

Alcor A-1349

Case Report



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and

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1. Overview

On Monday, February 4th, 2013, Alcor received an emergency text from the physician of member A-1349, who was on life support in a hospital in Long Island, NY. Suspended Animation and Alcor's Medical Response Director quickly deployed.

Once the supplies and personnel were on-site and prepared, the family requested that life support be withdrawn. Pronouncement occurred shortly after midnight on the east coast, Wednesday February 6th, 2013, and stabilization, cooling and washout procedures were begun immediately on Alcor's behalf by Suspended Animation.

After completion of the procedures, the patient was flown to Alcor for cryoprotective perfusion. A-1349, a whole-body member aged 77, became Alcor's 115th patient.

2. Personnel

Standby, stabilization and transport: Catherine Baldwin, Standby Team Leader, Suspended Animation, Inc; Aaron Drake, Medical Response Director, Alcor Foundation; a cardiac surgeon, a cardiac perfusionist, five supporting team members hired by Suspended Animation, including two with EMT training. They were supported by Max More, CEO; and Steve Harris, M.D., Chief Medical Advisor.

Surgery and cryoprotectant perfusion: Kara Villareal, MD, Surgeon; Aaron Drake, NREMT-P, Surgical Assistant; Hugh Hixon, Cryoprotection Perfusionist; Steve Graber, Assistant Cryoprotection Perfusionist; Max More, Ph.D., Scribe; Bonnie Magee, Refractometry; Jay Lewis, Assistant Refractometry; R. Michael Perry, Ph.D., Cooldown Coordinator. Surgical support: Jerry Searcy.

3. Pre-Deployment

A-1349 was a 77-year old male who had been a member of Alcor since 1991. His health history included diagnosis and treatment for hypertension, hyperlipidemia, paranoid schizophrenia and seizures.

On Monday, February 4th, 2013, at 10:00am, MST, Alcor received an emergency text from the physician of member A-1349. Medical Response Director, Aaron Drake, called the physician to discover that the member had suffered a cardiac arrest during a recent seizure. Although the

member was resuscitated, his doctors found readings of his brain activity (electroencephalograms) indicated severe anoxic brain injury and ongoing seizures. He was now on a ventilator in the Intensive Care Unit (ICU) at Long Island Jewish Hospital. The member's family wished to remove him from the ventilator as he was not expected to survive and the physician was letting Alcor know since he had seen the patient's medical alert bracelet.

Alcor received a second text about 20 minutes later, this time from the member's son, indicating the family had authorized the withdrawal of life support, which was to commence in approximately one hour. Aaron immediately called the son back and requested they delay that request for 24 hours in order to allow Alcor the needed time to send a team and be in place. This was vital in ensuring the member would get the best cryopreservation possible. Although emotionally stressed over the situation, the family finally agreed and passed this decision on to the medical providers. The hospital reluctantly agreed, saying they would wait 24 hours, but not a minute longer.

At 12:30pm, Alcor notified SA and requested they deploy a full standby team to New York and to be set up and be ready by 2:00pm EST (12:00pm MST) the following day. Since Winter Storm 'Nemo' was developing in the east and heading to that area of the country, Alcor decided to also send Aaron Drake in the event SA experienced any weather-related problems.

4. Deployment

After receiving the call from Alcor, SA notified their team members to deploy for New York as soon as possible. SA sent a cardiac surgeon, a cardiac perfusionist, two individuals with EMT training and three supporting team members to Long Island.

At 7:00am the next morning, February 5, SA's team leader met with the hospital Medical Director, the Executive Director, the Nurse Manager and Assistant Manager, the Attending Physician, the Intensive Care Unit staff, and the Hospital Security Director to exchange information about SA's stabilization procedures and the hospital's protocols. After sorting out the logistics associated with having the SA team stand by inside the ICU and the urgency of prompt pronouncement and death certificate filing for the patient, the Medical Director instructed ICU staff to provide whatever support SA asked for.

Alcor's Medical Response Director also joined the SA team at the hospital.

The SA team was given a large room in which to set up equipment in an unoccupied area of the ICU across from the patient's room.

As the team waited for the patient's extubation procedure to be scheduled, a steady stream of hospital staff, physicians and nursing students visited the "Cryonics Room" throughout the morning to see the equipment and ask about the stabilization process for human cryopreservation patients. A *New York Times* reporter who was covering the story of another Alcor member also visited.

SA's Team Leader was able to find a funeral director who ran a firm specializing in donated tissue recovery. The funeral director and his partners were willing to provide all-hours support with a prep area for SA's surgeon and perfusionist to work in, a transport vehicle to move the patient in SA's ice bath and make air shipment arrangements to Alcor.

The Team Leader collected vital statistics information and provided this to the funeral director to pre-fill out forms. The surgeon, surgical assistant and perfusionist went to the prep room to set up equipment and wait. The facility was about a twenty-minute drive from the hospital.

A light snow began falling, coating cars and streets. The funeral director assured the Team Leader that transport of the patient would be unaffected unless roads and airports closed. Severe weather was not in the immediate forecast, but expected at some point.

At 1:50pm, ICU nurses administered 2mg of morphine and 2mg of lorazepam and the patient was extubated. His heart rate was 95bpm, and respiration were 31. He was placed on six liters per minute of oxygen via nasal cannula.

By 3:40pm his heart beat irregularly and the rate ranged from 105-110bpm. His blood pressure was 92/61, respiration 36 and blood oxygen saturation was 63%.

At 6:08pm the patient was given 4mg of morphine and 8mg of lorazepam. His heart rate was 166bpm, blood pressure 98/66, respiration 35 and blood oxygen saturation was 47%.

About 7:30pm the patient was placed on a morphine drip of 8mg/hr with the 8mg of lorazepam remaining IV push, as needed.

At 9:40pm the patient's heart rate was 135bpm, blood pressure 80/51, respiration 30 and blood oxygen saturation 46%.

At 11:08pm the patient's morphine drip was increased to 10mg/hr. His heart rate was 140bpm, respiration 27, blood oxygen saturation 37%. Monitors could not detect peripheral blood pressure.

At 2:06am on February 6th, the patient ceased breathing and his heart stopped beating. He was pronounced legally dead a few minutes later by the physician on call.

While the other team members attended to the patient, the SA Team Leader requested a Security escort from the hospital, called the surgical and perfusion team members to return to the prep facility, called the funeral director to come sign out and transport the patient, and alerted the Alcor Medical Response Director so Alcor would be notified to begin preparations.

