CRYONIC SUSPENSION CASE REPORT: ROBERT GEORGE BINKOWSKI, A-1108

Alcor #: A-1108
Patient Name: Robert G. Binkowski
Date of Birth: 28 October, 1916
Date of Suspension: 08 May, 1988

Background History

Mr. Binkowski was a founding member of the Cryonics Society of South Florida (CSSF) in 1971. He became involved in cryonics as a consequence of reading Robert Ettinger's *The Prospect of Immortality* in 1964 and then writing to Ettinger for information (Ettinger subsequently forwarded Mr. Binkowski's name and address to Gregory Strom, the man who initially organized CSSF). In 1972 he completed suspension arrangements with CSSF. CSSF merged with Alcor on 18 November, 1984 and Mr. Binkowski executed Alcor paperwork on 1 February, 1986. Mr. Binkowski had met with Alcor staff on many occasions in Florida and was an active participant in CSSF who provided some help in establishing the CSSF (later Alcor) perfusion facility. Mr. Binkowski's 17-year history of involvement in and advocacy of cryonics, under the often trying conditions of setting up a cryonics organization, establishes his informed consent.

Medical History

Mr. Binkowski is a 71-year-old married caucasian male with a long-standing history of coronary artery disease and hypertension. In 1962 he experienced a myocardial infarction (MI) with subsequent slow deterioration in cardiovascular status (increasing angina and dyspnea on exertion). He underwent 3-vessel coronary bypass grafting in 1978 with apparently good results for approximately two years.

In 1983 he underwent treadmill testing with Thallium scan and cardiac catheterization which disclosed severe triple vessel disease and closure of two of the grafts to the left coronary artery. In view of his good left ventricular function at that time it was recommended that he be re-operated for coronary revascularization. The patient underwent a second CABG in September of 1983. During his work-up for the second CABG it was discovered that he had adult onset diabetes mellitus (non-insulin dependent). His past medical history is also remarkable for a 25 year history of tobacco abuse (stopped smoking in 1968), gout, degenerative joint disease, unipolar pacemaker, and chronic low back pain which was unrelieved by a 1986 L3-4 laminectomy.

Other surgical history: patient is status post cholecystectomy and post prostatectomy.

In 1987 the patient suffered an MI following laminectomy. His course thereafter appears to have been one of increasing disability with frequent exertional angina (4-5 times per day), dyspnea, and congestive heart failure (CHF). Early in 1988 he was advised that he was "essentially terminal" and that medical management of his CHF was unlikely to yield him much additional time, and further, that given the degree of his cardiac disease he was at greatly increased risk of sudden cardiac arrest.

At this time the patient contacted Mike Darwin at Alcor Southern California and related his situation. He was advised by Mike Darwin to see a general practitioner or

internal medicine physician for on-going care so that a death certificate could be signed promptly in the event of his deanimation. This was especially important since he was being seen by the Veterans Administration Medical Center in Miami (VAMC); the VA does not assign primary care physicians and it was thought likely that it would take a considerable period of time to access medical records from the VA for the Medical Examiner (ME) in the event of sudden deanimation. The patient refused to establish a relationship with a local physician to facilitate pronouncement. At this time it was noted that the patient appeared to be very depressed and a little confused, although he was overall appropriate.

On 10 April, 1988 the patient was hospitalized at the VAMC for lower GI bleeding. This exam revealed the presence of three sessile sigmoid polyps. On 30 April, 1988 the patient was again hospitalized, this time with severe angina with shortness of breath. The medical record does not record the outcome of this hospitalization. It is believed that the patient also presented at one or more medical facilities in his home town of Naranja, Florida, although there is no record of these admissions in his medical file.

Medications at the time of discharge from the VAMC on 30 April (and presumably at the time of deanimation) were noted in the medical record to be as follows:

1. Cimedtidine 400 mg. p.o. q. hs.
2. Digoxin 0.25 mg. p.o. q.d.
3. Diltiazem 90 mg. p.o. q. 6
4. Surfak 480 mg. p.o. q h.s.
5. Lasix 80 mg. p.o. q.d.
6. Glipizide 5 mg. p.o. q.d.
7. Hydroxyzine, 25 mg. p.o. q. 6h prn nausea and vomiting
8. Nitroglycerine p.r.n.
9. Nitrol patch, 1' topical q 6h
10. Enteric aspirin 1 p.o. q.d.
11. Xanax 0.25 mg. p.o. b.i.d.
12. Antacid 5 oz. q. 6 h p.r.n. abdominal pain
13. Percocet p.r.n. abdominal pain.

At 12:11 AM (0011 hours) on 8 May, 1988 the patient was found in full cardiac arrest by his wife. His son packed his head in ice and the paramedics and ME were summoned. The patient was subsequently transported to the Dade County ME's Office where he was placed under refrigeration at 4°C. It was later learned from the patient's wife that he was in serious distress for several days prior to deanimation but had been refused admission to the VAMC where he was told "there was nothing more they could do for him." The wife also reported that for approximately 48 hours prior to deanimation the patient was coughing up blood-tinged fluid.

Transport

When it became clear that the patient was at high risk for sudden cardiac arrest Alcor Florida member Bill Faloon contacted the Dade County ME and explained the situation with respect to the patient's terminal condition and his desire to be placed into cryonic suspension. Within 10 minutes of notification of the patient's cardiac arrest, Mr. Faloon was in contact with the ME appraising him of the situation. The ME agreed to meet with the family and Mr. Faloon at the ME's office at 0630. Cooperation from the ME was excellent and, after talking with the family and physicians at the VA, and drawing blood via a cardiac puncture for a toxicology screen, the patient was released to the Alcor Florida Transport team at 1000 on 5/8/88.

The patient was placed in a standard mortuary shipping container on a bed of Zip-Loc polethylene bags containing crushed water ice and then packed from head-to-toe in additional bags of ice. The shipping container was closed, wrapped in insulating materials (egg-crate foam and blankets) and transported by air freight to Alcor's facilities in Riverside, California.

The patient arrived at the facility at 2055, 8 May, 1988.

Perfusate Preparation

The composition of the base perfusate is given in Table I. Dry chemical perfusate components were prepared from reagent or medical grade chemicals weighed out using an Ohaus Centogram model 311, and Ohaus Triple Beam 2610 g balances. Dry components were mixed with ACS reagent grade glycerol and/or sterile water for injection USP, or sterile water for irrigation USP. Perfusates were sterilized by filtration into the concentrate or recirculating reservoir of the extracorporeal circuit through a Pall PP3802 0.20μ pre-bypass filter. Perfusate was prepared in three batches with the following volumes, osmolalities, and glycerol concentrations:

Description	**Volume**	**Glycerol %(w/v)**	**mOsm**
Flush	40 liters	0%	324
Recirculating	40 liters	5%	---
Concentrate	40 liters	86%	---

TABLE I

Base/Cryoprotective Perfusate

Component	*Molar Concentration (mM)*	*g/l*
Sucrose	170.0 (MW 342.30)	58.19
Adenine HCl	0.94 (MW 180.6)	0.17
D-Ribose	0.94 (MW 150.2)	0.14
Sodium Bicarbonate	10.00 (MW 84.0)	0.84
Potassium Chloride	28.30 (MW 75.56)	2.11
Calcium Chloride 10% (w/v) soln.	0.25 (MW 111)	0.028
Magnesium Chloride 20% (w/v) soln.	1.00 (MW 95.2)	0.095
Sodium HEPES	15.00 (MW 260.3)	3.90
Glutathione (free acid)	3.00 (MW 307.3)	0.92

Hydroxyethyl Starch	----	50.00
Glucose	5.00 (MW 180.2)	0.90
Heparin	_____	1,000 IU

pH: 7.9 (measured)

mOsm: 324 (measured)

Cryoprotective perfusate was prepared by dissolving the above components for 120 liters in sufficient water to yield three times the above concentrations, dividing the resulting solution into three equal parts, and diluting to the indicated concentration (making to 40 liters) with either water for injection/irrigation USP, or 5% (w/v) glycerol plus water for injection/irrigation USP to make 40 liters, or glycerol to make 40 liters.

Gross Assessment

At 2120 the patient was moved from the shipping container to a bed scale where he was weighed. Arrival weight was 65.3 kg. The patient was then transferred to the operating table, which had been previously prepared with a cooling blanket placed atop 2"-thick egg crate foam. The temperature of the water circulating in the cooling blanket (Blanketrol Unit) was set to 0°C and the patient was packed in ice from head-to-foot.

After the patient was transferred to the operating table, an external exam was undertaken. A pharyngeal copper-constantan (type T) thermocouple probe was placed and deep pharyngeal temperature measured at 2.1°C. The ice packs showed little evidence of melting, indicating that the patient was very near the ice point when he was removed from the ME's refrigerated morgue and prepared for transport.

Upon transfer to the operating table it was noted that the muscles of the eyelids and neck as well as the upper and lower brachial muscles were free from rigor. The pupils were dilated. The muscles of the jaw, digits, abdomen, and both lower extremities were in full rigor. The patient appeared well-nourished and showed no sign of trauma, skin lesions, or bruising. The skin was remarkable for large scars present at the thoracic mid-line and the interior aspects of both thighs, apparently the result of previous CABG surgery and saphenous vein excision. Post-deanimation lividity was present in dependent areas of the trunk and extremities. There was a puncture wound in the skin 1-2 mm in diameter in the 5th intercostal space adjacent to the sternum and approximately over the left ventricle. This puncture wound appeared to have been made post-deanimation as there was no clot and the wound had a "cored" nature suggesting a large bore needle; this was presumably the intracardiac puncture wound for the ME's toxicology screen.

A temperature monitoring probe was not placed rectally until approximately 0400, at which time a Shiley, vinyl coated, type T rectal thermocouple probe was placed. The initial temperature reading at that time was 7.0°C. The rectum was free of stool.

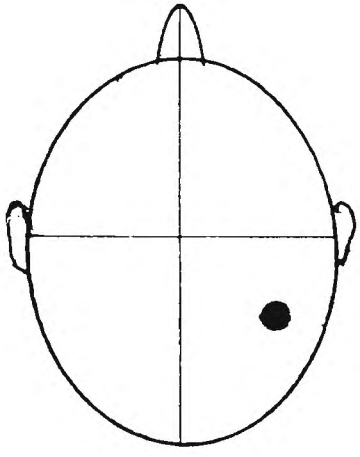
Operative Procedures

Pre-operative Prep

The patient was prepared for a median sternotomy and cranial burr-hole by shaving the head and thorax and scrubbing/swabbing them with povidone iodine solution (Betadine). The sternal operative site was defined by draping with sterile towels and an adhesive operative drape (3M) was placed over the sternum. A sterile drape sheet was placed over the patient, "tented" on two IV poles at the head and allowed to extend down to the feet and over the sides of the table by a minimum of 24". The top of the scalp was draped with a 16" x 16" plastic drape with an adhesive coating around a 2-1/2" aperture.

Cranial Burr-Hole

Surgery to open the cranial burr-hole was begun at 0120, 9 May, 1988. The vertex of the scalp approximately 3 cm. to the right of midline was incised with #10 scalpel blade and an incision approximately 4 cm long was made down to the periosteum. A periosteal elevator was used to expose the bone approximately 1.5 cm to the right of the midline. A 10 mm hole was made with a neuro burr and drill. The dura mater was opened and trimmed away with iris scissors to expose approximately 5 to 6 mm of the cortical surface. Burr-hole surgery was completed at 0214. Upon opening the dura it was noted that approximately 3/4ths of the burr-hole diameter was over a large venous sinus or pial vein; the pial vessels were observed to be blood-filled. Burr-hole location is shown schematically below.



Burr-Hole Location

Median Sternotomy/Vascular Access

Surgery to connect the patient to the heart-lung machine began at 2232, 8 May, 1988, with an incision over the midline of the sternum with a #10 scalpel blade. Fascia and connective tissue were cleared down to the sternum using an electrosurgical knife. A median sternotomy was then performed with some difficulty using a Sarns model 6090 reciprocating sternal saw; stainless steel wire sutures from the previous CABG surgery

were removed with Kelley forceps and Mayo scissors.

The edges of the sternotomy were padded with laparotomy sponges, a self-retaining retractor placed, and the sternotomy retracted open. Extensive to adhesions typical of patients with a prior CABG were present. The heart was mobilized by freeing it from adhesion to the chest wall and pleura bilaterally. The pericardium could not be identified. Scar tissue completely obscured the myocardial surface. Neither the right nor the left atrium was mobile or identifiable. The aorta and great vessels were also obscured by scar tissue and adhesions.

The lateral aspect of the right atrium was cleared of scar tissue with Metzenbaum scissors until a 2.5 cm square area of right atrial tissue was identifiable. Similarly, scar tissue was removed from the dorsal aspect of the ascending aorta from just above the aortic valve up to the second great vessel on the aortic arch. Due to the extensive scarring and adhesions, dissection required approximately three hours.

A 3-0 Tycron purse-string suture was placed in the aorta and a snare applied. An aortotomy was made with a #11 scalpel blade. A 22 Fr. aortic perfusion cannula was primed with normal saline and a clamp placed on the distal end. The cannula was then introduced into the aorta and snared in place with a hemostat on a Red Robinson snare tube.

A Satinsky partial occlusion clamp was placed on the exposed lateral right atrium. A purse string suture of 2-0 Tycron was placed in the atrium and a snare tube applied. An atriotomy was made with a #11 scalpel blade. A tube clamp was placed on the distal end of a 52 Fr. by 36 Fr. USCI 2-stage venous catheter and it was advanced through the atriotomy (with concurrent release of the Satinsky clamp) into the right atrium to the superior vena cava. The cannula was then snared in place.

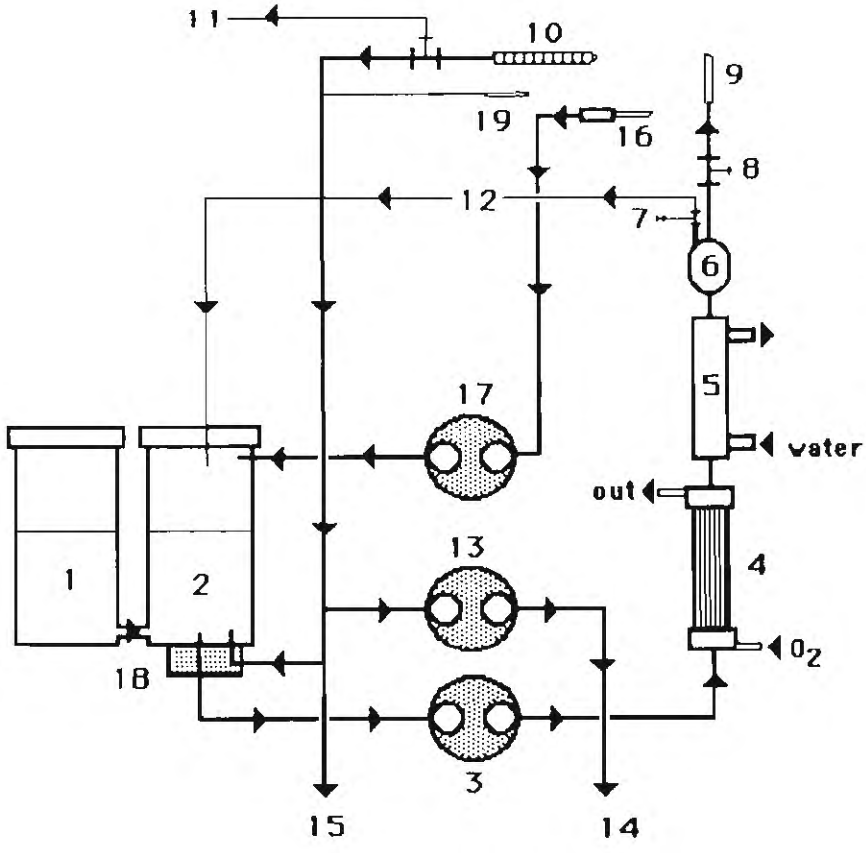
A 2-O silk purse string suture was placed in the left ventricular apex. A #11 blade was used to make a stab-wound through to the endocardium. A Kelley hemostat was then used to enlarge the stab wound and a 16 Fr. ventricular vent was placed and snared.

