



Clinical Protocol

CP.XX.xxx

The objective of this document is to be a resource, not a replacement for institutional specific protocols. It is intended as a template for your perfusion team to edit and adapt into a resource that fits your institutional specific needs. These Clinical Protocols may also be superseded by the judgment of the healthcare professional considering the facts and circumstances of the individual case.

SUBJECT/TITLE: **DEEP HYPOTHERMIC CIRCULATORY ARREST (DHCA)**

PURPOSE: To provide a guideline and resource to describe a perfusion technique for DHCA.

TARGET POPULATION: Adult patients that require DHCA during cardiothoracic surgery.

DEFINITIONS: (DHCA) will be utilized during procedures where flow to the upper extremities, including the arch vessels, needs to be temporarily reduced, or stopped. In the adult population, this is usually required during repairs of the ascending and transverse aorta, especially if the head vessels are involved in the repair. It can also be used for certain congenital heart defects, for tumor removal that involves the great veins and/or atria, for pulmonary endarterectomies, certain neurological procedures and for treating massive air embolism. However, this information is provided for the **adult** patient population.

During the period of DHCA there are alternate means for providing cerebral blood flow while lower-body perfusion is reduced or ceased altogether. This document describes the use of DHCA and the perfusion techniques during this time.

POLICY: Perfusionists shall work closely with surgeons, anesthesiologists prior to initiating DHCA and maintain close communication of patient's hemodynamics.

PERFUSION PUMP CONSIDERATIONS:

Cannulation techniques are described below:

Cannula utilized, and cannulation technique will need to be determined prior to initiation of Cardiopulmonary Bypass (CPB) and should be discussed in the team huddle. As with all forms of cannulation, pay specific attention to the risk of dissection.

1. The most frequent type of cannulation involves the femoral artery and femoral vein or right atrium. The venous line may be modified to incorporate a second venous cannula with the use of a “wye” connector and additional sterile tubing.
2. Axillary artery cannulation may also be used and is described below. If this is used, consider using both a right radial and left radial (or left femoral) line for arterial pressure monitoring.
3. Before and after circulatory arrest, perfusion should monitor **left** radial/femoral pressures.
4. If retrograde cerebral perfusion (RCP) is to be used, a cannula is placed directly into the superior vena cava and right radial pressure will be monitored during the circulatory arrest, as that represents the flow to the head. (See RCP document).

Considerations for DHCA are described as follows:

1. Standard cardiopulmonary bypass (CPB) circuit set-up and assembly. However, the additional vent or suction lines may be required for site drainage. One-way valves shall be utilized for all vents.
2. If retrograde cerebral perfusion (RCP) is being utilized please see RCP clinical protocol.
3. Consider use of near-infrared spectroscopy (NIRS) establishing baselines according to manufacturer's instructions-for-use.
4. Ice may be placed on the patient's head to further cool the cerebral tissue. Attention should be directed to placement of ice bags to not compress the carotid arteries.
5. Turn off the warming blanket during cooling and turn back on during rewarming.
6. If using vacuum assisted venous return turn off prior to starting circulatory arrest.
7. The LV vent may need to be off during circulatory arrest. Discuss with the surgeon.

Cooling and warming techniques for DHCA are described as follows:

Cooling of the patient must occur at the rate determined by the STS/SCA/AmSECT Clinical Practice Guidelines. Rapid or excessive cooling should be avoided due to the risk of reactive vasoconstriction of the arterial blood vessels compromising flow and distal perfusion.

Hypothermia during cardiac surgery has long been used as an adjunctive means of reducing the deleterious effects of reduced perfusion and inadequate nutrient delivery. It lowers metabolic demand reducing both oxygen consumption and enzymatic activity, both of which reduce substrate demand.

The four stages of hypothermia regarding clinical and physiologic characteristics are as follows:

Hypothermic Level	Temperature Range
Mild	28.1-34.0°C
Moderate	20.1-28.0°C
Deep	14.1-20.0°C
Profound	<14.0°C

While any period of circulatory arrest cannot be deemed safe, and there is not a consensus of circulatory arrest times among various temperatures with and without antegrade cerebral perfusion (ACP) or RCP. The chart below is often used for calculated durations of DHCA incorporating Cerebral Metabolic Rate (CMRO₂).⁴

Hypothermic Level	CMRO ₂ Rate (% baseline)	Calculated Max duration of Circulatory Arrest (min)
37°C	100	5
30°C	56 (52-60)	9 (8-10)
25°C	37 (33-42)	14 (12-15)
20°C	24 (21-29)	21 (17-24)
15°C	16 (13-20)	31 (25-38)
10°C	11 (8-14)	45 (36-62)

1. Take caution to monitor arterial temperature to patient, venous temperature from the patient, and heater cooler set temperature. Never exceed a 10°C temperature gradient during cooling or rewarming.
2. Initiate CPB and when instructed begin cooling to a target temperature. The most common core temperature for DHCA is between 18-20°C.
3. Some advocate using a pH-stat regimen during cooling then switching to an alpha-stat during arrest and during rewarming.
4. Never allow CPB arterial blood temperature to reach 37° C.

Anticoagulation and hematocrit/hemoglobin maintenance guidelines are described as follows:

1. Heparin is administered in the usual fashion prior to CPB and activated clotting times (ACT) are maintained at therapeutic levels according to institutional protocol. With additional Heparin given PRN to maintain therapeutic anticoagulation levels.
2. The hematocrit should be maintained according to protocol generally above 24% and no higher than 30%.