5. Field Stabilization & Cooling

After pronouncement, the SA team moved the patient to the waiting ice bath and used his existing intravenous line to administer 200mg of Propofol and 100,000 IU of Heparin. The AutoPulse cardiopulmonary support device provided chest compressions as the ice bath was wheeled to the nearby room where SA had set up. Stabilization procedures continued while waiting for the funeral director to arrive and sign out the patient.

In the first ten minutes after pronouncement, the patient was covered in ice and ice water recirculated over him using the SA cooling mask and tubing circuit. Team members placed and verified the Combi-tube airway, the nasopharyngeal probe, the rectal occluder and an EZ-IO intraosseous access line (left tibia). Approximately 200mls of Maalox antacid liquid was delivered through the Combitube's esophageal lumen. The intravenous and intraosseous lines were used to push 250,000 IU of Streptase, 10g of sodium citrate, 300mg of aspirin, 400mg of S-Methylthiourea, 500mg niacinamide, the first of two doses of 100 IU of vasopressin and the first dose of 1mg of epinephrine, administered every three minutes thereafter.

In the next ten minutes, the automated ventilator was applied to the patient, the remaining low volume medications were given (1.5g L-kynurenine sulfate, 7.5mg Ketorolac, 80mg Gentamicin) and high volume medications started as IV and IO drips (150ml of Vital-Oxy in saline, 100mls of 1M tromethamine, 250ml 6% hetastarch, 100g 20% Mannitol). Each high volume medication was converted to IO push over the next 30 minutes, starting with Vital-Oxy and tromethamine.

The funeral director arrived to sign out the patient at approximately 2:45am. The patient's temperature at this time read 30 °C nasopharyngeal, 38 °C rectal. Some blood was visible in the Combitube airway.

After 38 minutes, the AutoPulse battery indicated it needed to be changed but replacement with two other fully charged batteries failed to restart the device. Team members provided assisted manual chest compressions using the Ambu CardioPump for the next 40 minutes.

The funeral director, a member from security and the team were ready to move the patient at 2:57am for the slippery trek to the transport vehicle and the drive to the prep facility. Two team members rode with the patient to continue delivering chest compressions.

The patient arrived at the prep facility at approximately 3:30am. His nasopharyngeal temperature read 20 °C. Alcor's Medical Response Director and the SA surgical and perfusion team members had previously arrived.

Once the ice bath with the patient was wheeled into the room, the prep area became very cramped with the surgical team and all the equipment.

The patient's health history included no prior open chest surgery making him a good candidate for an emergency thoracotomy procedure to speed cannulation and cooling. This would be the second time the emergency thoracotomy would be attempted in the field.

After prepping and draping the patient, the surgeon performed a median sternotomy. The aorta was cannulated with a flexible 22/24Fr aortic cannula and the right atrium cannulated with a 36/46Fr 2-stage venous drainage cannula. Drainage began at 3:45am, however, the patient's aortic cannula decannulated. The surgeon decided that the cannula was too flexible for the procedure (where cannula are not typically sutured into place). He replaced it with a 7mm curved catheter and secured it with a Prolene pursestring.

The venous cannula also decannulated after this due to tension on the bypass circuit that was stretched to reach to the patient from the perfusion set up at the side of the ice bath. Typically, the circuit comes over the head of the patient, but this was not possible in the small prep area. The venous cannula was repositioned and pursestrung in the atrium. The patient had to be removed from bypass each time the cannula was repositioned. The chest quickly filled with blood that had to be suctioned out to clear the field of view.

At 4:00am the perfusionist began recirculating MHP-2 organ preservation solution through the patient. The minimum flow rate was 1.0 liters/minute and maximum was 3.4 liters/minute.

At 4:13am the patient's arterial temperature read 7 °C and his venous temperature read 14 °C. Additional alcohol was added to the circuit cooling bath.

At 4:25am approximately 30ml of the remaining Vital-Oxy was added to the patient's circuit.

At 4:38am, the patient's arterial temperature: 4 °C, venous: 6 °C and nasopharyngeal temperature: 1 °C.

The perfusion pump was shut off at 4:45am.

The surgeon disconnected the circuit from the patient, removed the cannula and sewed the cannulation sites closed. He closed the sternum with #6 sternal wire and stapled the skin together at 5:20am.

6. Transportation

While the patient was undergoing surgery and perfusion, the funeral director made tentative air shipment arrangements and Alcor's Medical Response Director made reservations for the flight on which the patient was to be shipped. It was the only morning flight available to Phoenix that could take the patient.

When no death certificate was found filed online, the Team Leader called the physician on-call to request that she please login to her account and sign off as soon as possible. After fifteen minutes had passed with no certificate filed, another call was made to explain how the certificate was required in order to process additional paperwork to transport the patient and that time was of the essence in order to make the morning flight.

The physician signed the death certificate. But when the funeral director noticed the language used to describe the cause of death ("seizure due to epilepsy"), he said he was certain that it would not be acceptable to the Health Department and coroner and would possibly trigger a hold on the patient. The SA Team Leader asked for clarification and some guidance on how to describe the cause of death with language that would be acceptable. The funeral director then called a former coroner's investigator for advice. The investigator made some suggestions and the Team Leader called the physician on-call again to try to explain the necessity of modifying the language describing the cause of death.

The physician went back online and revised the language describing cause of death by adding more language. The funeral director said the new language would actually be more problematic for the coroner than before. The Team Leader asked that the funeral director speak directly to the physician to try to help her.

Meanwhile, the patient had been removed from the ice bath and placed into a body bag inside a Ziegler case. SA team members insulated the Ziegler with custom cut foam board. Double-bagged water ice was packed around the patient before the Ziegler was closed and loaded into the air shipment tray.

When the physician finally satisfactorily revised the language of the cause of death, she signed the certificate in the wrong place and several more phone calls were required to get her to go back online yet again and correct the error. The SA Team Leader recruited the Alcor Medical Response Director to call and speak to the physician to convey the urgency of their request. After a lengthy discussion, the physician finally agreed to comply with the Medical Response Director's request, but there would now barely be enough time to make the cargo acceptance cutoff time for the flight.

The air tray was loaded into the funeral director's van with Alcor's Medical Response Director and departed for the airport. They arrived at the airline cargo shipping department with a few minutes to spare before the cut off. The flight departed as scheduled and headed for Phoenix Sky Harbor airport.

The funeral home with which Alcor contracts, arrived at airline cargo in Phoenix and took possession of the patient and transported him directly to Alcor in Scottsdale.