A central venous pressure monitoring catheter was placed through the wall of the right atrium and secured with 3-O silk suture. The tip of the catheter rested in the vena cava, just above the atrium.

A fourth small purse-string suture of 5-0 silk was was placed in the left lateral aspect of the ascending aorta and an aortotomy made with a #11 scalpel blade. A Cobe 3-way stopcock was fitted to an Aloe arterial pressure monitoring catheter, the catheter was then flushed with normal saline and introduced through the aortotomy into the ascending aorta. The catheter was secured in place by applying a snare to the 5-0 suture.

The sterile perfusion tubing was then brought up to the surgical field and secured in a Travenol tubing holder towel clamped to the drapes. The arterial-venous loop of the perfusion circuit was clamped and divided by cutting out the 1/2" - 3/8" adapter with Mayo scissors. A 1/2" connector with a Cobe 3-way stopcock was used to connect the 1/2" ID venous return line to the venous cannula. Air was cleared from the system with 65 cc plastic syringe. A Cobe 8 ft. pressure monitoring line was fitted to the arterial pressure catheter, flushed with normal saline and handed off the field to be connected to a Trantec Model 800 pressure transducer and Tektronix model 412 monitor. A second Cobe line was connected to the CVP catheter and the pressure transducer.

Surgery to connect the patient to the perfusion circuit was completed at approximately 0210 on 5/9/88.



A-1108 WHOLE BODY PERFUSION CIRCUIT

1) Cryoprotective Concentrate Reservoir
2) Recirculating Reservoir
3) Arterial Pump
4) Oxygenator (Sci-Med)
5) Heat Exchanger (Sarns)
6) 40μ Filter (Pall)
7) Sample Port (Arterial)
8) Connector With Port
9) Cannula (Arterial)
10) Cannula (Venous)
11) Sample Port (Venous)
12) Vent Line (Arterial)
13) Withdrawal (Ramp) Pump
14) Withdrawal (Discard) Line
15) Total Body Washout Discard Line
16) Cardiotomy Sucker
17) Cardiotomy Suction Pump
18) Magnetic Stirring Table
19) Left Ventricular Vent

Perfusion Circuit

The extracorporeal circuit for cryoprotective perfusion is shown in schematic above. The circuit consisted of two parts: a recirculating system to which the patient was connected and a cryoprotective addition system. The recirculating system was comprised of a 60 liter reservoir sitting atop a magnetic stirring table, an arterial (recirculating) roller pump, a Sci-Med 3.5 square meter spiral wound membrane oxygenator, a Sarns Torpedo heat exchanger and a Pall EC1440 40 micron blood filter. The recirculating (mixing) reservoir was continuously stirred with a 2-7/8" teflon coated magnetic stirring bar driven by a Thermolyne type S-7225 magnetic stirrer. 86% (w/v) glycerol perfusate contained in a second 60 liter reservoir was continuously added to the recirculating reservoir, and recirculating perfusate simultaneously withdrawn and discarded from the venous line using a Drake-Willock model # 7401 hemodialysis pump. The glycerol concentrate reservoir was connected to the recirculating reservoir by a 1/2" section of silastic tubing. As perfusate was withdrawn from the recirculating system using the Drake-Willock pump, the level in the recirculating reservoir falls causing glycerol concentrate perfusate to flow into the recirculating reservoir.

Arterial and venous samples for evaluation of chemistries and glycerol concentration were drawn at 15-minute intervals during cryoprotective perfusion. Arterial samples were drawn from a 3-way stopcock interposed between the arterial filter and the filter vent line. Venous samples were drawn from a 6' Cobe monitoring line connected to a Cobe 3-way stopcock attached to the venous connector connecting the venous cannula and the venous

return line. (The dead-space of the Cobe monitoring line was determined and this volume was drawn up and discarded before each sample was taken.)

Due to the long ischemic interval the patient sustained, glucose was omitted from the perfusate and the perfusate was not oxygenated.

The perfusion circuit was prepared in advance of need and was sterilized with ethylene oxide using an appropriate protocol of post-sterilization outgassing and aeration.

Perfusion

Open-circuit perfusion of 5% (w/v) glycerol perfusate was begun at 0215 at flow rate of 500 cc/min., mean arterial pressure (MAP) of 50 mmHg, a pharyngeal temperature of 3.0°C and an arterial temperature (perfusate) of 5.2°C. Venous pH was measured at 6.90 at 0330. Venous return was noted to be very poor, the central venous pressure (CVP) was 25 mmHg, and the cerebral cortical surface was noted to be bulging into the burr hole. Perfusion was interrupted, the venous cannula repositioned and perfusion resumed. The venous cannula was repeatedly manipulated in the superior vena cava with little consequent improvement in venous return and the CVP was still 20 mmHg.

Finally, the venous cannula was removed and it was observed that there were clots which had been trapped in, and were obstructing, the intake holes of the cannula. The tip of the cannula was trimmed off with Mayo scissors to prevent plugging by small emboli once it was re-inserted.

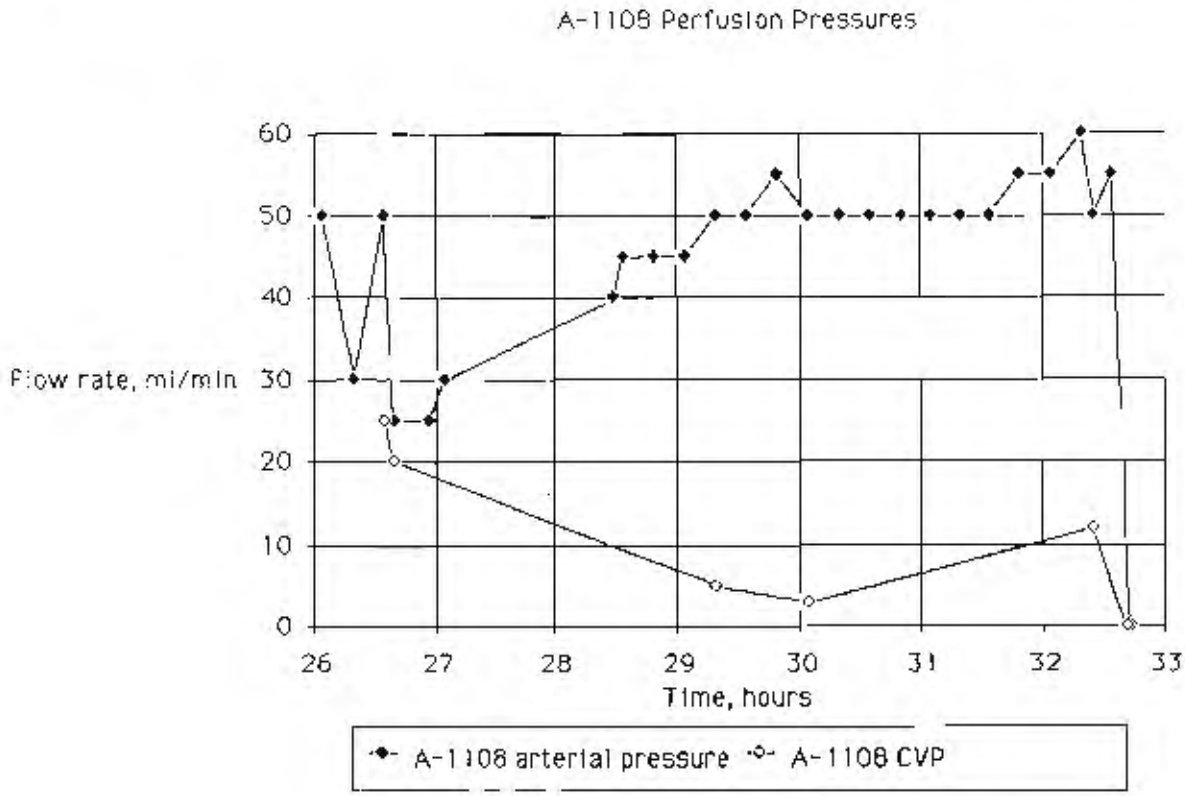
The atriotomy was then held open with forceps and the venous return allowed to drain freely into the chest where it was removed with the cardiotomy suction line. The neck and limbs were massaged, the abdomen compressed manually and the heart and vena cava were manipulated to dislodge clots. Forceps were also used to reach inside the atrium and extract large clots which lodged there and which occasionally plugged the atriotomy and blocked venous outflow. These maneuvers were continued until the venous return flowing out of the atriotomy was observed to be clear and free of blood clots.

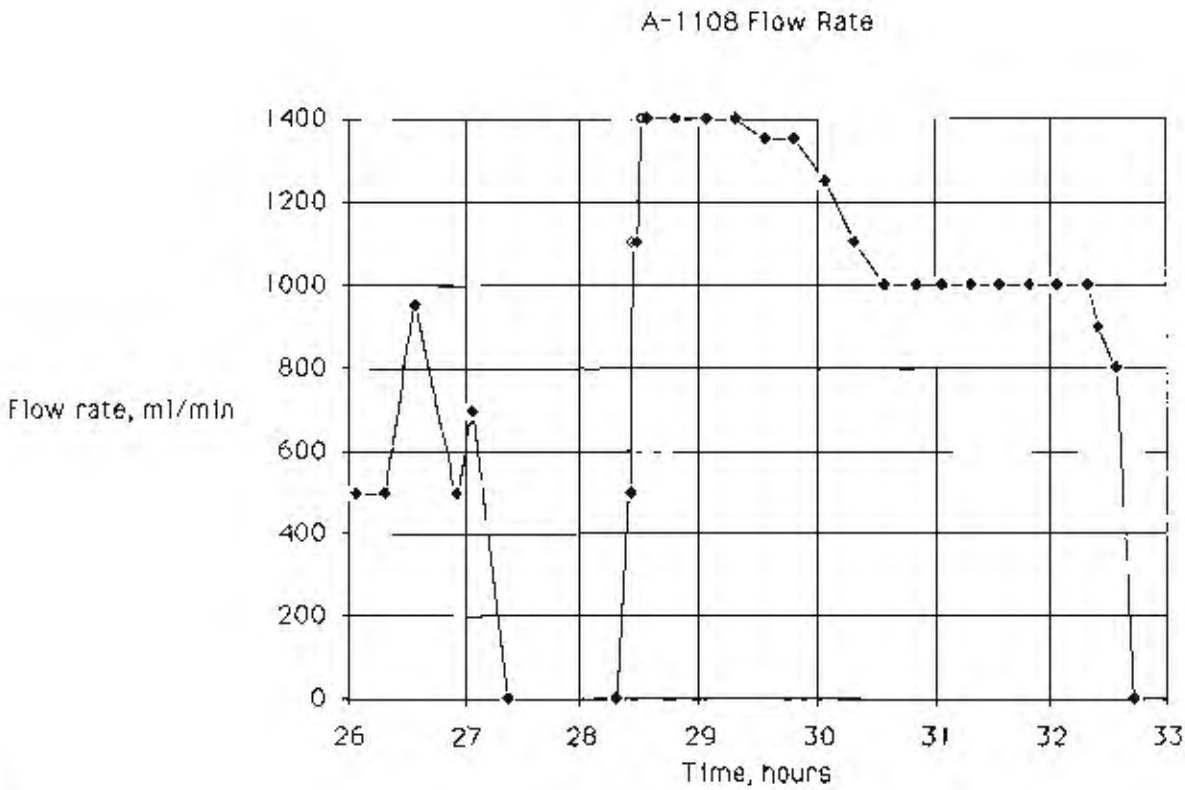
Approximately 10 liters of 5% (w/v) glycerol perfusate was flushed through the patient open circuit. The cortical surface and cortical venous sinus were observed to be blood free at 0325.

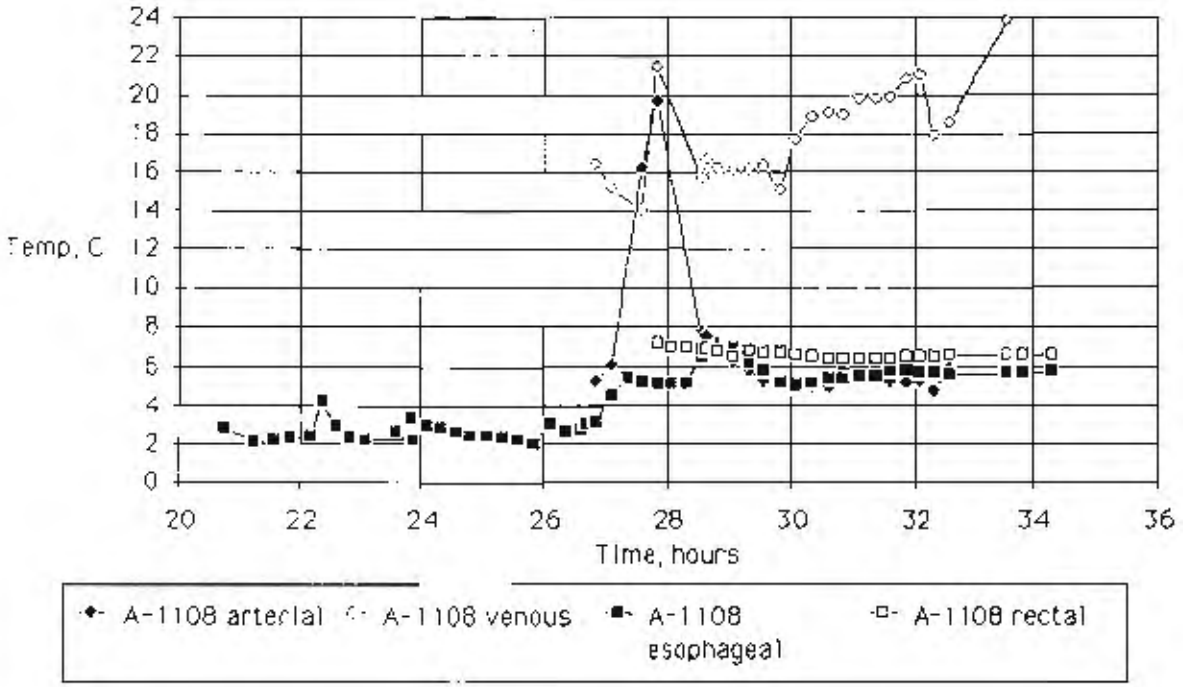
Open circuit perfusion was concluded at 0330 with approximately 10 liters of 5% (w/v) glycerol perfusate flushed through the patient. At that time it was noted that there was massive pulmonary edema as evidenced by swelling of the lungs out of the chest wound and significant drainage of fluid from the nose and mouth.

