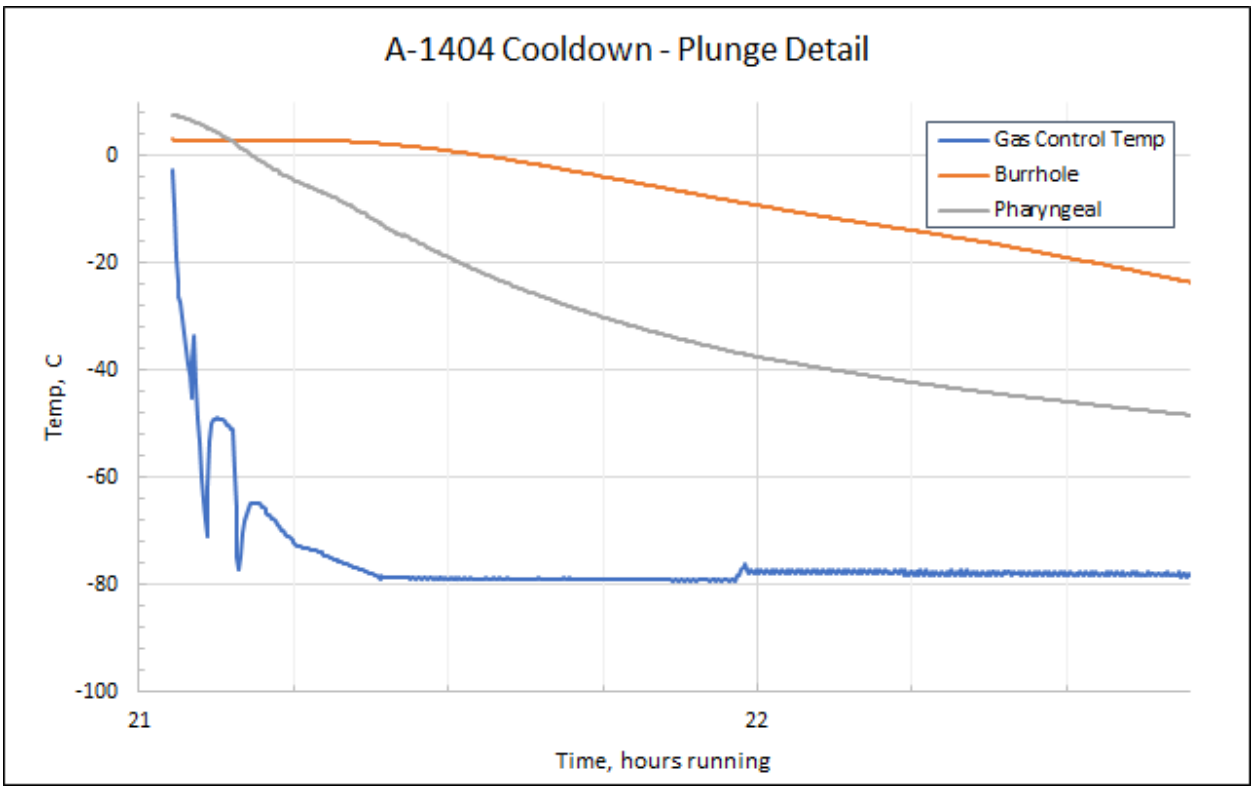



A-2408 cryoprotection - pressure and pump speed
begin washout
begin ramp
Arterial pressure
Main pump, l/min
Pressure, mmHg
pump speed, l/min
Time, hours post-arrest