7. Surgery

When the patient arrived at Alcor, the body bag was offloaded from the funeral home's vehicle on to a church truck that was rolled directly into Alcor's operating theatre. The surgical table had been pre-covered with a base layer of ice bags. The body bag was unzipped and a MegaMover was placed under the patient and was lifted up by connecting the fabric straps to Alcor's hydraulic patient mover. Additional bags of ice were placed on top of the patient to continue cooling.

Aaron Drake shaved the head and then aseptically prepped the top of the scalp prior to establishing burr holes. Dr. Villareal made two vertical incisions with a #10 scalpel blade to expose the skull. Aaron parted the scalp with Weitlanders and then created bilateral burr holes using a Codman Craniotome fitted with a Codman perforator. Dr. Villareal cleaned each of the burr holes with a Kerrison rongeur prior to inserting two crack-phone elements bilaterally and a thermocouple wire all secured with 2.0 Silk.

Aaron removed the sternal staples placed by with Dr. Wesley with a Miltex surgical staple remover and then cut and removed the stainless steel monofilament suture wire that was threaded through the sternum. The rib cage was opened with Finochietto rib spreaders, revealing the exposed heart. The chest was draped and secured with Backhaus towel clamps. Aaron suctioned the accumulated fluid within the pericardial sac and the sutures used to close the surgical wound from the previously placed cannulae were removed by Dr. Villareal.

New pursestring sutures were established around the surgical wounds in the aorta and right atrium. The wholebody perfusion tubing had been primed and was connected to the venous and

aortic cannulae. The venous cannula was inserted into the right atrium and the aortic cannula was placed into the aortic arch. Both were secured in place with basket stitches.

The arterial line was unclamped and return was noted. However, a large leak was identified around the aorta. The tubing was clamped and 2.0 silk was used to close off the leak. The tubing was flushed through the bypass to remove any remaining bubbles; however, foam was noted in the reservoir. It took 48 minutes to clear the system and build up pressure in the ramp. Once clear, the tubing was unclamped and the pump was restarted. The tubing was secured using a Cardiomed tubing loom.

8. Perfusion Summary

Air was pumped into the system due to Hugh being distracted by helping in the surgical field. This was compounded by a short bag of B1 being used to prime the system. This also resulted in some variation in the ramp [M22]. The primary concern was if this problem was detected and remedied before any air was pumped into the patient. After reviewing the overhead perfusion video, it shows clearly that the patient was still clamped off from the perfusion system when bubbles were detected. The bubbles were diverted into the return bypass loop and once the air was cleared from the system, the cryoprotection proceeded uneventfully.

There was an excursion by the LN2 perfusate cooling system because the perfusate circulation had been stopped and the feedback loop was broken. This resulted in the freezing up of the perfusate heat exchanger, which had to be thawed out. Later, the feedback loop was shortened.

The new data collection system was used, which controlled the perfusate temperature, and worked well with the one problem noted above.

Cryoprotection was performed with M22 perfusate. There was much less leakage to the table, but this can also be ascribed to a commendably short transportation time and the field washout being done by aortic-ventricular perfusion. As usual, the cryoprotectant destroyed the semi-permeable lining of the lungs, allowing cryoprotectant to fill them and leak out the patient's mouth, causing major loss of perfusate to the table. There was perfusion to the limbs, but some areas of the skin (the scalp) did not exhibit the stiffness normally seen after cryoprotection. The brain appeared to shrink but was not measured.

M22 requirement calculation for a patient of this weight indicates 84 liters. However, only about 69 liters of M22x1.25 was used; this was unusual.

Crackphone elements were placed in both burr holes, towards the centerline of the brain. There were very few crackphone events observed during the cooldown, mostly noise from activity around the dewar.

9. Timelines

February 6th, 2013, EST

Stabilization:

- 02:06 Patient ceases breathing, no heartbeat
- 02:07 Nurses begin disconnecting ICU equipment from patient
- 02:09 Physician arrives to pronounce
- 02:12 Patient is moved from bed to ice bath
- 02:13 100K IU Heparin and 200mg Propofol pushed into IV line, AutoPulse started
- 02:14 Wheeled ice bath into adjacent room, added ice to bath, 250K IU streptokinase pushed
- 02:15 Rectal occluder in, water added to ice bath
- 02:16 10g Sodium citrate pushed
- 02:17 Combitube inserted, AutoPulse off for airway verification, 300mg aspirin pushed, 100 IU vasopressin pushed, EZ IO access set left tibia
- 02:18 1ml epinephrine pushed, ice water recirculation started
- 02:19 400mg S-methylthiourea pushed
- 02:20 Nasopharyngeal probe in, 500mg niacinamide pushed, 60ml Maalox administered
- 02:22 1ml epinephrine pushed, ventilator on, 0.75g L-kynurenine pushed, 60ml Maalox administered
- 02:24 0.75g L-kynurinine pushed, 7.5mg Ketorolac pushed, 80mg gentamicin pushed, high volume meds piggy-backed on IO line
- 02:27 1ml epinephrine pushed
- 02:30 1ml epinephrine pushed
- 02:32 50ml tromethamine pushed
- 02:33 1ml epinephrine pushed, 55mls Vital-Oxy in saline pushed
- 02:36 50mls tromethamine pushed
- 02:37 100 IU vasopressin pushed, 1ml epinephrine pushed
- 02:39 55mls Vital-Oxy in saline pushed
- 02:40 60mls Hetastarch pushed, 1ml epinephrine
- 02:42 40mls Vital-Oxy in saline pushed
- 02:43 60mls Hetastarch pushed, 1ml epinephrine
- 02:45 60mls Mannitol pushed, 60mls Hetastarch pushed
- 02:46 1ml epinephrine pushed, nasopharyngeal temp 30 °C, rectal 38 °C
- 02:47 60 mls Mannitol pushed
- 02:48 AutoPulse off for battery replacement, 60mls Mannitol pushed, 1ml epinephrine
- 02:49 AutoPulse fails to restart, begin chest compressions with Ambu Cardio Pump
- 02:50 60mls Mannitol pushed
- 02:51 1ml epinephrine pushed
- 02:52 60mls Mannitol pushed
- 02:54 1ml epinephrine pushed, mouth suctioned