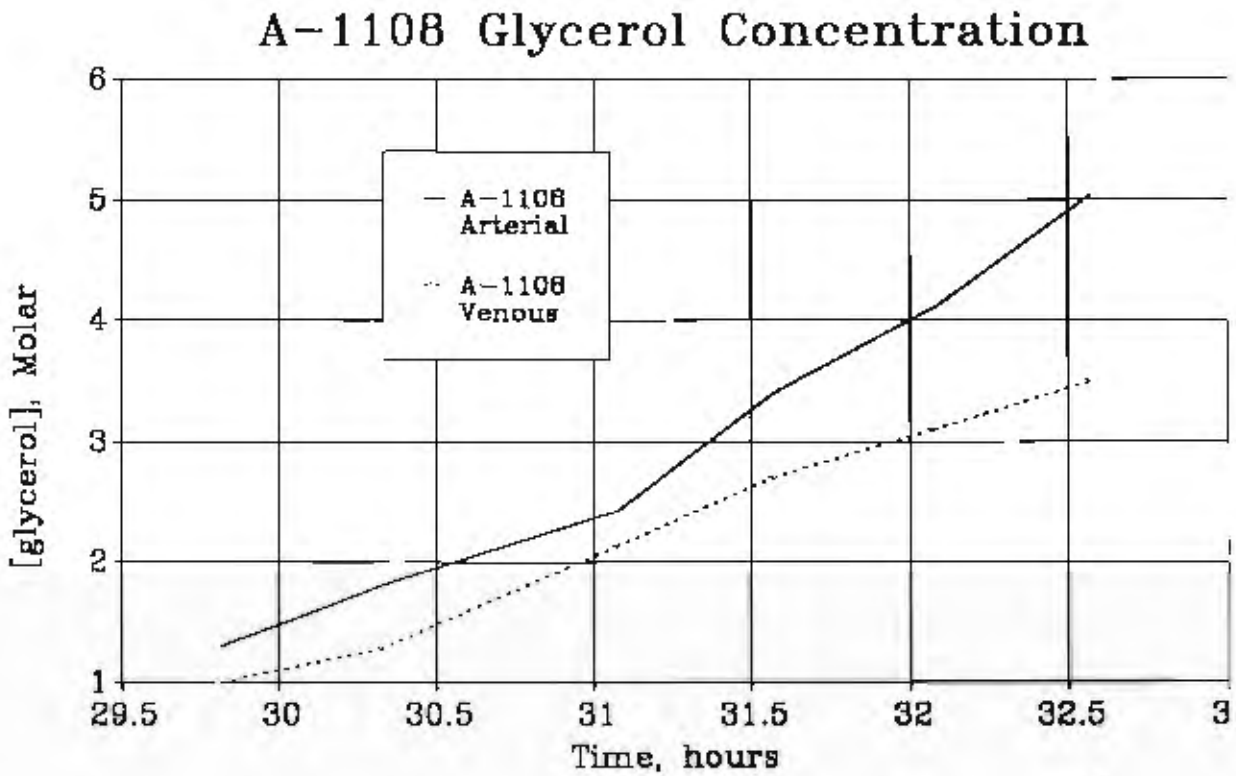
Perfusion resumed at 0437 with the start of the cryoprotective ramp. Perfusion (arterial) flow rate began at 1,100 cc/min., MAP 45 mmHG, CVP 5 mmHg, esophageal temperature 5.4°C, rectal temperature 6.4°C, and arterial temperature 5.9°C . Arterial and venous pH were recorded at 0450 and were 7.56 and 7.08 respectively. The recirculating perfusate withdrawal flow rate was initially set at 200 cc/min. Subsequently at 0512 the withdrawal flow rate was increased to 200 cc/min. to yield an an average arterial/venous difference in glycerol concentration of 400 to 500 mM during the first 2/3rds of the cryoprotective perfusion. As edema began to become severe during the last hour of perfusion, the A-V glycerol concentration difference was further increased (by increasing the withdrawal rate to 300 cc/min.) to .75 to 1.0 M in an attempt to control the edema and reach a reasonable terminal glycerol concentration. The average rate of

increase in arterial glycerol concentration during cryoprotective perfusion was 25.9 mM per min. The MAP, CVP, arterial flow rate, pharyngeal and rectal temperatures, and the concentration of glycerol in the arterial and venous effluent is shown graphically below. Times given are decimal hours post-arrest.






Temp, C
Time, hours
A-1108 arterial
A-1108 venous
A-1108 esophageal
A-1108 rectal

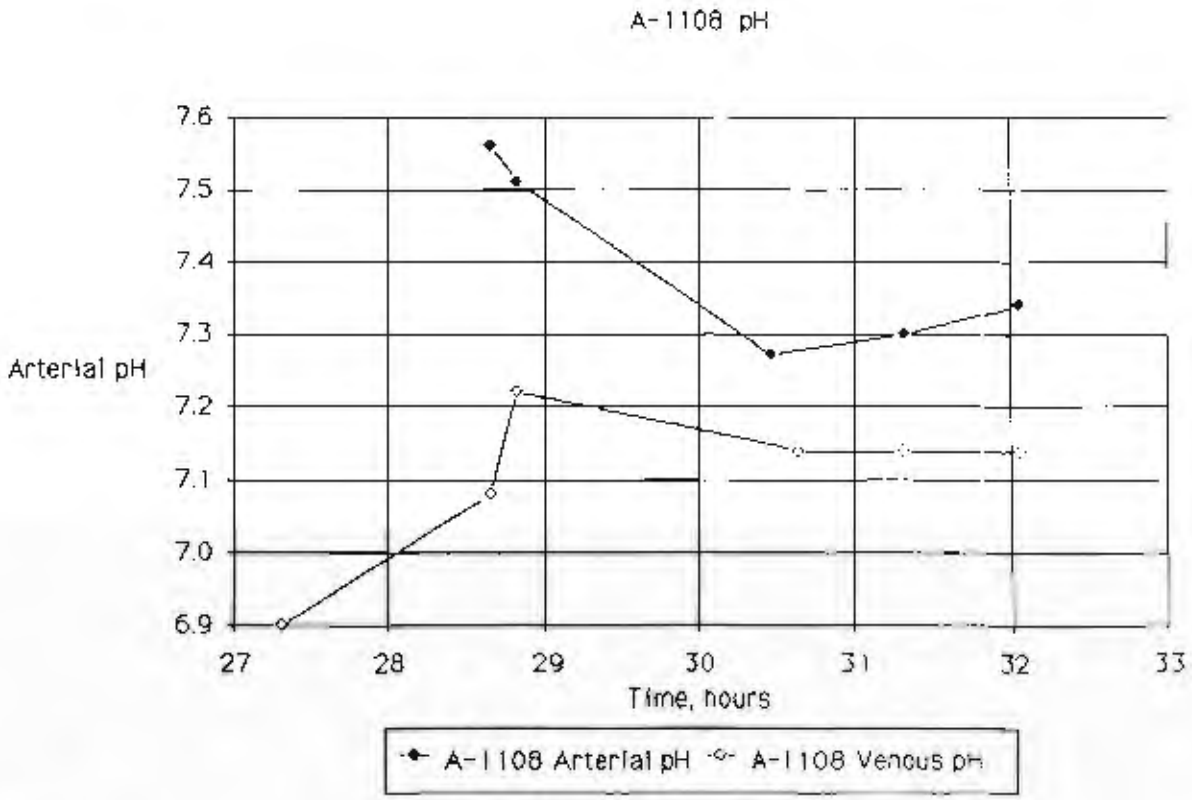

A-1108 Glycerol Concentration
[glycerol], Molar
Time, hours
A-1108 Arterial
A-1108 Venous

Throughout perfusion a steady stream of clots estimated to be from 2 mm to 1 cm in diameter were observed in the venous return line. Additionally there was a steady stream of what appeared to be agglutinated red cells presenting a "grains of sand" sediment-like appearance in the venous line. Small clots and quantities of agglutinated material were also shed in the perfusate leaking from the margins of the burr hole scalp wound, bone and dura. Occasionally 1 mm to 2 mm long by approximately 0.25 mm in diameter clots were shed from severed vessels in the margin of the scalp wound.

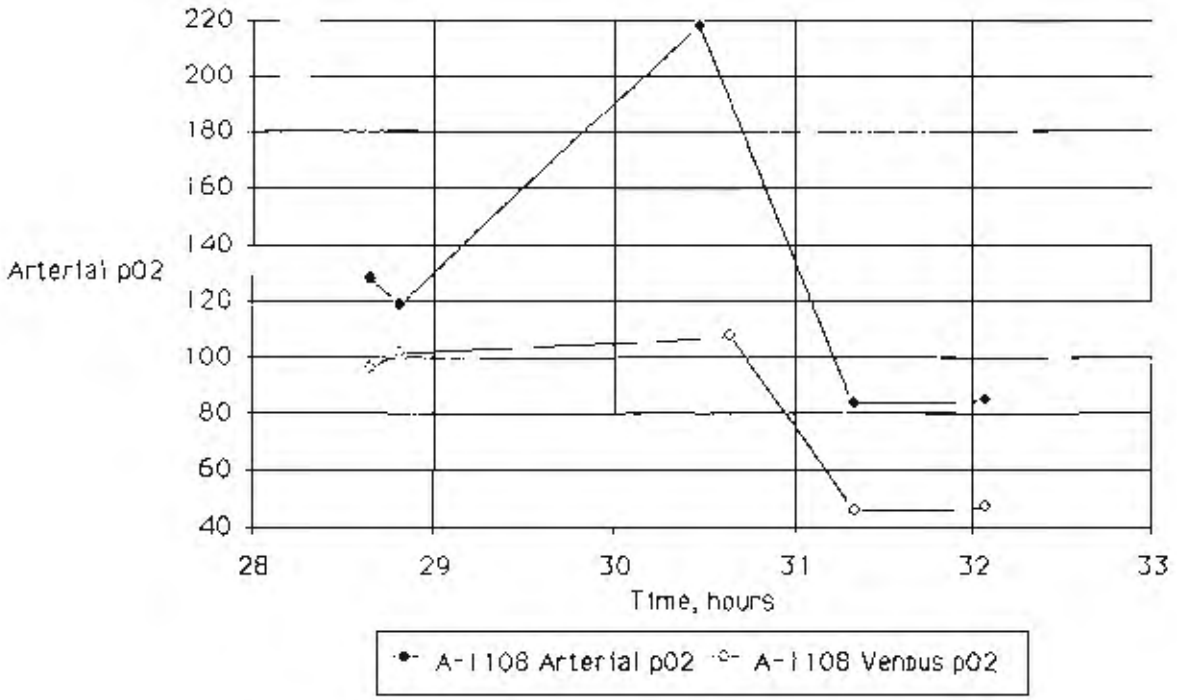
Pulmonary edema continued to be a serious problem with copious drainage of fluid coming from the nose and mouth. A nasal endotracheal tube was threaded into the posterior pharynx and a suction catheter threaded down the ET tube and attached to continuous suction; 2,150 cc of fluid was suctioned off in this way during the course of glycerol perfusion.

Brain volume remained fairly constant throughout perfusion with the cortical surface bulging into the burr hole 1mm to 2 mm. This modest degree of cerebral edema and apparent good blood washout was surprising considering the amount of ischemic time this patient experienced and especially in view of the obvious presence of intravascular clotting and the pronounced facial edema that developed during perfusion.

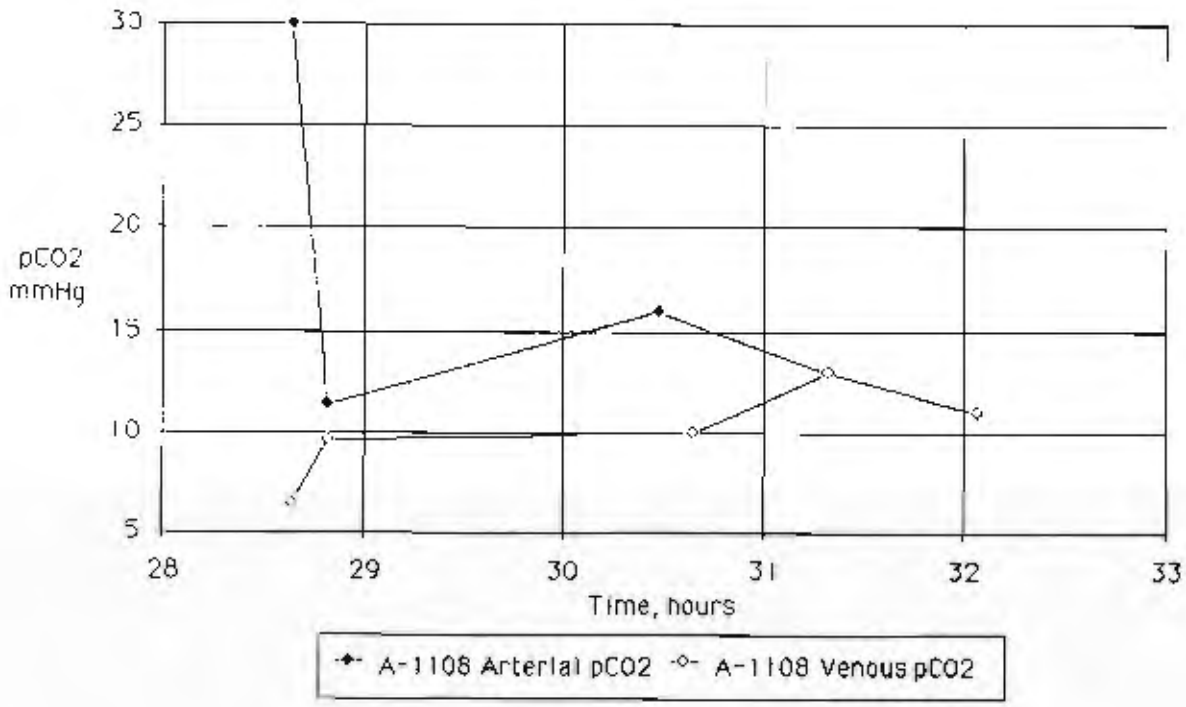
An arterial pO_2 and pCO_2 determination was first made at at 0450. Arterial pO_2 was 128 mmHg and arterial pCO_2 was 30 mmHg, arterial pH was 7.56, venous gases were pO_2 97 mmHg and pCO_2 64 mmHg, pH 7.08. Perfusion pH and gases approximately mid-way through cryoprotective perfusion were drawn at 0640 and were: arterial pO_2 218 mmHg, arterial pCO_2 16 mmHg, arterial pH 7.27, venous pO_2 108, venous pCO_2 10, and venous pH 7.14. A final determination of arterial and venous pO_2 and pCO_2 was made at 0815 and was: arterial pO_2 85 mmHg, arterial pCO_2 11, arterial pH 7.34, venous pO_2 47, venous pCO_2 11, and venous pH 7.14. Perfusion pH, pO_2, and pCO_2 are shown graphically below. Times shown are decimal hours post-arrest.



A-1108 pO2



A-1108 pCO2



Perfusion to the skin of the lower thorax and trunk was observed to be very poor or absent as evidenced by lack of glycerol-induced dehydration of the skin. Additionally, the musculature of the trunk and lower extremities did not exhibit the changes in firmness normally associated with glycerolization. This was in sharp contrast to the skin of the head, neck, and both arms which, while mottled with occasional unglycerolized areas, was nevertheless largely glycerolized. Both arms were profoundly dehydrated by glycerolization; the hands were dehydrated to an intermediate degree. The surface of the cerebral cortex exposed in the burr hole was pearly-white and apparently blood-free at the conclusion of glycerol perfusion.

Cryoprotective perfusion was concluded at 0855 at a flow rate of 800 cc/min., MAP of 55 mmHg, pharyngeal temperature of 5.5°C, rectal temperature of 6.6°C, and arterial temperature of 5.9°C. Terminal glycerol concentration was 5.04 M in the final arterial sample and 3.53 M in the final venous sample.

Decannulation and Chest Wound Closure

Decannulation and chest wound closure were begun at 0855. The venous and arterial cannula were clamped with tube-occluding forceps. The snare was removed from the venous cannula and as the cannula was removed the atriotomy was closed with the purse-string suture and tied. The same procedure was used to remove the arterial perfusion cannula.