Pharmacology considerations for DHCA are described as follows:

Consult with the surgeon and/or anesthesiologist about the administration and timing of medications during the preoperative huddle.

General medications that may be considered for use, but not limited to include:

- Methylprednisolone (7-10 mg/kg).
- Mannitol (12.5 to 25 G) in pump prime.
- Magnesium sulfate (1 G).
- Lidocaine (2.5 mg/kg).
- NaHCO₃ (50 mEq) upon resumption of CPB or as indicated by blood gas results.
- Thiopental (10-20 mg/kg).

PROCEDURE:

Conduct of Initiation of DHCA

1. When the desired temperature is reached, the surgeon will request the pump flow to be reduced and terminated to begin the DHCA.
 - a. If VAVD is being used, be sure to disable prior to continuing with the following steps.
 - b. If your institution policy is to add pre-DHCA medications to the pump, you would add them prior to termination of flow.
2. Clamp the arterial line.
3. Leave the venous line open to drain the volume from the patient. Once the patient is fully drained, and no more volume is returning, clamp the venous line.
4. Turn off any pharmacological and anesthetic agents that are running.
5. Unclamp the recirculation line and begin to circulate slowly through the oxygenator.
6. Clamp the arterial line distal to the filter and open the purge line to reduce any stagnation of blood.
7. Set the “sweep” gas flow rate to match pump recirculation flows, aim to maintain blood at normocapnic levels.
8. Charting is continued at 10 to 15-minute intervals or at prescribed intervals per hospital policy while keeping record of all events.

9. Notify the surgeon at determined times, which are generally at 10-minute intervals.

Reinitiating Full CPB and Rewarming

1. If the aortic cannula was removed during DHCA it may be returned to the original location. An alternative may be to reposition the cannula (or insert a new model) from the femoral artery and place it in the ascending aorta or through a sidearm of a woven graft, if utilized. This will allow the restoration of blood flow through the head vessels while the distal aorta is still clamped.
2. When flow is re-instituted, it will probably be without venous drainage. Once the venous line is open and full flow can be achieved, rewarming begins.
3. Clamp the recirculation line and turn off any purge lines.
4. Upon the surgeon's request, slowly release the arterial clamp and transfuse perfusate to the patient.
5. After approximately 500 ml has been infused open the venous line and increase flow.
6. Once full flow is reached or at surgeon's request, begin rewarming the patient as described above in safe warming techniques.
7. Increase the patient's hematocrit/hemoglobin as the temperature allows with the use of hemoconcentration and/or diuretics.
8. Turn on anesthetic gasses once back on full CPB.
9. Obtain both an arterial and venous blood gas after re-initiation and correct acid-base imbalances per institutional policy through the use of pharmacological agents and metabolic management.

CLINICAL ASSESSMENT/SCREENING:

A. Contraindications: None.

RELATED DOCUMENTS:

A. Retrograde Cerebral Perfusion Clinical Protocol.

REFERENCES:

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3. Yan TD, Bannon PG, Bavaria J, et al. Consensus on hypothermia in aortic arch surgery. *Ann Cardiothorac Surg*. 2013; 2:163–8.
4. McCullough JN, Zhang N, Reich DL, et al. Cerebral metabolic suppression during hypothermic circulatory arrest in humans. *Ann Thorac Surg*. 1999; 67:1895–9.
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6. O'Neill B, Bilal H, Mahmood S, Waterworth P. Is it worth packing the head with ice in patients undergoing deep hypothermic circulatory arrest? *Int Cardiovasc Thorac Surg*. 2012; 15:696-701.
7. Engelman R, Baker RA, Likosky DS, et al. The Society of Thoracic Surgeons, The Society of Cardiovascular Anesthesiologists, and The American Society of ExtraCorporeal Technology: Clinical practice guidelines for cardiopulmonary bypass—temperature management during cardiopulmonary bypass, *J ExtraCorp Tech*. 2015;47:145-54.

8. Hori D, Everett AD, Lee JK, et al. Rewarming rate during cardiopulmonary bypass is associated with release of glial fibrillary acidic protein. *Ann Thorac Surg.* 2015; 100:1353–9.
9. Grigore AM, Grocott HP, Mathew JP, et al, Neurologic Outcome Research Group of the Duke Heart Center. The rewarming rate and increased peak temperature alter neurocognitive outcome after cardiac surgery. *Anesth Analg.* 2002; 94:4-10.

IMPORTANT INFORMATION ABOUT THESE PROTOCOLS:

If this protocol/process is adopted as is, the AmSECT logo must be removed and replaced with an institution specific logo.

This protocol/process encourages high quality patient care but observing it cannot guarantee any specific patient outcome.

This protocol/process should be reviewed or revised as warranted by institutional specific protocol, taking into account the evolution of technology and practice.

Review period: Review as changes occur or per institutional protocol.

Original hard copies and/or computer copies of this protocol are stored under the supervision of the Chief Perfusionist, Department of Cardiovascular Perfusion.

APPROVED BY: *(signature of CMO and CNE only required)*

- Source:** *(originating department/committee)*
- Effective Date:** *(can use 'created date' for this)*
- Version Number:** *(should match # of revisions, use 1.0 if new document)*
- Date Revised:** *MM/YYYY; all dates any content changes were made*
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Date:

<Insert Name, Chief Nursing Executive>