02:55 Security and funeral director ready to move, 60ml Mannitol pushed, added privacy cover to ice bath
 02:57 Wheel patient through hospital, downstairs and out morgue exit to transport
 03:00 Nasopharyngeal temp 29 °C
 03:30 Arrive prep facility, nasopharyngeal temp 21 °C
 03:36 Ventilator off, ice water recirculation off
 03:38 Prep and drape patient
 03:43 First incision
 03:51 Aortic and Atrial cannula in
 03:56 On bypass forward pump flow 2.4 liters/minute
 03:57 Pump off, decannulation
 04:00 Pump on
 04:02 Decannulation, pump off
 04:04 Secured venous cannula
 04:08 Replaced arterial cannula
 04:10 Perfusion pump flow rate at 3 liters/minute
 04:13 Arterial temp 7 °C, venous temp 14 °C
 04:26 Add approximately 40mls Vital-Oxy to recirculation
 04:38 Arterial temp 4 °C, venous temp 6 °C, nasopharyngeal 1 °C
 04:45 Perfusion pump off

Surgical:

14:46 Arrived at Alcor
 14:58 Patient loaded on to Megamover
 15:00 Patient on surgical table
 15:05 Wholebody tubing packs had no probes ready or attached
 15:06 Nasopharyngeal (NP) temperature 2.6 °C
 15:12 Head shaved and alcohol applied
 Hugh clamped off circuit; Steve had to unclamp; Need to coordinate better
 15:21 Burr holes were established; Hugh identified leak in connection to new pressure monitors
 15:24 Inconsistent pressure readings: 110 (Hugh), 130 (Steve, digital)
 15:30 Removed chest staples; chest was stapled and sewn as if he were a recovering patient
 15:36 3.4° C burr hole temperature
 15:40 Chest retracted and suctioned; Vessels clamped closed – no cannulas left in; Note made to request SA surgeon to leave in cannula and clamp off
 15:52 Dr Villareal stated that she prefers 2.0 silk as it holds suture better
 16:04 Cannulas unclamped; Pump restarted; Pressure rising fast; Suctioning: purse string leak
 16:07 Pressure to zero due to clamping off
 Pressure surge noted; Hugh wants to flush before trying again
 16:11 Foam noted; Reservoir volume dropped causing pump to cavitate
 16:15 Shut down pump

16:20 Cleared bubbles out; Had to ramp up pressure
 17:03 Resumed perfusion
 17:09 2.5 liters/minute; Pressure: 140
 17:12 Burr hole temp dropped to 3.5 °C (from 4). NP: 3.9 °C
 17:36 Some drainage noted from mouth
 17:40 Dumped 1.5 liters of effluent (first dump)
 18:06 Pressure in upper 140's; climbed slowly; 2.3 °C: chiller temp;
 18:18 Closed patient box to stop heat loss
 18:23 WB box temp 8.0 °C; once the box was closed, the temps measured from the patient
 dropped and converged with chiller temps
 18:28 Midway in ramp, first 20 liter bag of M22x1.25 used up; Paused for equilibration
 18:40 Ramp started again; Switched to minus 3 on all systems
 18:41 2 liters/minute; Pressure: 117; 7.8 liters reservoir volume
 18:56 Speed now 1.6 liters/minute to adjust pressure
 18:59 Opened up effluent removal lines; Reservoir at 11 liters
 19:13 Dumped 15 liters from table drain
 19:15 Clamped off effluent removal line again; 7.5 liters in the reservoir
 19:18 Effluent reservoir at 15 liters
 19:22 1.4 liters/minute; 175 mm; 9.2 liters reservoir
 19:33 Switched to third bag of M22
 19:35 Opened effluent line; 15.5 liters in effluent reservoir; 11.7 liters in mixing reservoir;
 Pressure: 170; Down to 1.2 to reduce pressure
 19:37 Burr hole: 1.5 °C; NP: - 0.3 °C; Venous: - 4.3 °C; Speed = 1.1 liters/minute; Press. = 170
 19:59 Effluent reservoir = 25.8 liters; Mixing reservoir = 8.1 liters; Waste = 6 liters
 20:02 Speed = 1 liter/minute
 20:08 Speed = 0.88 liters/minute
 20:17 Shut off ramp generator; Arterial 51.3 to 51.6
 20:25 Controller showed declining concentration, started pump; Opened effluent line; Now 29
 liters; Reservoir = 11 liters; Table waste = 9 liters; 60 liters of cryoprotectant; Finished
 20:33 Pump off. Arterial = 51.5
 20:47 Ramp on
 21:02 782 is the venous refractometer
 21:14 Ramp off
 22:01 Pump is off; Disconnected line sensors; Burr hole: -3.1 °C; NP: -2.8 °C; Venous: -2.6 °C
 23:21 Begin cooldown plunge to -80 °C

Feb 8th, 2013

17:13 Transferred A-1349 to cooldown to LN2
 17:58 Grounded and shielded cooldown system

On February 27th, 2013, A-1349 was placed into long-term LN2 storage.

10. Issues and Actions

A. Issue: AutoPulse failed to restart even with fully charged batteries.

Action: Send AutoPulse in for service and battery testing (Zoll technicians identified no issues with AutoPulse, Zoll replaced all NiMH batteries with lighter Lithium Ion batteries and charger).

B. Issue: Surgical team insufficiently organized and set up to begin surgery at patient arrival resulting in 10 min delay.

Action: Re-training for surgical assistant and Perfusionist.

C. Issue: Arterial cannula in thoracotomy kit too flexible for emergency thoracotomy procedure.

Action: Remove flexible cannula and replace with those recommended by surgeon. (Replacements made May, 2013).

D. Issue: Surgeon requests Ethibond and Vicryl sutures for pursestrings and tissue closure as well as robust needle holders and surgical wire cutters for sternal wire closures.

Action: Purchase requested items (purchased March/April 2013).