Four Davis & Geck sternal wires of 22 gauge stainless steel were used to close the median sternotomy. The skin was closed with 2-0 Tycron on a cutting needle and the suture line was protected with spray-on bandage.

Burr-Hole Closure

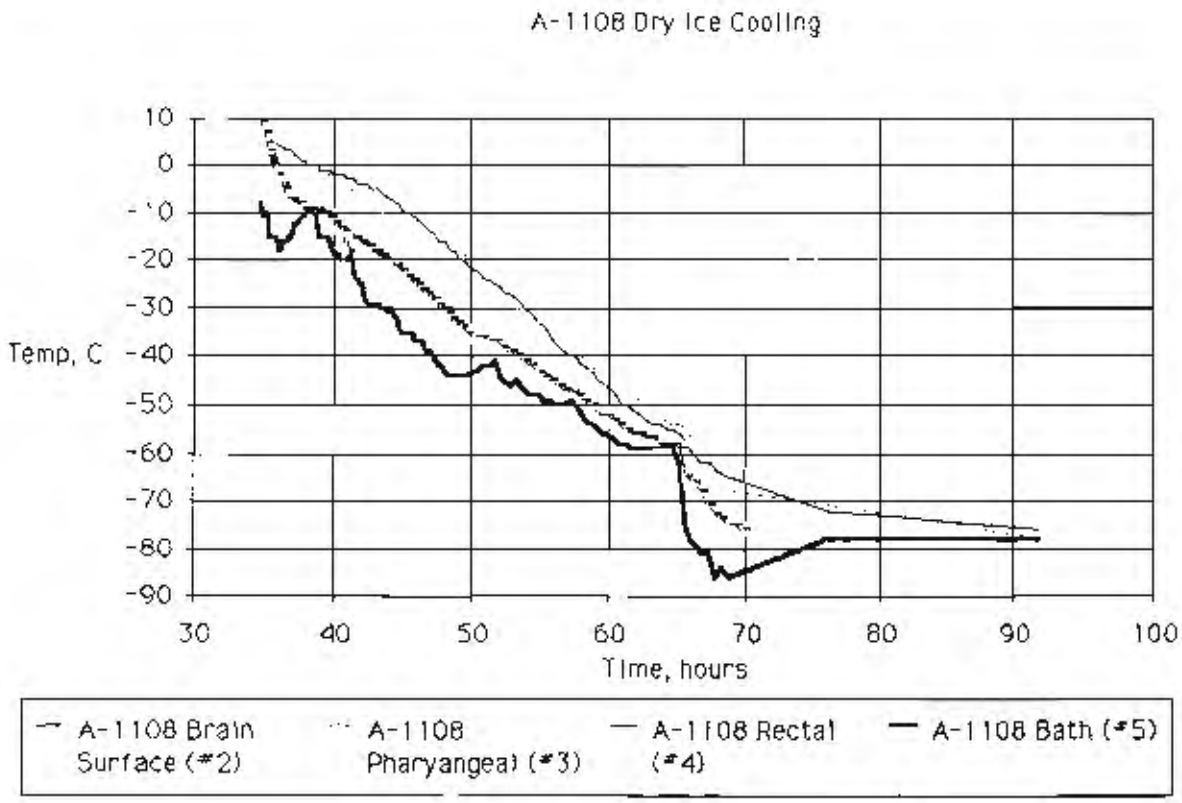
At 0850 the silastic coated tip of 15' long, 30 gauge Capton-wrapped copper-constantan (type T) thermocouple probe (Instrument Laboratory # 53-30-513) was threaded into the burr-hole and placed on the cortical surface. The burr hole was filled with bone wax and the scalp closed with surgical staples. The probe was anchored to the scalp with surgical staples and 3-O silk. The suture line was protected with spray-on bandage. Cerebral cortical temperature was measured at 9.0°C at 1107.

Cooling to Dry Ice Temperature

Temperature descent to -77°C was monitored with probes in the oral pharynx, rectum and externally on the ankle in addition to the brain surface probe. The pharyngeal, rectal, and ankle probes were Instrument Laboratories 53-20-507, "load type", 20 gauge, teflon-coated copper-constantan thermocouples. These probes were used to replace the vinyl-clad clinical TC probes employed to monitor temperature during perfusion. TC probes were anchored into place with 3-0 silk suture and/or surgical staples.

The patient was then wiped down with absorbent towels and transferred to a table top covered with absorbent bath blankets. The patient was maneuvered inside two 5 mil polyethylene bags with TC probes brought out through the open end of the bags. The patient, within the protective bags, was then lowered into a sheet-metal tank (mortuary shipping box) insulated with 4" of expanded polystyrene (EPS) containing approximately 220 liters of 5 centistoke polydimethylsiloxane oil (Silcool) which had been pre-cooled to -8°C. The first temperature readings after transfer to the cooling bath taken at 1107 were: cerebral cortical surface 9.0°C, pharyngeal 6.0°C, rectal 6.0°C, ankle 5.0°C, and

bath -8.0°C. The bags were then evacuated of air with a household vacuum cleaner and closed with nylon cable ties. The patient was prevented from floating in the Silcool bath by wedging varying lengths of lumber under the lip of the metal tank in such a way as to hold the patient under the Silcool liquid surface. Cooling to a pharyngeal temperature of -75°C was at a rate of 4.76°C per hour with a bath to pharyngeal temperature differential of approximately 20°C and a brain surface to pharyngeal temperature differential of approximately 10 to 15°C. Cooling to -77°C was complete by 0808 on 5/10/88. The patient's dry ice cooling curve is presented below. Times shown are decimal hours post-arrest.



Cooling to -196°C

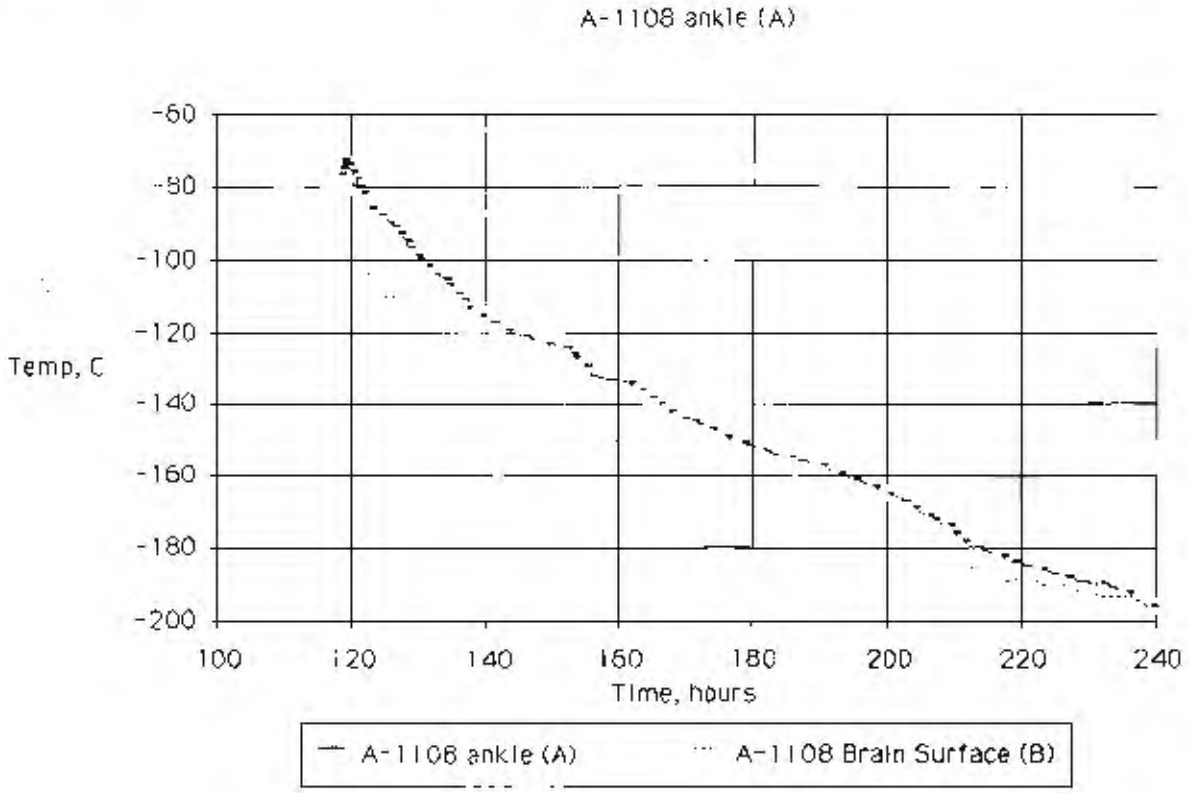
At 2200 on 5/12/88 the patient was removed from the silcool bath, the outer Silcool-soaked plastic bag was stripped off, and the patient was placed inside a Dacron wool insulated "mummy type" nylon shell sleeping bag atop a wooden stretcher. A heavy-walled aluminum container measuring 12" x 12" (neurocan) was slipped over the patient's head. The neurocan, sleeping bag and stretcher had been pre-cooled with liquid nitrogen. Additional Instrument Laboratory 53-20-507 load TC probes were anchored inside the neurocan and to the inside of the sleeping bag in positions such that body surface temperature readings could be taken from the head, upper chest, back, and abdomen. An additional TC probe was placed inside the sleeping bag on the outside of the neurocan.

At 2219 on 5/12/88, the patient on the stretcher was inserted into an MVE A-9000 dual patient cryogenic dewar which had been precooled with liquid nitrogen vapor to about -100°C. The dewar was then rocked into an upright position. The highest temperatures that were recorded during the transfer from the Silcool/dry ice bath were at 2253 and were

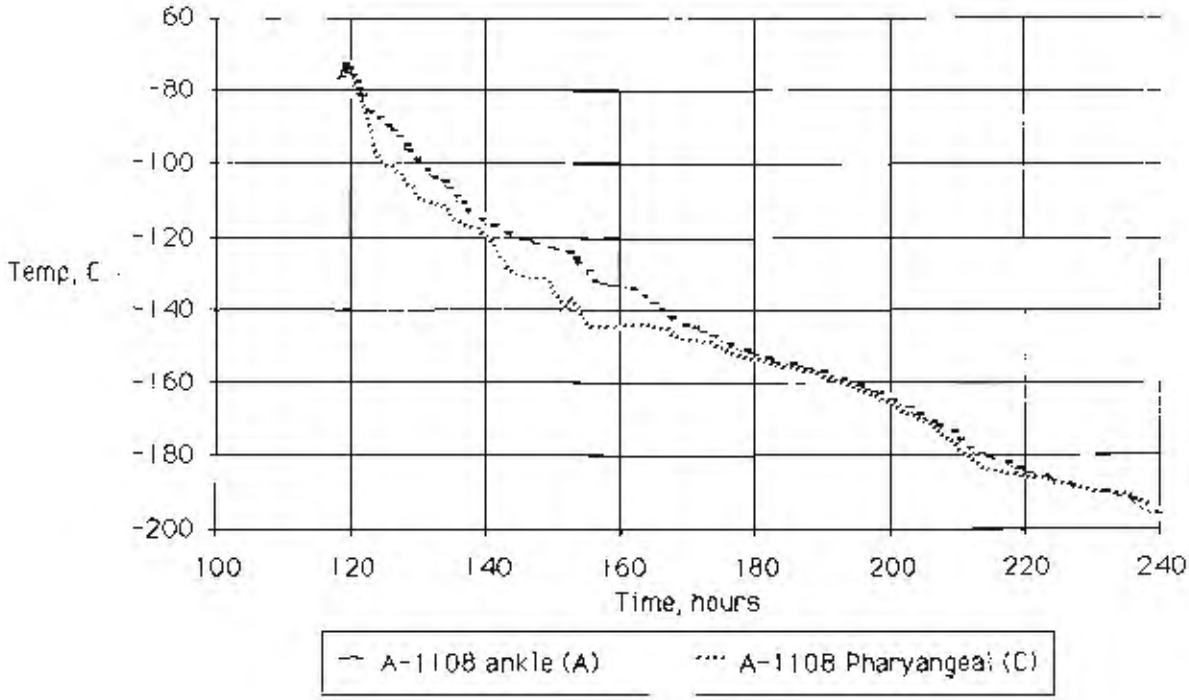
ankle -73°C, cerebral cortex surface -74°C, and rectal -76°C.

A specially fabricated cool-down lid with a variable speed fan mounted on the inside surface and a liquid nitrogen line with solenoid control was then used to close the dewar. The TC probes were externalized through the top of the dewar to allow for monitoring of the cool-down.

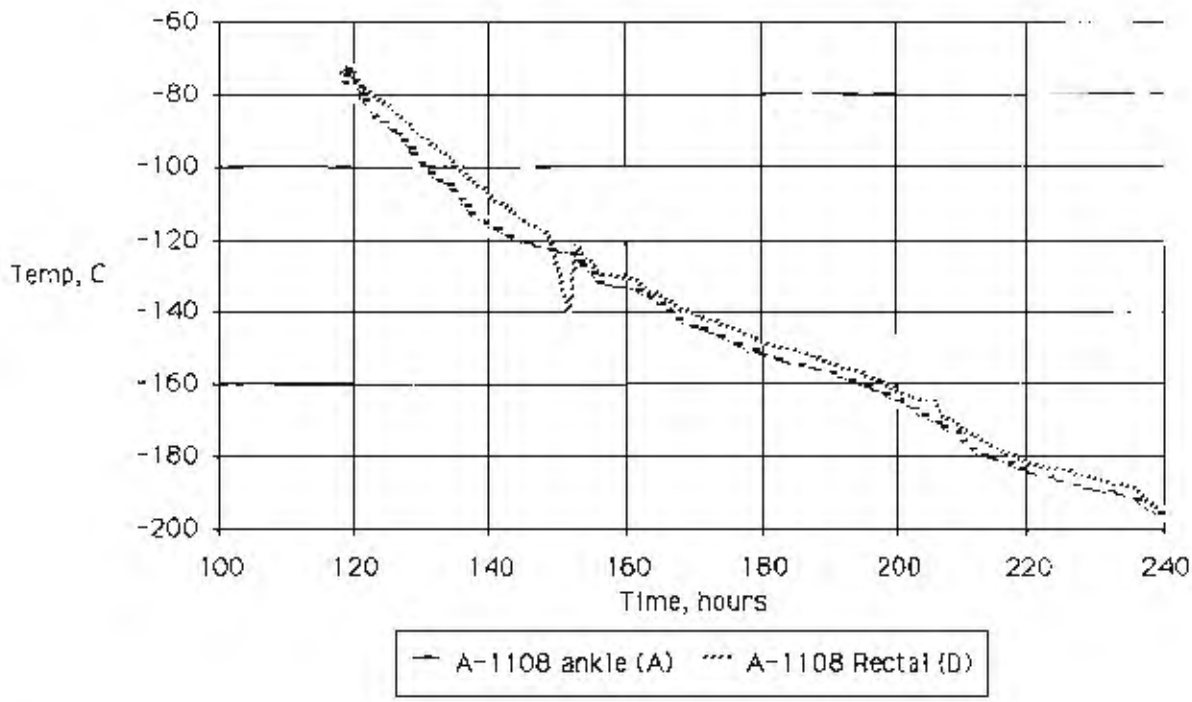
The fan on the cool-down lid was then activated and liquid nitrogen was added such that the patient cooled to -196°C at rate of approximately 0.6°C per hour. The patient reached -196°C at 2310 on 5/19/88. The patient's liquid nitrogen cooling curve for the various probes, is presented below. Each curve is shown with the temperature at the ankle shown for comparison. Times shown are decimal hours post-arrest.



