



**Pediatric Clinical Protocol**  
**CP.XX.xxx**

\*The intent of this product is to be a resource; not a replacement for institutional protocols. Standard 1 of AmSECT's Standards and Guidelines for Pediatric and Congenital Perfusion Practice (2019).<sup>1</sup> These Standards and Guidelines may also be superseded by the judgment of the healthcare professional taking into account the facts and circumstances of the individual case.

**SUBJECT/TITLE: Modified Ultrafiltration: Arterial-Venous**

**PURPOSE:**

1. Modified ultrafiltration (MUF) is a technique used post cardiopulmonary bypass (CPB) to remove the fluid overload and inflammatory mediators, improve cardiac function, and reduce pulmonary vascular resistance after CPB (1).
2. MUF has been shown to reduce morbidity and red blood cell transfusion after cardiac operations in the pediatric patient population (2).
3. MUF is initiated following CPB and provides improvements in hemodynamic, pulmonary, coagulation and other end-organ functions. MUF can decrease blood transfusion requirements, as well as reduce total body water and blood loss after cardiothoracic surgery in pediatric and adult congenital populations. (2, 3, 4, 5,6).

**TARGET POPULATION:** MUF can be used after CPB in the neonatal, pediatric, and adult congenital populations.

**DEFINITIONS:**

**CPB:** Cardiopulmonary Bypass

**MUF:** Modified Ultrafiltration

**A-V MUF:** Arterial-Venous modified ultrafiltration

**NIRS:** Near-Infrared Spectroscopy

**POLICY:**

1. The AmSECT Standards and Guidelines for Pediatric and Congenital Perfusion Practice document defines MUF in Guideline 16.1:
  - a. Guideline 16.1: The use of modified ultrafiltration (MUF) should be utilized (unless contraindicated) to optimize hemodynamics and hematocrit.
2. All team members shall be responsible for the policies and procedures regarding MUF.
3. All team members shall be aware of the risks and benefits regarding MUF, along with all other procedures of CPB.

## **PERFUSION PUMP CONSIDERATIONS:**

### **MUF Circuit Components:**

1. Patient size appropriate hemoconcentrator (HC)
2. Heat exchanger: cardioplegia or stand-alone IV fluid warmer\*
  - a. MUF Circuit should contain a heat exchanger.
  - b. Heat exchanger is added into MUF circuit post MUF pump.
  - c. Wye to cardioplegia circuit or stand-alone IV fluid warmer.
3. Vacuum source available (may apply to HC to accelerate the filtration rate)
4. A luer connection on the venous cannula/line OR stand-alone MUF return cannula

## **PROCEDURE:**

### **Arterial-Venous MUF:**

1. Blood is drawn retrograde through the arterial line via the MUF pump
2. Blood is then pumped through the HC
3. Next, blood is pumped into the heat exchanger (see above)
4. The concentrated blood is then returned to the patient through a luer connector on the venous cannula OR directly into the right atrium.

## **PRE-MUF CHECKLIST:**

1. 'Unslave' the MUF rollerhead from the arterial rollerhead, so they can be operated independently of each other during the MUF period.
2. Ensure cardioplegia heat exchanger is warm and water is circulating.
3. Ensure cardioplegia solution has been flushed from the entire cardioplegia/MUF circuit, including the delivery line.
4. Ensure the HC effluent line is clamped and vacuum source is on and connected to the effluent line.
5. Ensure the arterial line is unclamped to prevent air entrainment.
6. Verify MUF circuit is appropriately configured and free of air.
7. Verify final bypass HC effluent has been documented in the fluid balance section of the patient's CPB record.

## **INITIATION OF MUF:**

1. After CPB has been terminated, the venous line and/or venous cannula must be drained into the venous reservoir.
2. When requested by the physician at the surgical field, slowly run (trickle) the MUF pump to make an air-free connection to the venous cannula luer connector.
3. Slowly initiate MUF ensuring the arterial line pressure remains positive.
  - a. This will draw (i.e. 'steal') systemic cardiac output generated by the left (systemic) ventricle retrograde down the arterial line.
4. Slowly begin adding volume from the venous reservoir via the arterial rollerhead to maintain hemodynamic stability:
  - a. Patient hemodynamics are more labile at the start of MUF, and may require volume administration (from the venous reservoir) via the arterial rollerhead to maintain acceptable central venous pressure (CVP) and hemodynamics.
  - b. The arterial flow rate should not exceed MUF flow rate due to potentially decreased efficiency.
    - i. Hemodynamic instability may require stopping MUF or, in some situations, may require infusing volume up the arterial line by exceeding the MUF flow rate.
5. Gradually increase the MUF rollerhead flows between 10-20 ml/kg/min while maintaining a positive arterial line pressure.
  - a. Avoid negative arterial line pressures to prevent air from being pulled across membrane fibers, de-priming the oxygenator and generating an embolic risk to the patient. Ideally, the MUF and arterial pumps are servoregulated to stop at negative arterial line pressures.
  - b. As MUF continues and effluent is removed, hemodynamics will improve and volume administration can usually be decreased.
6. Ensure adequate anticoagulation for the duration of MUF.