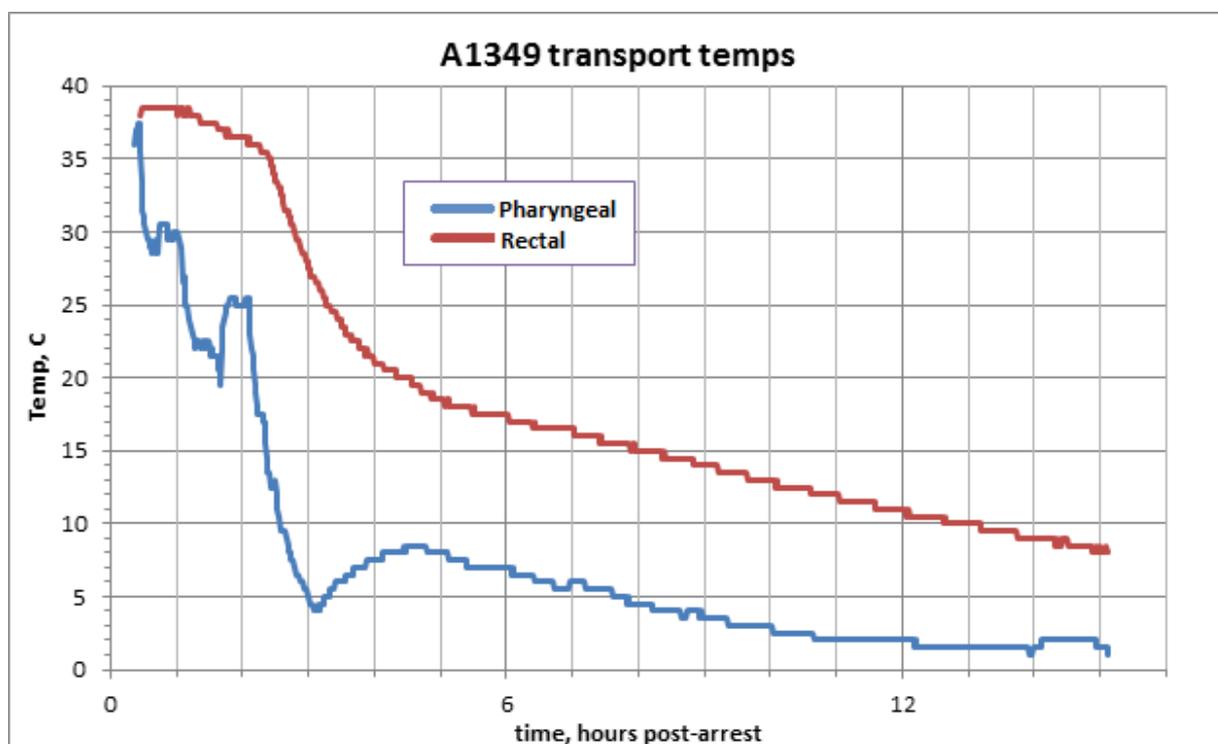
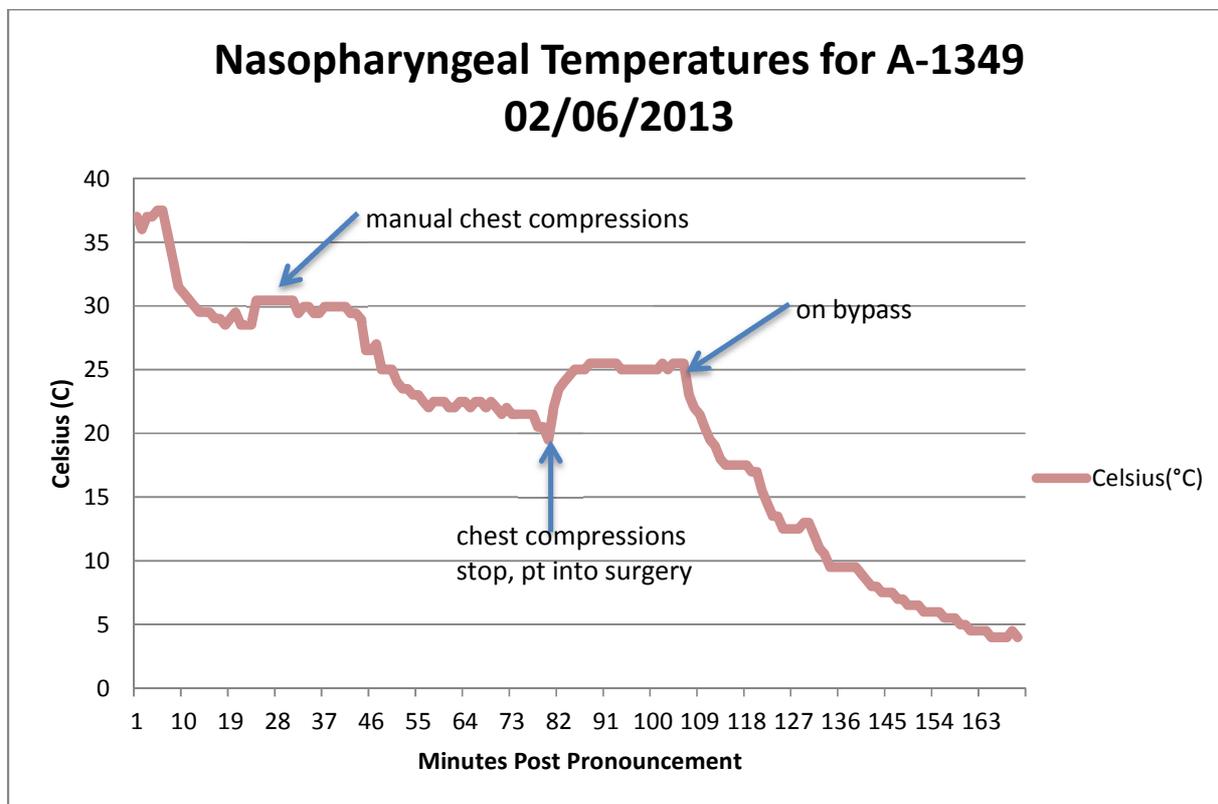
E. Issue: Physician signing death certificate was not any of those previously educated about the case over the course of the day and evening.