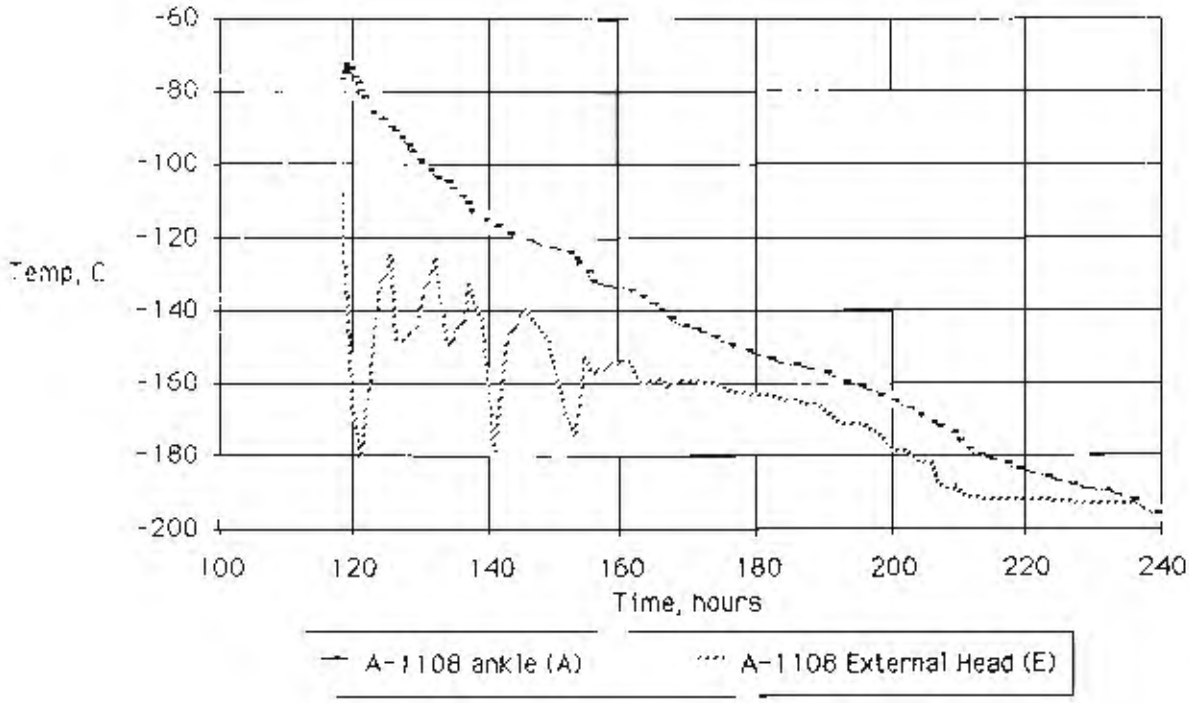
A-1108 ankle (A)



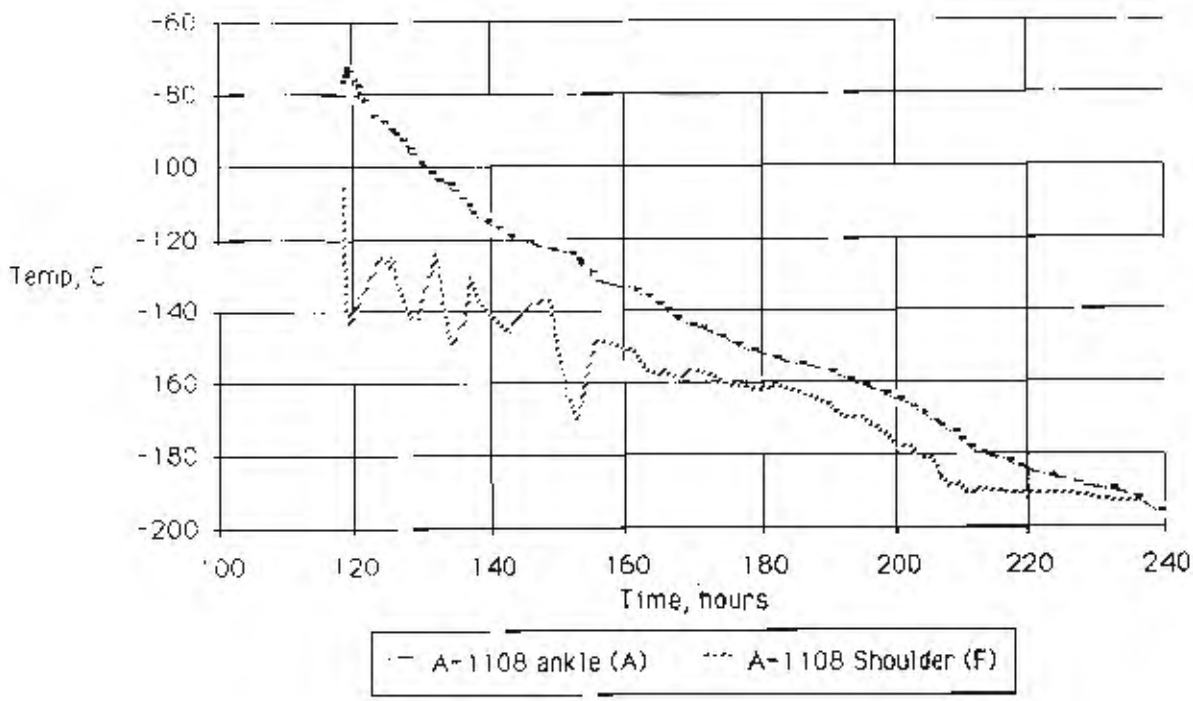
A-1108 ankle (A)

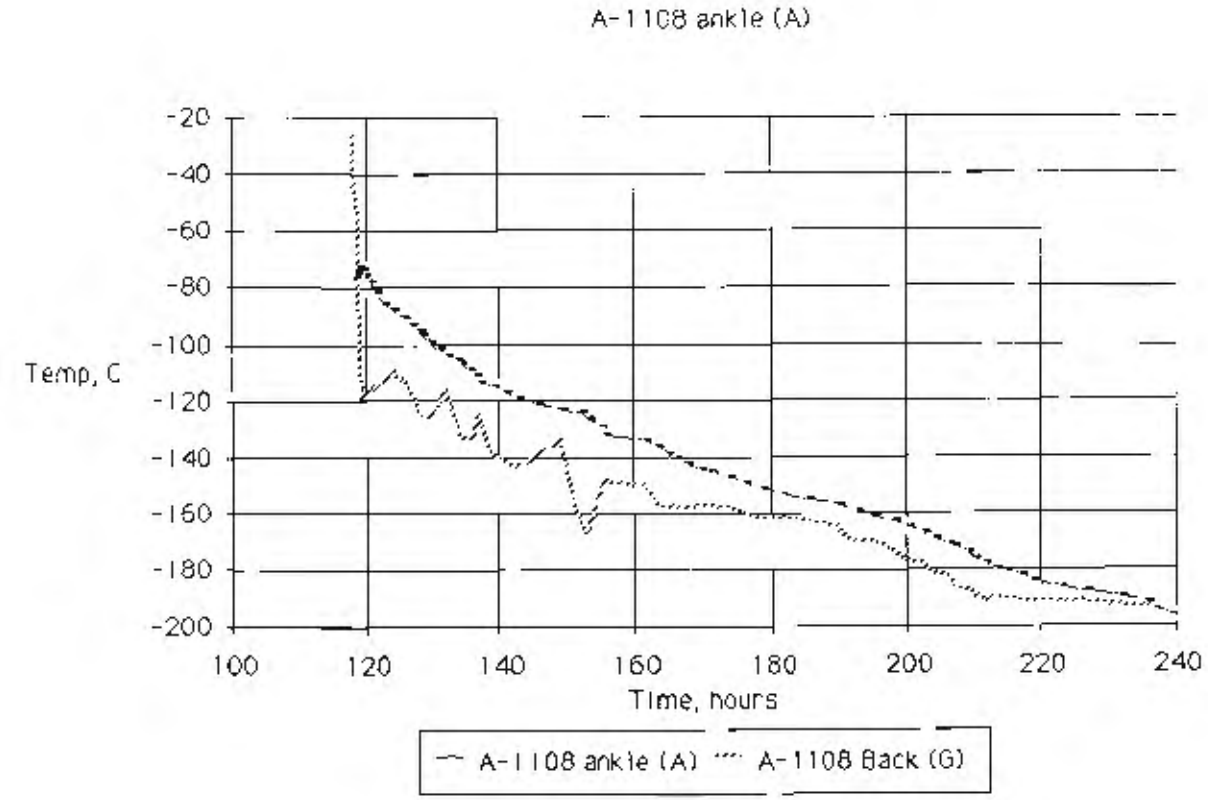


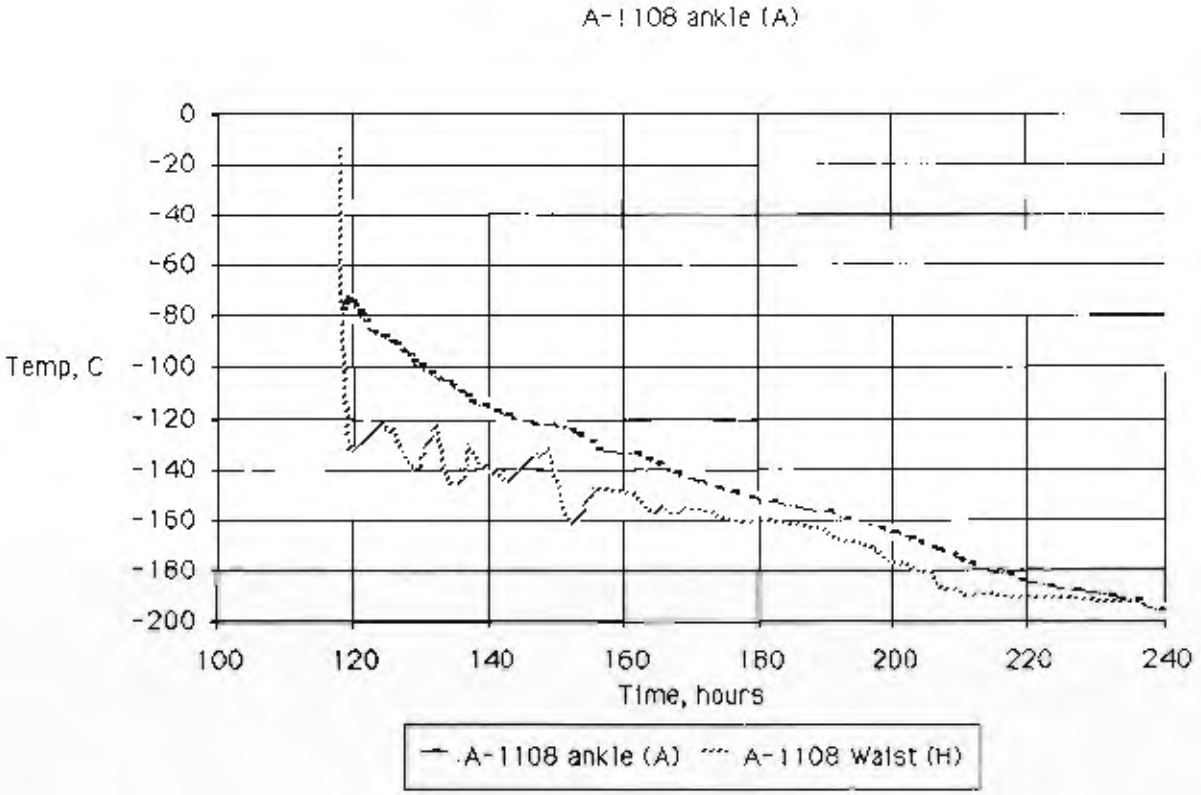
A-1108 ankle (A)

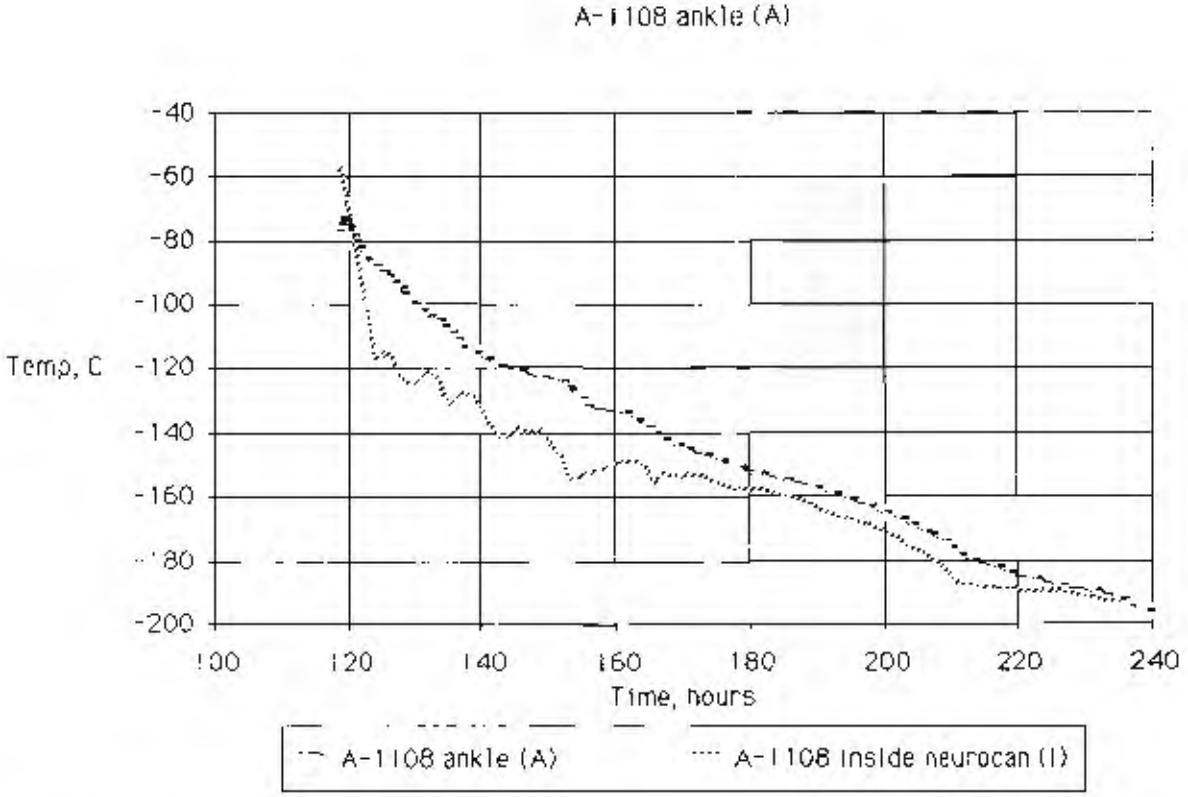


A-1108 ankle (A)




A-1108 ankle (A)
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
Temp, C
100
120
140
160
180
200
220
240
Time, hours
A-1108 ankle (A)
A-1108 Back (G)


A-1108 ankle (A)
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
Temp, C
100
120
140
160
180
200
220
240
Time, hours
A-1108 ankle (A)
A-1108 Waist (H)



Laboratory Evaluations

Laboratory evaluations of samples taken during cryoprotective perfusion are presented in full in both graphic and tabular form as an addendum to this document. The following general observations are made:

An accurate hematocrit was impossible to obtain at the start of blood washout, presumably as a result of clotting and sedimentation of formed blood elements within the larger vessels of the circulatory system. The hematocrit of the first venous effluent was 15%, clearly not accurate.