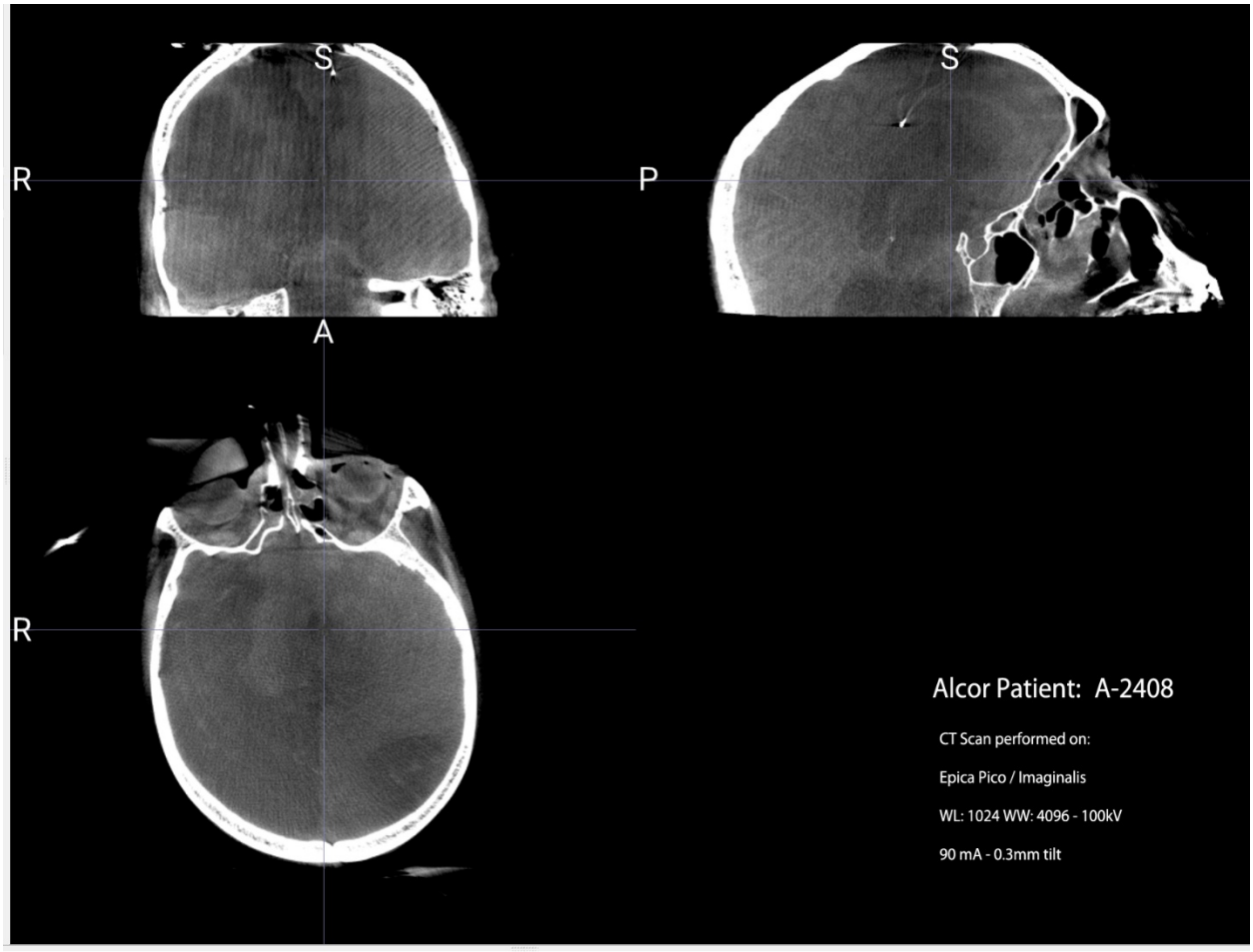

A-2408 cryoprotection - [M22] and brain shrink distance
begin washout
begin ramp
100%
0%
Venous
Arterial
Brain shrink distance, mm
[M22], Brix
Brain shrink distance, mm
Time, hours post-arrest


A-2408 Cooldown
Temp, C
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
0
24
48
72
96
120
144
168
192
216
240
264
Time, hours post-arrest
Gas Control Temp
Burrhole
Phyrangeal
Patient transferred to TallBoy


A-2408 Cooldown - Plunge
Temp, C
0
-20
-40
-60
-80
-100
-120
21
22
23
24
25
26
27
28
Time, hours running
Gas Control Temp
Burrhole
Pharyngeal


A-1404 Cooldown - Plunge Detail
Gas Control Temp
Burrhole
Pharyngeal
0
-20
-40
-60
-80
-100
Temp, C
21
22
Time, hours running

Post-cryopreservation CT scan



On T+1 days the pre-cryoprotection CT scan was obtained at 02:45 hrs at an NPT of 5.9°C. At 04:51 hrs the same day the post-cryoprotection CT scan was obtained at an NPT of 5.1°C and a burr hole temperature of 0.7°C.

The Vimago CT density output values were too imprecise to be used for quantitative CT, therefore the lookup table for cryoprotectant concentration wasn't applied.