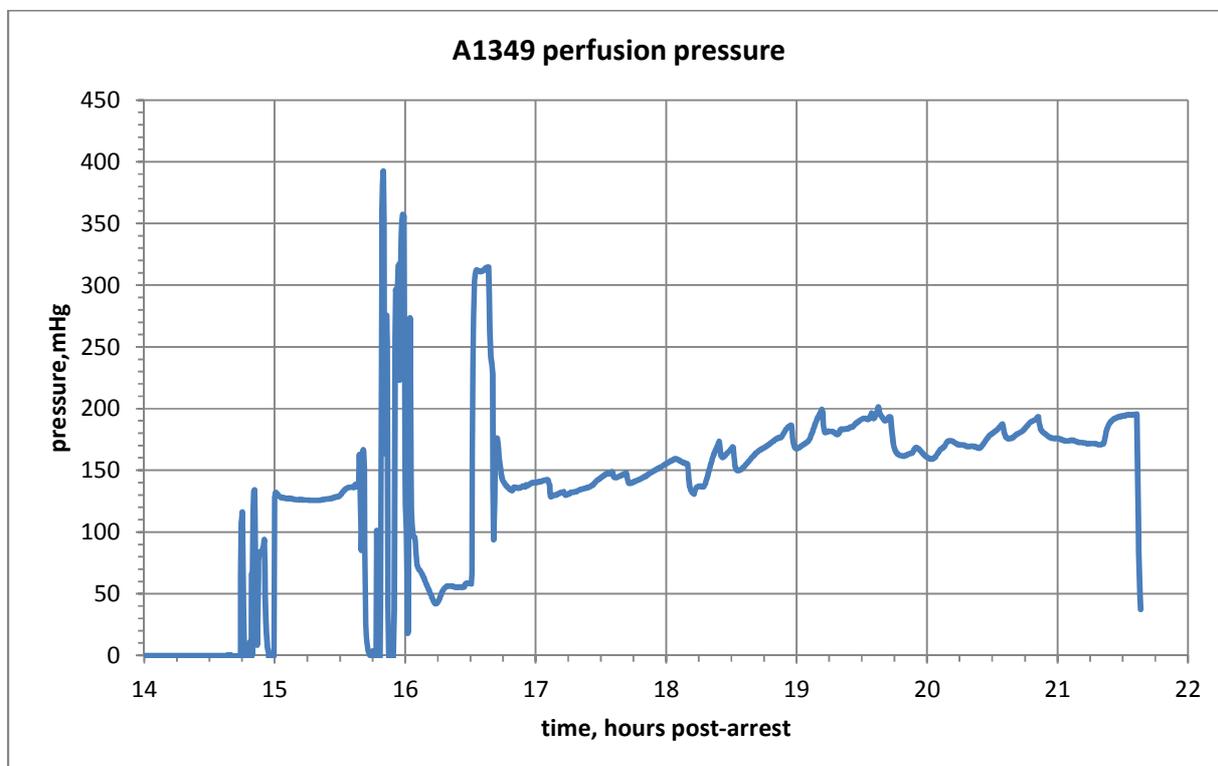
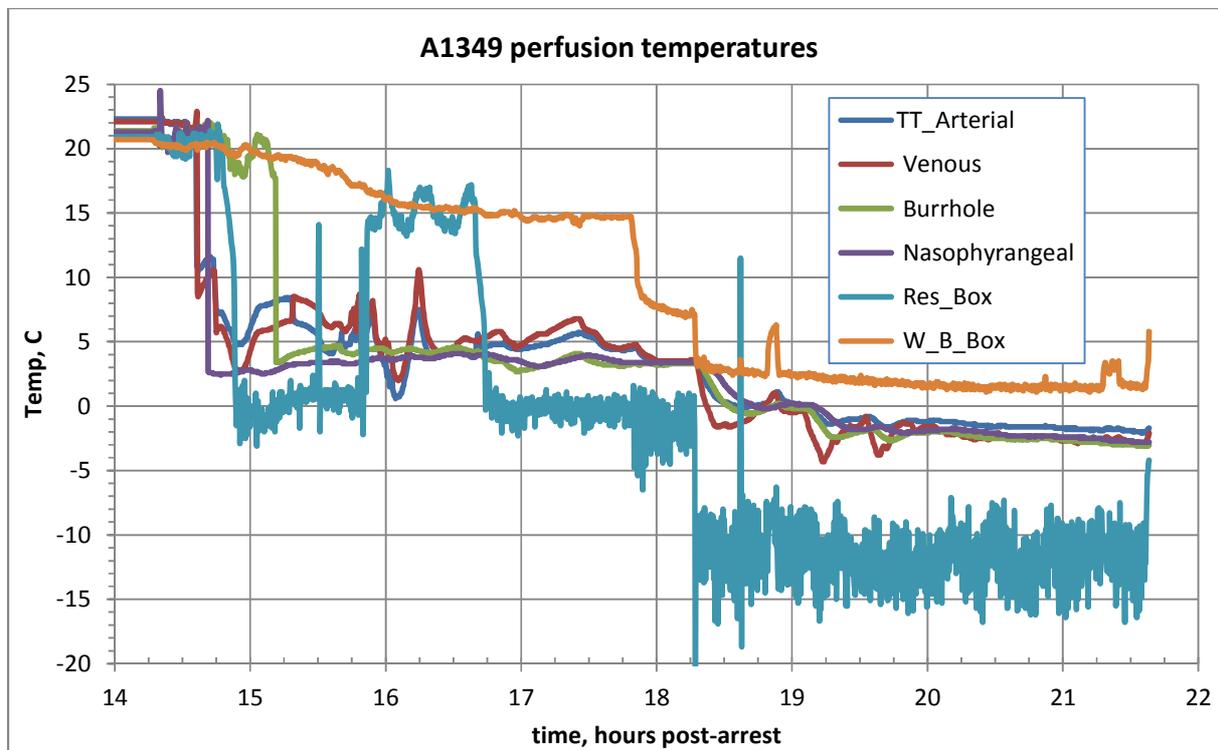
Action: Try to specifically identify and educate each shift physician on-call.