All blood and perfusate samples collected showed a slight degree of hemolysis with the exception of the initial few samples which were markedly hemolytic.

The venous BUN and creatinine were mildly elevated (24 mg/dl and 0.8 mg/dl, respectively) at the start of perfusion, possibly indicating diminished function secondary to low cardiac output during the last few days of life. As would be expected, BUN and cretinine declined steadily during blood washout and subsequent cryoprotective perfusion.

The venous SGOT and SGPT were markedly elevated at the start of cryoprotective perfusion with the SGOT at 342 IU/l and the SGPT at 60 IU/l. While the level of these enzymes declined during perfusion, they remained elevated with the SGOT remaining at 120-130 IU/l and the SGPT remaining at between 30 IU/l and 40 IU/l throughout perfusion.

Similarly, the venous LDH was extremely high at 1724 IU/l at the start of perfusion and then declined to approximately 800 IU/l where it remained. A similar pattern was

observed with alkaline phosphatase levels.

Surprisingly, GGT levels were low at 2.0 IU/l at the start of blood washout, and then declined to 1.0 IU/l where they remained fairly constant (with some unexplained scatter) for the remainder of perfusion.

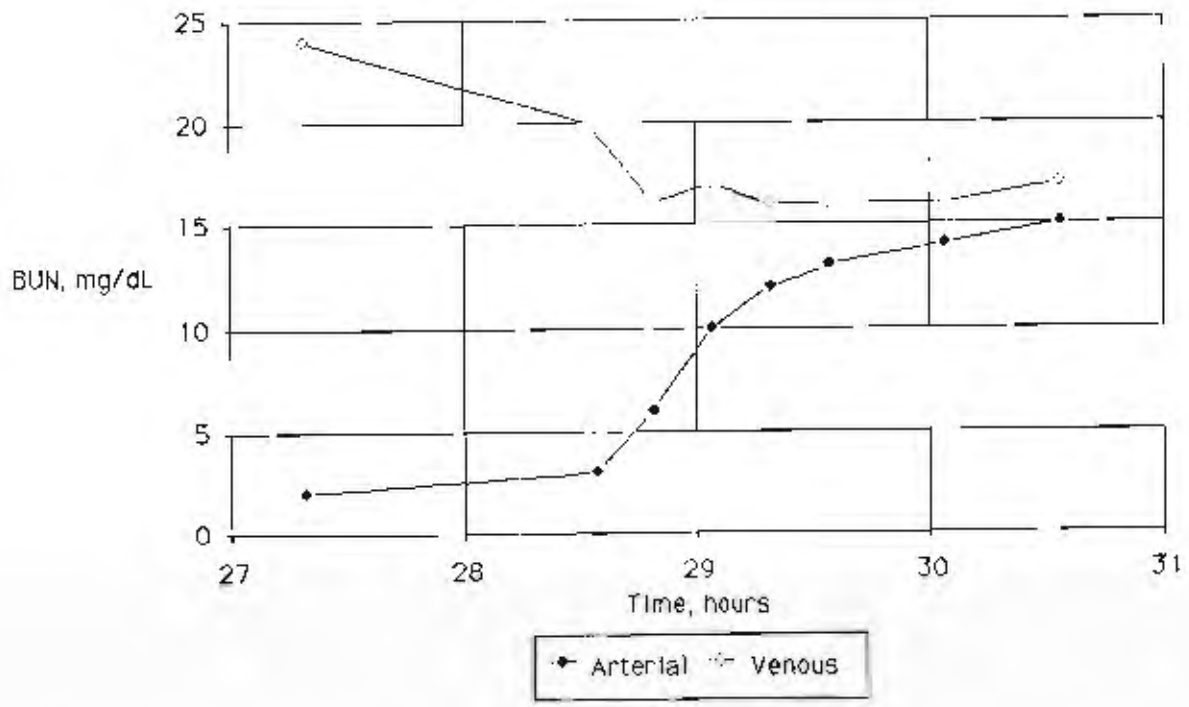
Venous CPK levels were massively elevated (greater than 5000 IU/l) and remained high throughout. This was reflected in a steadily and steeply rising CPK concentration in the arterial perfusate with no sign of leveling off.

The extent to which CPK levels were elevated and the fact that CPK release was sustained throughout perfusion would seem to indicate particularly severe injury to the muscles and/or brain.

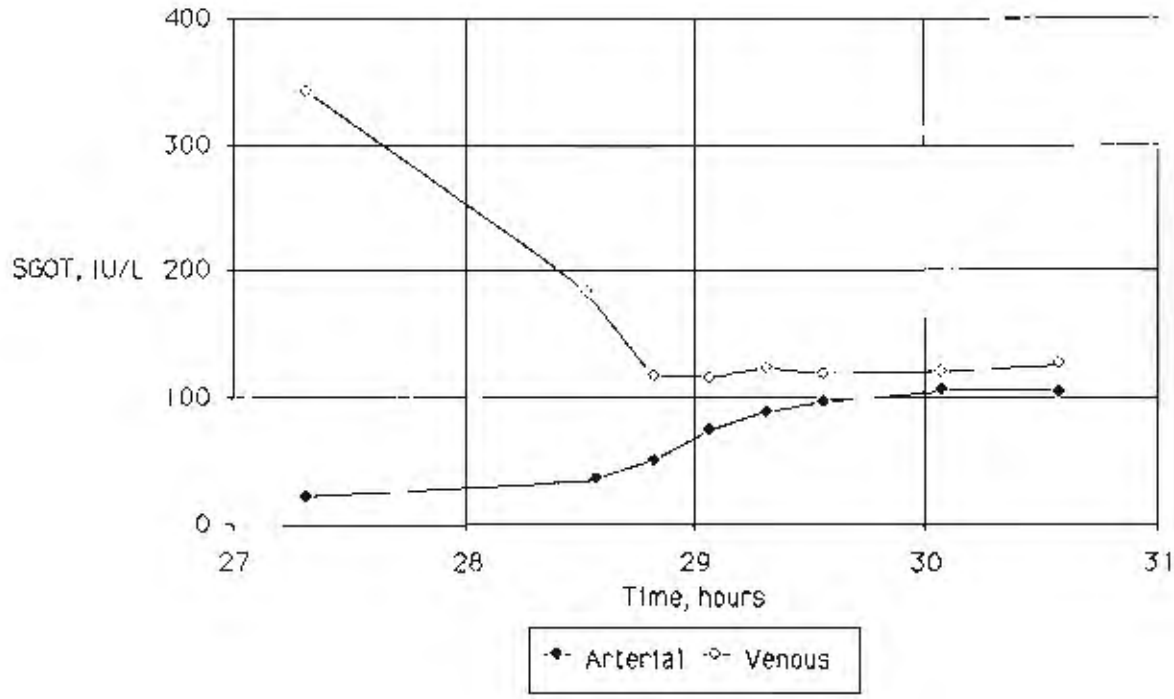
The pathologically elevated levels of SGOT, SGPT, LDH, CPK, and alkaline phosphatase are not surprising considering the warm and cold ischemic time this patient suffered in the absence of any stabilization or transport procedures beyond simple refrigeration with ice/air cooling.

Venous sodium, calcium, chloride, and glucose levels show an unexplained abrupt increase in concentration in sample #4 or #5; this spike is not reflected in the arterial samples.