## **MUF MANAGEMENT:**

1. Ensure appropriate patient hemodynamics and near-infrared spectroscopy (NIRS) values throughout the MUF period. Excessive MUF circuit flow may result in a decrease in NIRS, and/or myocardial function. MUF may temporarily alter saturation and blood oxygen levels because oxygenated blood is being delivered to the venous system.
2. To fill the patient (increase CVP) during MUF:
  - a. Increase the arterial rollerhead speed to slightly less than the MUF rollerhead speed and/or clamp the HC effluent line until desired hemodynamics or volume transfer INTO the patient is achieved; then return rollerhead flow(s)

to the previous rate(s).

3. Once all reservoir blood has been transfused into the patient, continue flushing the CPB circuit volume through the oxygenator by adding crystalloid to the venous reservoir.
4. Aim to remove at least your original circuit prime volume during MUF, or until the volume infusion from the venous reservoir (via the arterial rollerhead) begins to dilute the blood volume in the MUF circuit.
5. The duration of MUF is dependent on the institution/surgeon preferences, circuit volume status, and hemodynamics of the patient.

#### **TERMINATION OF MUF:**

1. Clamp the HC effluent line
2. Simultaneously turn off the arterial rollerhead and the MUF rollerhead.
3. Isolate the circuit from the patient by clamping the MUF delivery line and clamping the arterial line.
4. Notify the surgeon that MUF is complete
6. Record total MUF time, total MUF effluent volume removed, and patient parameters post MUF.

#### **CONTRAINDICATIONS:**

1. Air in the circuit/ the MUF circuit has been compromised:
  - a. Air in the circuit is usually caused by a cannula obstruction. Once air has been introduced in the circuit, it must be de-aired before safely resuming MUF or CPB.
2. Aortic root venting:
  - a. If the aortic root vent cannot be discontinued due to the presence of air as detected by the post CPB Transesophageal Echocardiography, be aware if the root vent is continued after all blood volume from the venous reservoir is infused and crystalloid solution is added to flush the volume through the MUF circuit, the effectiveness of MUF will be compromised.
3. Excessive bleeding:
  - a. Excessive pump sucker return post CPB will continuously introduce new blood into the venous reservoir, reducing the ability to flush the circuit and limiting the effectiveness of MUF.
4. Complicated anatomy:
  - a. Single ventricle anatomy, in particular Fontan patients, require high central venous pressures. Excessive MUF may reduce the CVP and compromise the

hemodynamics of the patient. In addition, any potential air in the circuit may be at risk of systemic embolization.

## **SAFETY CONSIDERATIONS**

- 1. Bubble traps:** Possible bubble traps include:
  - a. Arterial Line Filters
  - b. Oxygenator
  - c. Cardioplegia Filter
- 2. Arterial Line Bubble Detector (Peds S&G Standard 6.2):**
  - a. A bubble detector on the arterial line will detect any air coming retrograde from the arterial cannula or antegrade, should the MUF pump flow higher than the arterial pump flow.
- 3. Cardioplegia Line Bubble Detector (Peds S&G Guideline 6.3):**
  - a. A bubble detector on the cardioplegia delivery line will detect any air entrainment in the cardioplegia system or air pulled across the oxygenator.
- 4. Arterial Pressure Monitoring Lines/ High Pressure Servoregulation (Peds S&G Standard 6.1):**
  - a. Monitoring of arterial line pressure is standard of care in cardiovascular perfusion practice. High limits are set according to institution protocols and CCP needs.
- 5. Arterial Pressure Monitoring Line/ Low or Negative Pressure Servoregulation:**
  - a. Arterial line pressure servoregulation with alarm limits set at -5 to -10 mmHg and shut-off at -10 to -20 mmHg help minimize the risk of entrained air from an occluded arterial line or a misconfigured MUF circuit.
- 6. Cardioplegia Pressure Monitoring Line (Peds S&G Standard 6.1):**
  - a. Monitoring of cardioplegia line pressure is standard of care in cardiovascular perfusion practice.

## **REFERENCES:**

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5. Naik S, Knight A, Elliott M. A successful modification of ultrafiltration for cardiopulmonary bypass in children. *Perfusion*. 1991;6(1):41-50.
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\*The HOTLINE® 3 Blood and Fluid warmer. Smiths Medical, Minnesota, United States

#### **DISCLAIMER:**

1. In emergency situations, immediate life support measures of whatever appropriate nature come first with attention turning to measures described in this protocol/process as soon as possible and practical.
2. This is a minimal protocol/process that may be exceeded at any time based on the judgment of the involved patient care personnel.
3. This protocol/process encourages high quality patient care but observing it cannot guarantee any specific patient outcome.
4. This protocol/process is subject to revision from time to time, as warranted by the evolution of technology and practice.
5. Review period: Review as changes occur or per institutional protocol. Original hard copies and computer copies of this protocol are stored under the supervision of the Chief Perfusionist, Department of Cardiovascular Perfusion. Documents relating to patient care standards are developed according to the accepted hospital standards.

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

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*(originating department/committee)*

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*(can use 'created date' for this)*

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*(should match # of revisions, use 1.0 if new document)*

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*MM/YYYY; all dates any content changes were made*

**Date Reviewed:**

**Signatures:**

Date:

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<Insert Name, Title>

Date:

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Date:

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<Insert Name, Chief Nursing Executive>

**Departmental Clinical  
Protocol Manual**



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