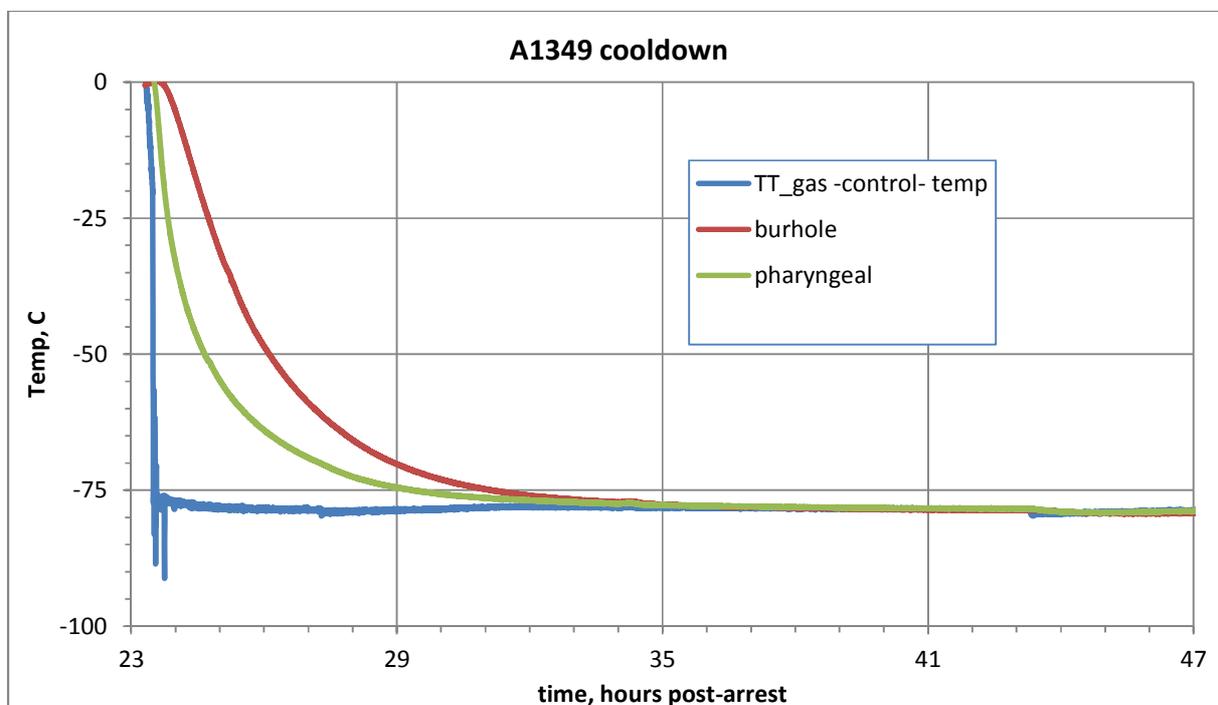
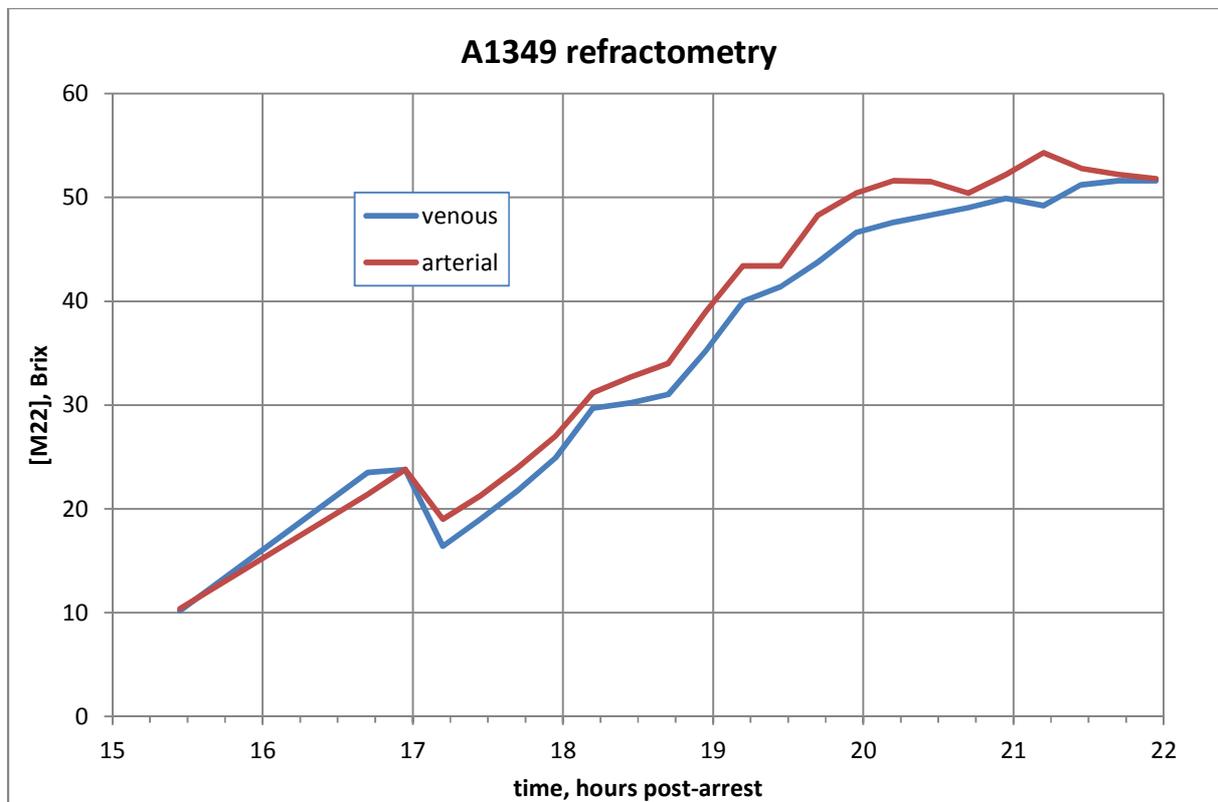
F. Issue: The recirculating reservoir, during cryoprotectant perfusion, ran dry due to distraction and a smaller-than-usual starting volume.