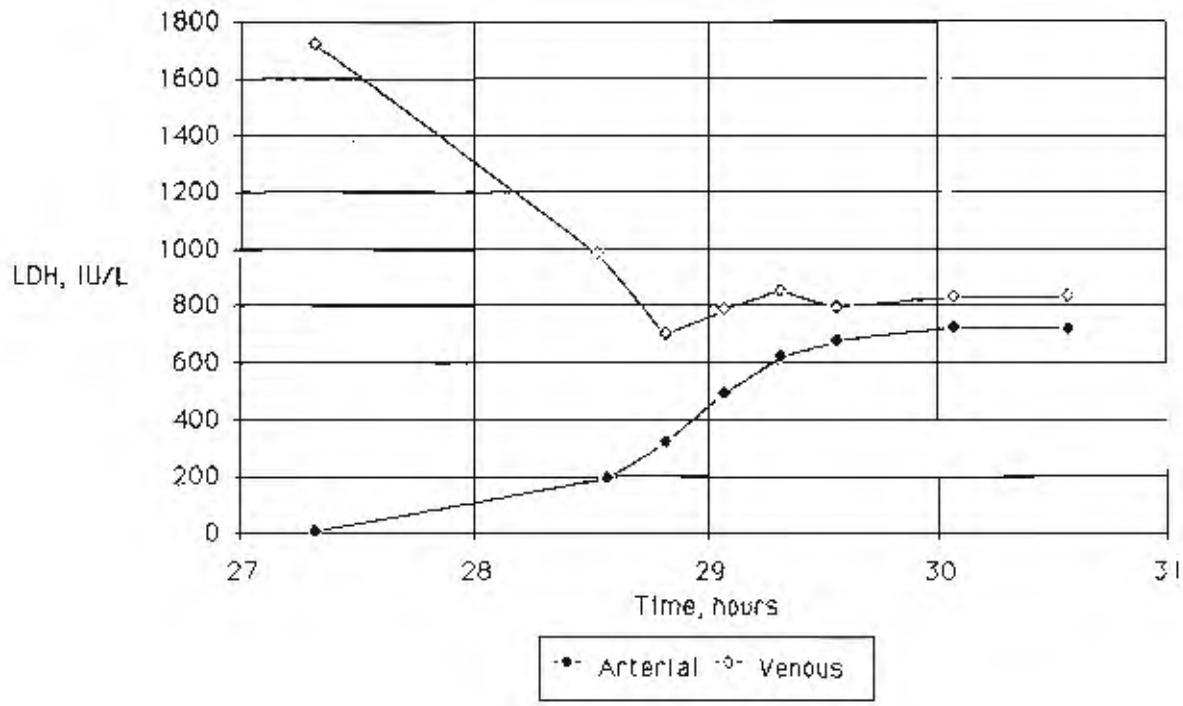
A-1108 Blood Urea Nitrogen



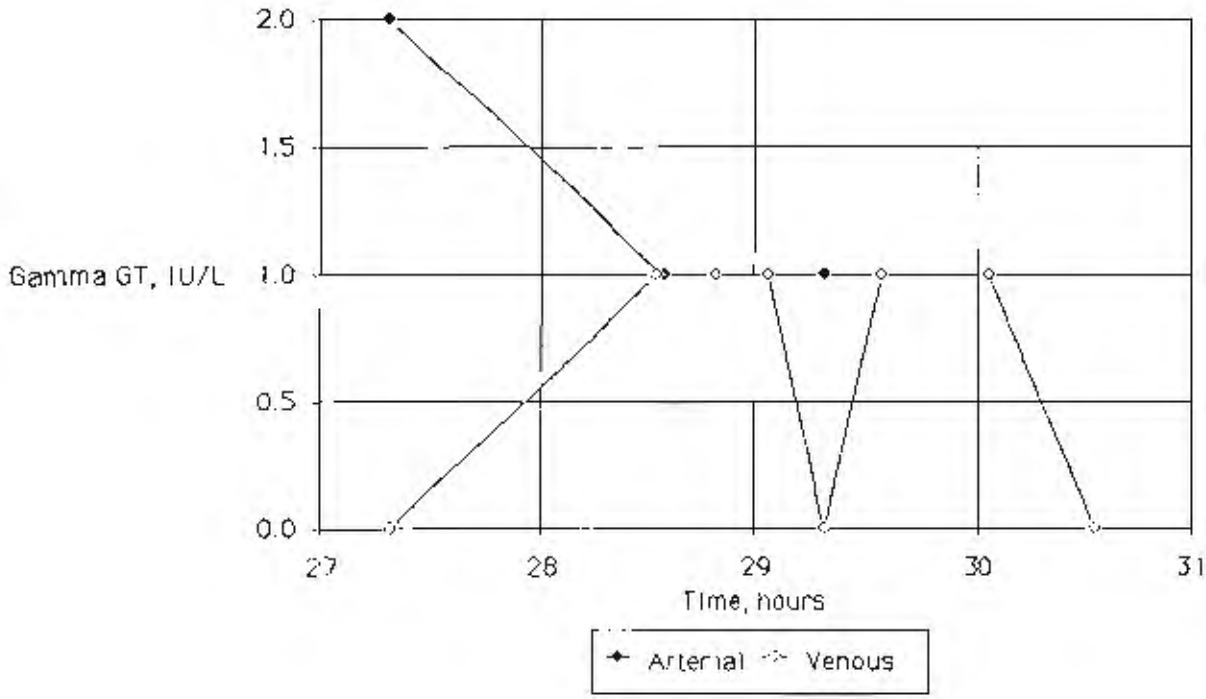
A-1108 SGOT



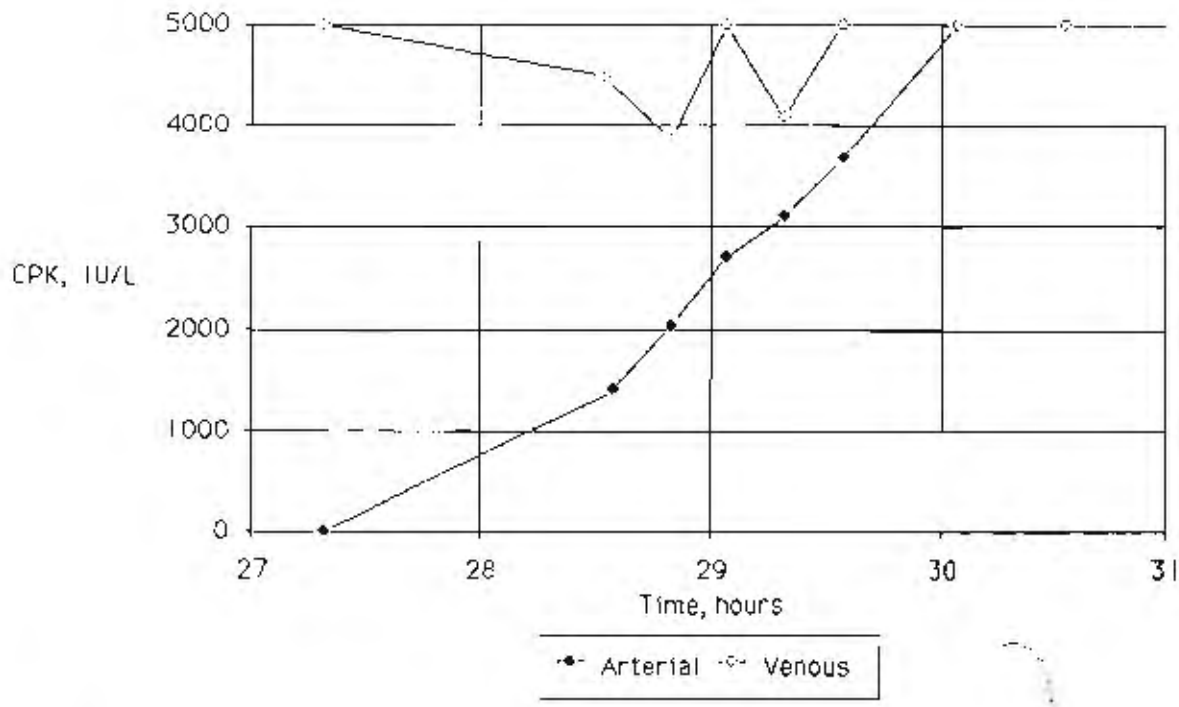
A-1108 Lactate Dehydrogenase



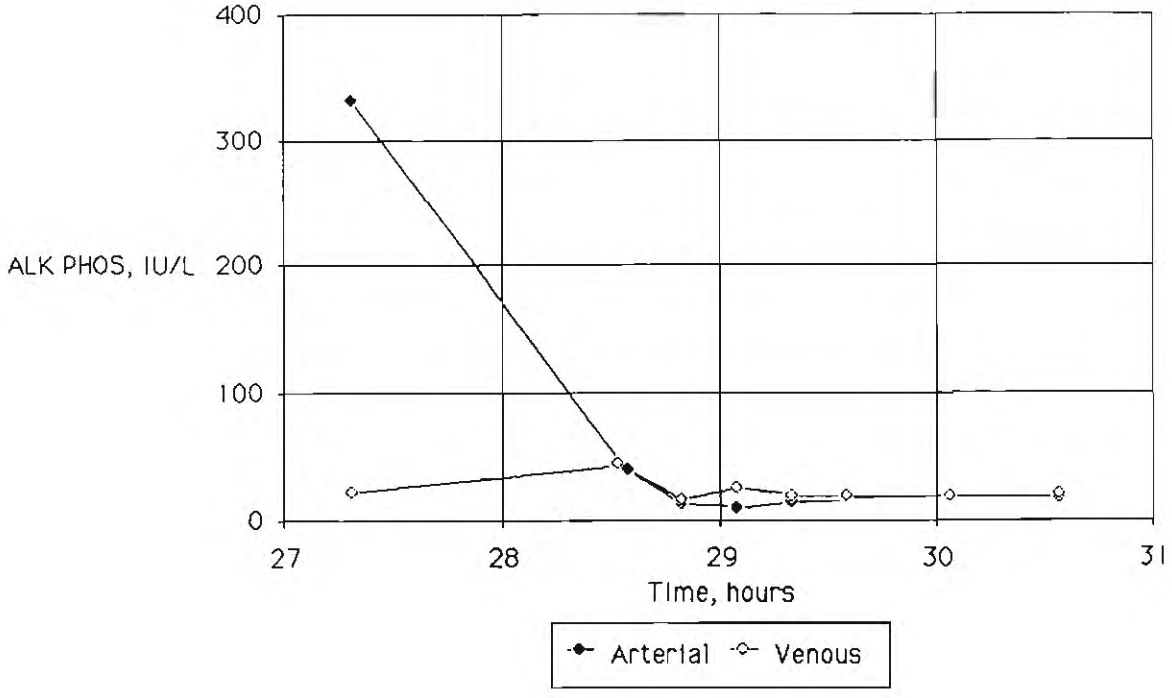
A-1108 Gamma GT



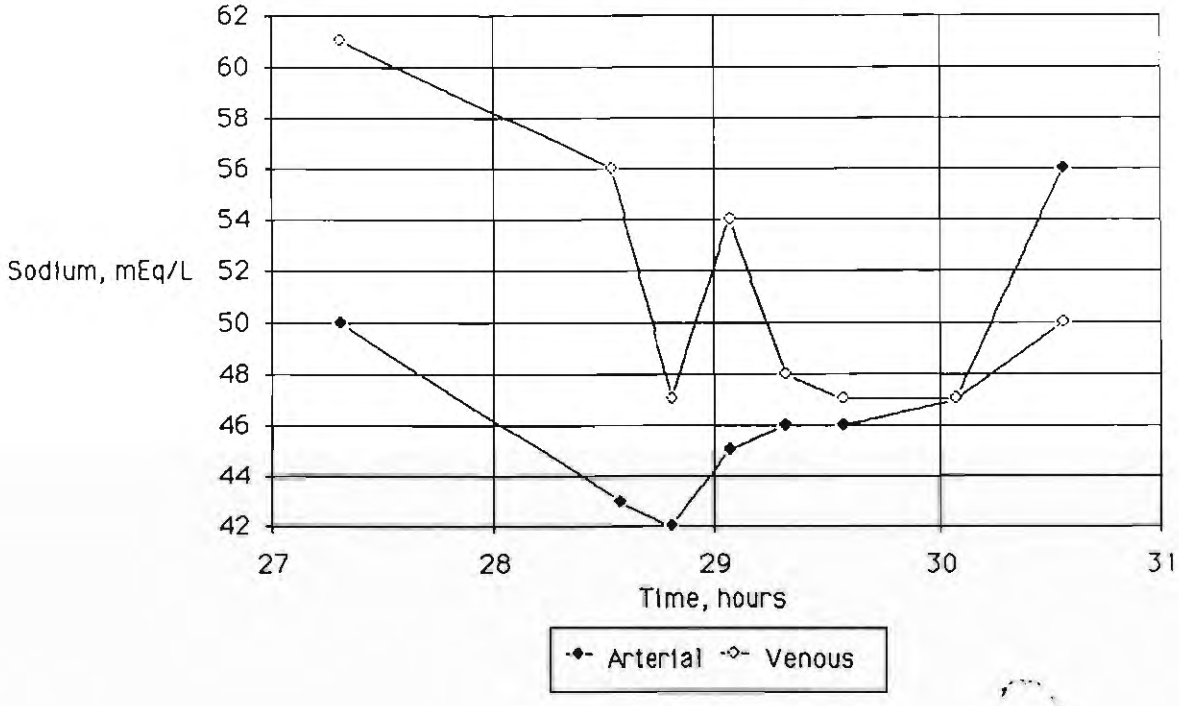
A-1108 CREATINE PHOSPHOKINASE



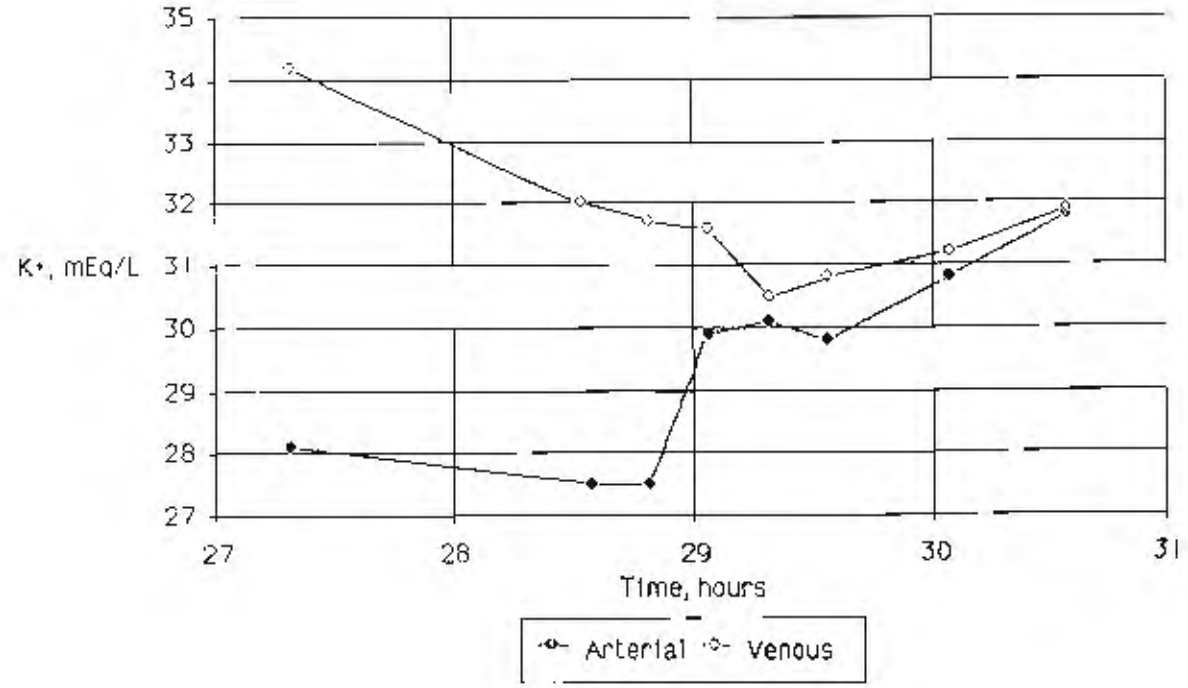
A-1108 ALK PHOSPHATASE



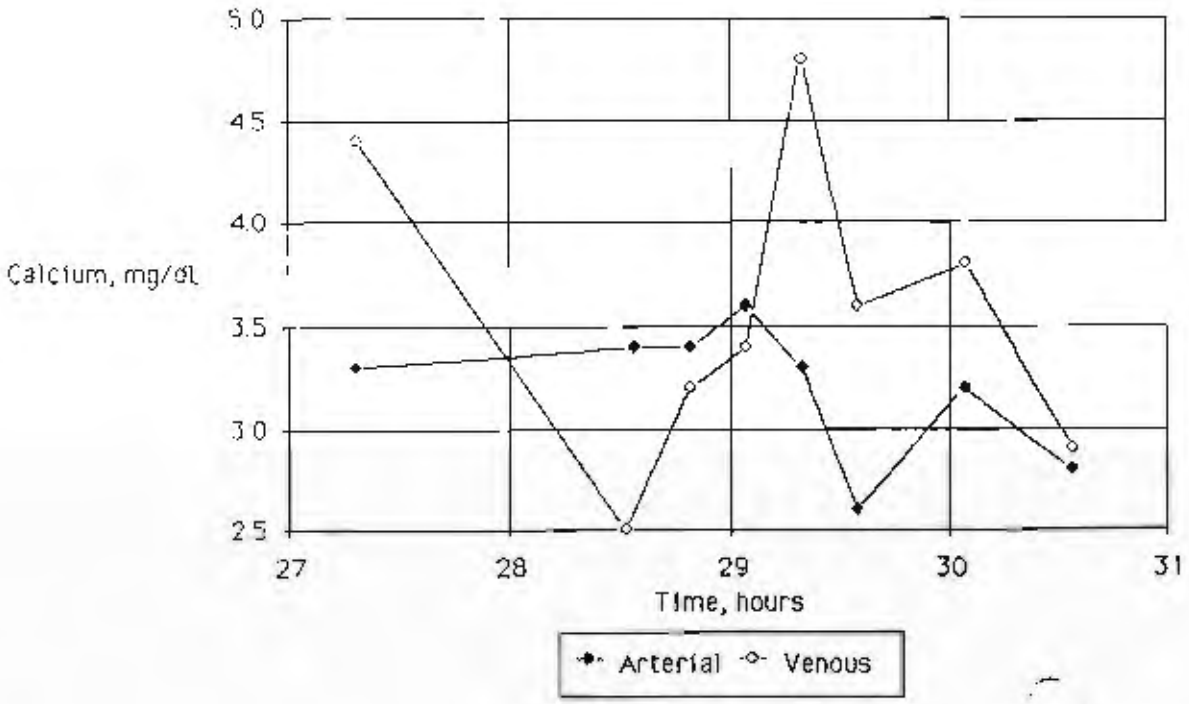
A-1108 SODIUM



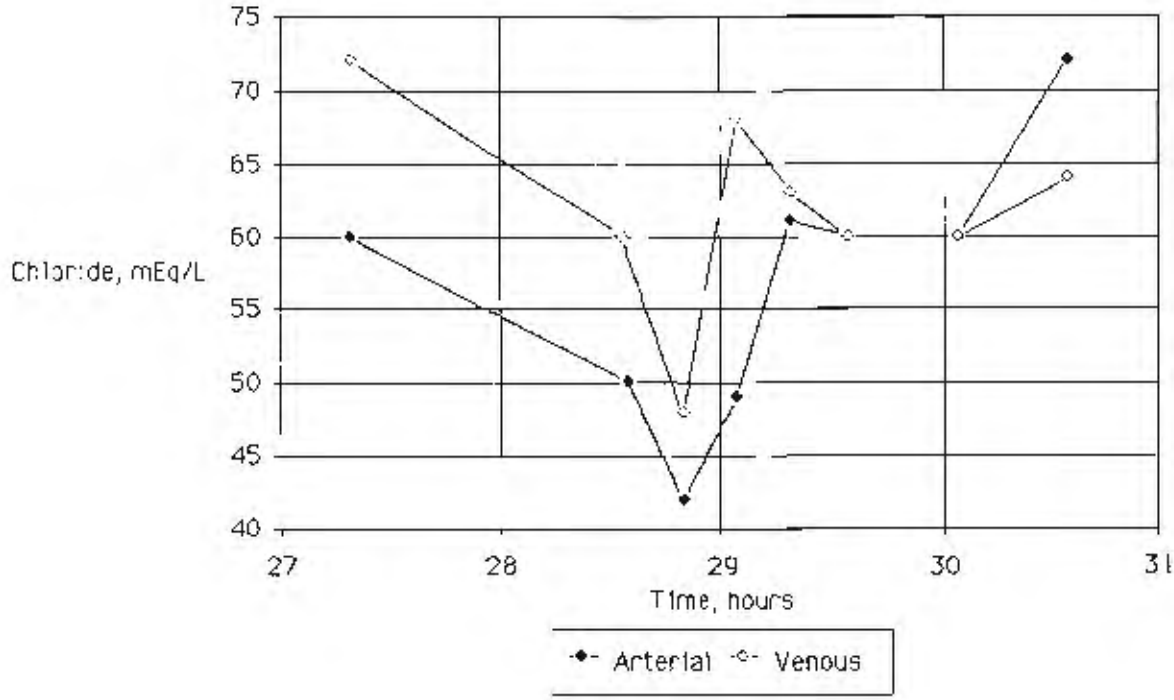
A-1108 Potassium



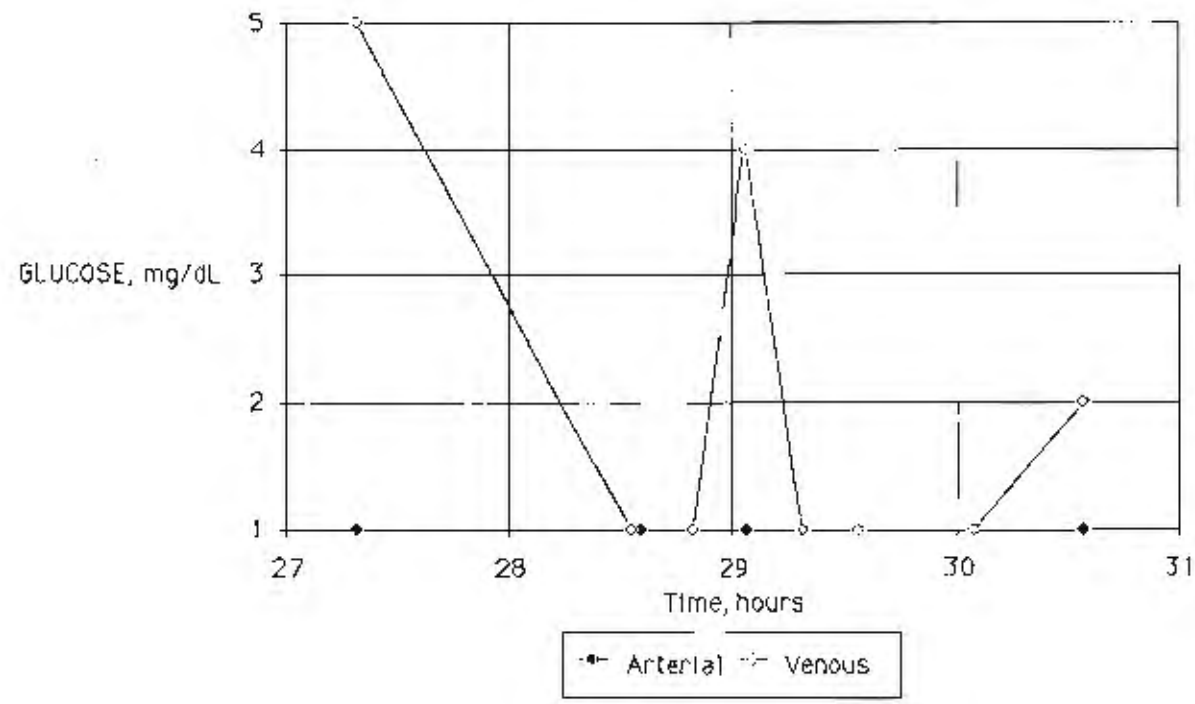
A-1108 CALCIUM



A-1108 Chloride



A-1108 GLUCOSE



Date Collected: 9 May, 1988. Time Collected: 0330. Sample Source: arterial filter, blood washout.