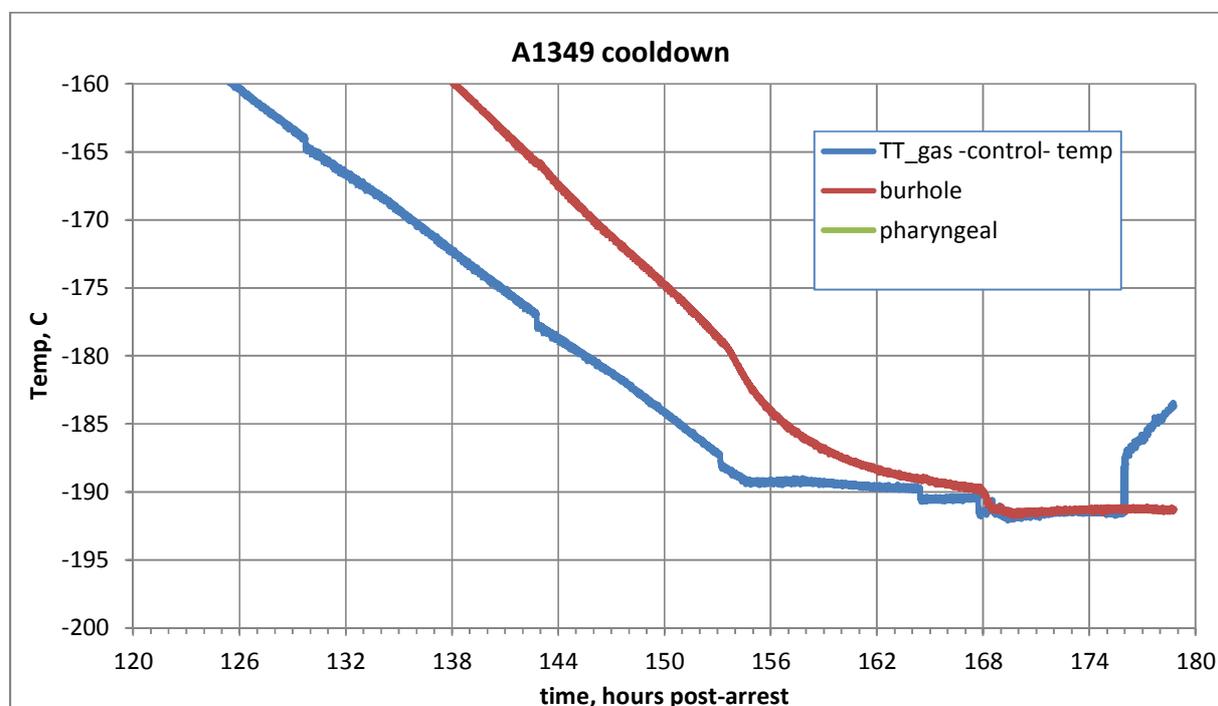
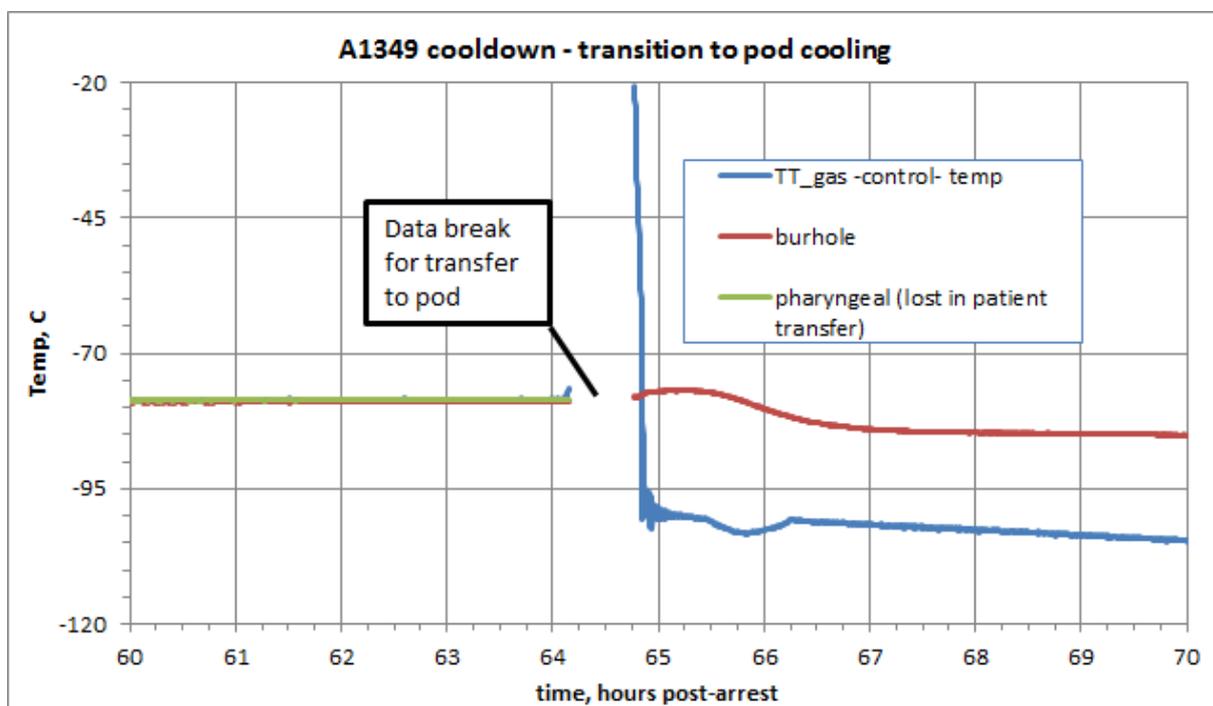
Action: Volume metering of the mixing reservoir is now a component of the perfusion system which should eliminate this issue from occurring in the future.

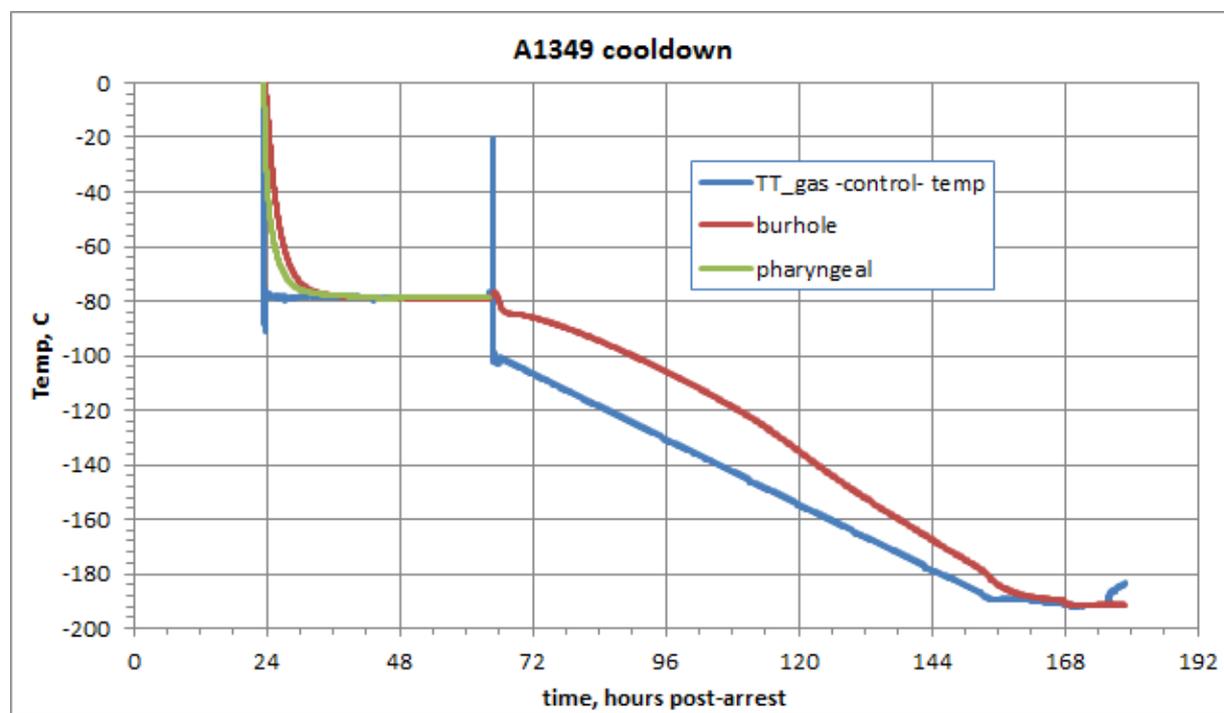
11. Graphs











--End of report--