HCT	N/A
SGOT	22 IU/l
SGPT	10 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	2 mg/dl
Creatinine	0.1 mg/dl
Cholesterol	37 mg/dl
Alkaline Phosphatase	332 IU/l
Glucose	1 mg/dl
Phosphorus	1.0 mg/dl
Calcium	3.3 mg/dl
Total Protein	0.3 g/dl
Albumin	0.0 g/dl
Globulin	0.0 g/d
Sodium	50.0 mEq/l
Potassium	28.1 mEq/l
Chloride	60 mEq/l
CO_2	16 mEq/l
Creatine Phosphokinase	7 IU/l
Gamma GT	2 IU/l
Uric Acid	0.1 mg/dl
Lactate Dehydrogenase	5 IU/l
Amylase	<25 IU/l
Lipase	<25 IU/l

Date Collected: 9 May, 1988. Time Collected: 0445. Sample Source: arterial filter, recirculating, 5% glycerol perfusate.

HCT	N/A
SGOT	36 IU/l
SGPT	5 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	3 mg/dl
Creatinine	0.2 mg/dl
Cholesterol	2 mg/dl
Alkaline Phosphatase	40 IU/l
Glucose	1 mg/dl
Phosphorus	1.7 mg/dl
Calcium	3.4 mg/dl
Total Protein	0.6 g/dl
Albumin	0.0 g/dl
Globulin	0.6 g/d
Sodium	28.1 mEq/l
Potassium	27.5 mEq/l
Chloride	50 mEq/l
CO_2	18 mEq/l
Creatine Phosphokinase	1416 IU/l
Gamma GT	1 IU/l
Uric Acid	0.2 mg/dl
Lactate Dehydrogenase	197 IU/l
Amylase	<25 IU/l
Lipase	<25 IU/l

Date Collected: 9 May, 1988. Time Collected: 0500. Sample Source: arterial filter, cryoprotective perfusion.

HCT	N/A
SGOT	51 IU/l
SGPT	5 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	6 mg/dl
Creatinine	0.3 mg/dl
Cholesterol	1 mg/dl
Alkaline Phosphatase	13 IU/l
Glucose	1 mg/dl
Phosphorus	3.3 mg/dl
Calcium	3.4 mg/dl
Total Protein	0.7 g/dl
Albumin	0.1 g/dl
Globulin	0.6 g/d
Sodium	42.0 mEq/l
Potassium	27.5 mEq/l
Chloride	42 mEq/l
CO_2	15 mEq/l
Creatine Phosphokinase	2026 IU/l
Gamma GT	1 IU/l
Uric Acid	0.4 mg/dl
Lactate Dehydrogenase	322 IU/l
Amylase	<25 IU/l
Lipase	25 IU/l

Date Collected: 9 May, 1988. Time Collected: 0515. Sample Source: arterial filter, cryoprotective perfusion.

HCT	N/A
SGOT	75 IU/l
SGPT	5 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	10 mg/dl
Creatinine	0.3 mg/dl
Cholesterol	2 mg/dl
Alkaline Phosphatase	10 IU/l
Glucose	1 mg/dl
Phosphorus	4.7 mg/dl
Calcium	3.6 mg/dl
Total Protein	0.9 g/dl
Albumin	0.1 g/dl
Globulin	0.8 g/d
Sodium	45.0 mEq/l
Potassium	29.9 mEq/l
Chloride	49.0 mEq/l
CO_2	10 mEq/l
Creatine Phosphokinase	2714 IU/l
Gamma GT	1 IU/l
Uric Acid	0.7 mg/dl
Lactate Dehydrogenase	495 IU/l
Amylase	<25 IU/l
Lipase	<25 IU/l

Date Collected: 9 May, 1988. Time Collected: 0530. Sample Source: arterial filter, cryoprotective perfusion.

HCT	N/A
SGOT	90 IU/l
SGPT	22 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	12 mg/dl
Creatinine	0.3 mg/dl
Cholesterol	9 mg/dl
Alkaline Phosphatase	15 IU/l
Glucose	1 mg/dl
Phosphorus	5.8 mg/dl
Calcium	3.5 mg/dl
Total Protein	1.2 g/dl
Albumin	0.2 g/dl
Globulin	1.0 g/d
Sodium	46.0 mEq/l
Potassium	30.1 mEq/l
Chloride	61 mEq/l
CO_2	15 mEq/l
Creatine Phosphokinase	3107 IU/l
Gamma GT	1 IU/l
Uric Acid	0.7 mg/dl
Lactate Dehydrogenase	623 IU/l
Amylase	<25 IU/l
Lipase	27 IU/l

Date Collected: 9 May, 1988. Time Collected: 0545. Sample Source: arterial filter, cryoprotective perfusion.

HCT	N/A
SGOT	98 IU/l
SGPT	13 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	13 mg/dl
Creatinine	0.5 mg/dl
Cholesterol	8 mg/dl
Alkaline Phosphatase	17 IU/l
Glucose	1 mg/dl
Phosphorus	6.2 mg/dl
Calcium	2.6 mg/dl
Total Protein	1.3 g/dl
Albumin	0.3 g/dl
Globulin	1.0 g/d
Sodium	46.0 mEq/l
Potassium	29.8 mEq/l
Chloride	60 mEq/l
CO_2	13 mEq/l
Creatine Phosphokinase	3682 IU/l
Gamma GT	1 IU/l
Uric Acid	0.8 mg/dl
Lactate Dehydrogenase	679 IU/l
Amylase	<25 IU/l
Lipase	37 IU/l

Date Collected: 9 May, 1988. Time Collected: 0615. Sample Source: arterial filter, cryoprotective perfusion.

HCT	N/A
SGOT	107 IU/l
SGPT	21 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	14 mg/dl
Creatinine	0.6 mg/dl
Cholesterol	10 mg/dl
Alkaline Phosphatase	19 IU/l
Glucose	1 mg/dl
Phosphorus	6.7 mg/dl
Calcium	3.2 mg/dl
Total Protein	1.6 g/dl
Albumin	0.3 g/dl
Globulin	1.3 g/d
Sodium	47.0 mEq/l
Potassium	30.8 mEq/l
Chloride	60 mEq/l
CO_2	13 mEq/l
Creatine Phosphokinase	>5000 IU/l
Gamma GT	1 IU/l
Uric Acid	0.9 mg/dl
Lactate Dehydrogenase	724 IU/l
Amylase	<25 IU/l
Lipase	52 IU/l

Date Collected: 9 May, 1988. Time Collected: 0645. Sample Source: arterial filter, cryoprotective perfusion.

HCT	N/A
SGOT	106 IU/l
SGPT	29 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	15 mg/dl
Creatinine	0.6 mg/dl
Cholesterol	5 mg/dl
Alkaline Phosphatase	17 IU/l
Glucose	1 mg/dl
Phosphorus	6.7 mg/dl
Calcium	2.8 mg/dl
Total Protein	2.0 g/dl
Albumin	0.4 g/dl
Globulin	1.6 g/d
Sodium	56.0 mEq/l
Potassium	31.8 mEq/l
Chloride	72 mEq/l
CO_2	10 mEq/l
Creatine Phosphokinase	>5000 IU/l
Gamma GT	Too hemolyzed
Uric Acid	0.9 mg/dl
Lactate Dehydrogenase	720 IU/l
Amylase	<25 IU/l
Lipase	54 IU/l

Date Collected: 9 May, 1988. Time Collected: 0330. Sample Source: venous line, cryoprotective perfusion.

HCT	N/A
SGOT	342 IU/l
SGPT	60 IU/l
Total Bilirubin	Too hemolyzed
Direct Bilirubin	Too hemolyzed
Indirect Bilirubin	Too hemolyzed
BUN	24 mg/dl
Creatinine	0.8 mg/dl
Cholesterol	29 mg/dl
Alkaline Phosphatase	22 IU/l
Glucose	5 mg/dl
Phosphorus	12.0 mg/dl
Calcium	4.4 mg/dl
Total Protein	1.6 g/dl
Albumin	0.8 g/dl
Globulin	0.8 g/d
Sodium	61.0 mEq/l
Potassium	34.2 mEq/l
Chloride	72 mEq/l
CO_2	14 mEq/l
Creatine Phosphokinase	>5000 IU/l
Gamma GT	Too Hemolyzed
Uric Acid	4.4 mg/dl
Lactate Dehydrogenase	1724 IU/l
Amylase	<25 IU/l
Lipase	<25 IU/l

Date Collected: 9 May, 1988. Time Collected: 0443. Sample Source: venous line, cryoprotective perfusion. **NOTE: Some hemolysis present in sample. Results calculated from 2x dilution.**

HCT	N/A
SGOT	184 IU/l
SGPT	60 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	20 mg/dl
Creatinine	0.8 mg/dl
Cholesterol	6 mg/dl
Alkaline Phosphatase	44 IU/l
Glucose	1 mg/dl
Phosphorus	8.6 mg/dl
Calcium	2.5 mg/dl
Total Protein	0.6 g/dl
Albumin	0.2 g/dl
Globulin	0.4 g/d
Sodium	56.0 mEq/l
Potassium	33.0 mEq/l
Chloride	60 mEq/l
CO_2	22 mEq/l
Creatine Phosphokinase	4486 IU/l
Gamma GT	1 IU/l
Uric Acid	2.2 mg/dl
Lactate Dehydrogenase	984 IU/l
Amylase	<25 IU/l
Lipase	<25 IU/l

Date Collected: 9 May, 1988. Time Collected: 0500. Sample Source: venous line, cryoprotective perfusion. **NOTE: Some hemolysis present in sample.**

HCT	N/A
SGOT	118 IU/l
SGPT	21 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	16 mg/dl
Creatinine	0.3 mg/dl
Cholesterol	4 mg/dl
Alkaline Phosphatase	16 IU/l
Glucose	1 mg/dl
Phosphorus	6.6 mg/dl
Calcium	3.2 mg/dl
Total Protein	0.8 g/dl
Albumin	0.2 g/dl
Globulin	0.6 g/d
Sodium	47.0 mEq/l
Potassium	31.7 mEq/l
Chloride	48 mEq/l
CO_2	11 mEq/l
Creatine Phosphokinase	3868 IU/l
Gamma GT	1 IU/l
Uric Acid	1.2 mg/dl
Lactate Dehydrogenase	703 IU/l
Amylase	<25 IU/l
Lipase	46 IU/l

Date Collected: 9 May, 1988. Time Collected: 0515. Sample Source: venous line, cryoprotective perfusion. **NOTE: Some hemolysis present in sample.**

HCT	N/A
SGOT	117 IU/l
SGPT	36 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	17 mg/dl
Creatinine	0.5 mg/dl
Cholesterol	6 mg/dl
Alkaline Phosphatase	26 IU/l
Glucose	4 mg/dl
Phosphorus	7.4 mg/dl
Calcium	3.4 mg/dl
Total Protein	1.3 g/dl
Albumin	0.4 g/dl
Globulin	0.9 g/d
Sodium	54.0 mEq/l
Potassium	31.6 mEq/l
Chloride	68 mEq/l
CO_2	9 mEq/l
Creatine Phosphokinase	>5000 IU/l
Gamma GT	1 IU/l
Uric Acid	1.0 mg/dl
Lactate Dehydrogenase	788 IU/l
Amylase	<25 IU/l
Lipase	37 IU/l

Date Collected: 9 May, 1988. Time Collected: 0530. Sample Source: venous line, cryoprotective perfusion. **NOTE: Some hemolysis present in sample.**

HCT	N/A
SGOT	125 IU/l
SGPT	18 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	16 mg/dl
Creatinine	0.6 mg/dl
Cholesterol	17 mg/dl
Alkaline Phosphatase	20 IU/l
Glucose	1 mg/dl
Phosphorus	7.8 mg/dl
Calcium	4.8 mg/dl
Total Protein	1.2 g/dl
Albumin	0.4 g/dl
Globulin	0.8 g/d
Sodium	48.0 mEq/l
Potassium	30.5 mEq/l
Chloride	63 mEq/l
CO_2	17 mEq/l
Creatine Phosphokinase	4073 IU/l
Gamma GT	Too hemolyzed
Uric Acid	1.1 mg/dl
Lactate Dehydrogenase	854 IU/l
Amylase	<25 IU/l
Lipase	47 IU/l

Date Collected: 9 May, 1988. Time Collected: 0545. Sample Source: venous line, cryoprotective perfusion.

HCT	N/A
SGOT	119 IU/l
SGPT	31 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	16 mg/dl
Creatinine	0.7 mg/dl
Cholesterol	11 mg/dl
Alkaline Phosphatase	19 IU/l
Glucose	1 mg/dl
Phosphorus	7.1 mg/dl
Calcium	3.6 mg/dl
Total Protein	1.2 g/dl
Albumin	0.3 g/dl
Globulin	0.9 g/d
Sodium	47.0 mEq/l
Potassium	30.8 mEq/l
Chloride	60 mEq/l
CO_2	16 mEq/l
Creatine Phosphokinase	>5000 IU/l
Gamma GT	1 IU/l
Uric Acid	1.1 mg/dl
Lactate Dehydrogenase	795 IU/l
Amylase	<25 IU/l
Lipase	50 IU/l

Date Collected: 9 May, 1988. Time Collected: 0615. Sample Source: venous line, cryoprotective perfusion. **NOTE: Some hemolysis present in sample.**

HCT	N/A
SGOT	121 IU/l
SGPT	25 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
	16 mg/dl
	0.6 mg/dl
	12 mg/dl
iosphatase	20 IU/l
	1 mg/dl
	7.6 mg/dl
	3.8 mg/dl
	1.4 g/dl
	0.3 g/dl
	1.1 g/d
	47.0 mEq/l
	31.2 mEq/l
	60 mEq/l
C	12 mEq/l
C	>5000 IU/l
Gan	1 IU/l
Uri	1.1 mg/dl
La	835 IU/l
	<25 IU/l
	59 IU/l

Date Col[illegible]: 9 May, 1988. Time Collected: 0645. Sample So[illegible]ne, cryoprotective perfusion. **NOTE: Some hemolysis present in sample.**

HCT	N/A
SGOT	127 IU/l
SGPT	42 IU/l
Total Bilirubin	0.1 mg/dl
Direct Bilirubin	0.0 mg/dl
Indirect Bilirubin	0.1 mg/dl
BUN	17 mg/dl
Creatinine	0.7 mg/dl
Cholesterol	14 mg/dl
Alkaline Phosphatase	21 IU/l
Glucose	2 mg/dl
Phosphorus	8.0 mg/dl
Calcium	2.9 mg/dl
Total Protein	1.7 g/dl
Albumin	0.3 g/dl
Globulin	1.4 g/d
Sodium	50.0 mEq/l
Potassium	31.9 mEq/l
Chloride	64 mEq/l
CO_2	9 mEq/l
Creatine Phosphokinase	>5000 IU/l
Gamma GT	Too hemolyzed
Uric Acid	1.2 mg/dl
Lactate Dehydrogenase	830 IU/l
Amylase	<25 IU/l
Lipase	74 IU/l