**AMERICAN SOCIETY OF
EXTRACORPOREAL TECHNOLOGY**
Lead - Collaborate - Educate - Care

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 These Clinical Protocols may also be superseded by the judgment of the healthcare professional considering the facts and circumstances of the individual case.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:	**MASSIVE AIR EMBOLISM**
PURPOSE:	To explain how to react to a massive air event to minimize or eliminate detrimental effects to the patient.
TARGET POPULATION:	A massive air event can happen to any patient population.
DEFINITIONS:	Massive or gross air is a large slug of air that is visible within the circuit that is an emergent event threatening stroke or death to the patient. Massive air can have numerous origins, such as pulled air from the aortic cannula, cracked circuit entraining air, or a drained reservoir pumping air.
POLICY:	During a massive air situation, if the air is still within the circuit the perfusionist will try to remove the air as quickly as possible. If the air has reached the patient, the surgeon will determine the best course of action.
	Ideally, for this emergent event to be resolved smoothly with the least patient impact, this protocol or possible solutions should be determined in detail at an earlier date by all parties involved for the best in vivo recovery. An air embolism drill or simulation should be performed or discussed annually to keep all members aware of their roles.

PERFUSION PUMP CONSIDERATIONS: None.

PROCEDURE:

1. If massive air is identified in the cardiopulmonary bypass circuit, the surgical team should be made aware, and immediate steps taken to remedy the situation.
2. Stop the pump and clamp all lines and shunts, announce off bypass loudly to the team. **VENTILATE the PATIENT**.
3. Identify the source of air and eliminate it by:
    a. Inspecting cardioplegia lines.
    b. Verifying oxygenator exhaust port is not occluded.
    c. Ensure the arterial filter port is not occluded.
    d. Ensure there is not a cracked/loose connector or port.

4. Inspect circuit of any remaining air:
   a. Possible methods to remove air:
      i. "Walk-out" or suction air to luer port or area for removal.
      ii. Disconnect arterial tubing from the arterial cannula so the air is forced out through forward flow.
      iii. Flow forward through a luer port on the arterial cannula with the distal end of the cannula (in the aorta) clamped.
   b. Reprime or recirculate briefly, if possible, to ensure all air is removed.
      i. Drop additional fluid if needed, to assist in repriming.
   c. With bubble detector on, remove clamps and reinitiate bypass.
   d. Stop flow and recheck lines if bubble detector alarms again.
5. If the air embolism has reached the patient:
   a. Place the patient in Trendelenburg position.
   b. Assign someone to compress carotid arteries.
   c. Prepare for hypothermic retrograde cerebral perfusion (RCA), if approved by the Surgeon.
   d. Have the Surgeon reposition venous cannula up the superior vena cava (SVC).
      i. If bicaval cannulation is used, then clamp inferior vena cava line (IVC).
      ii. Ensure all air out of venous cannula and lines by draining back or flushing forward into a basin.
   e. Configure circuit to pump up venous cannula for retrograde perfusion, this can be achieved through several methods depending on your institution:
      i. Clamp arterial and flow up arterial-venous bridge. (If previously built into circuit)
      ii. Move a recirculation shunt line to the venous line.
         1. A luer port connector may need to be placed in the venous line near the reservoir to accommodate this shunt line - with the proximal venous line clamped.

6. If there is not a pre-existing arterial-venous bridge:
   a. The Surgeon can cut into the arterial tubing line and connect it directly to venous cannula.
      i. Ensure the arterial line is free of any air if this is where the issue occurred.
   b. Cool blood and patient down to temperature requested by surgeon.
   c. Reinitiate bypass with retrograde cerebral perfusion at 1-2 L/min.
   d. Aortic root vent should be on to remove air.
      i. The surgeon can open the aorta or remove the arterial cannula.
      ii. Blood exiting the aorta should be returned to the circuit using a pump sucker.
   e. Increase FiO2 to 100%,to increase alveolar gradient for elimination of Nitrogen.
   f. Maintain a normal pCO2 to prevent cerebral edema.
   g. Person assigned to compressing carotid arteries, can now massage carotids to help purge air.
   h. Continue retrograde flow 1-2 minutes or until the Surgeon visualizes air from the aorta or decides to stop.
   i. Return circuit and cannulas to original orientation.
   j. Reinitiate standard cardiopulmonary bypass.
      i. Maintain higher flows and pressure (increased hydrostatic pressure

helps shrink bubble size and higher flow pushes bubbles out of vasculature).

     ii.   The Surgeon may want to maintain systemic hypothermia for 45 minutes (lower temperature increases gas solubility which will help to reabsorb bubbles).

    iii.   Rewarm slowly (temperature gradients between blood and tissue greater than 8°C may bring air back out of solution).

    1. The Surgeonmay request to leave the patient cold 32-35°C as a precaution.

     i.   Consider 25g Mannitol to decrease tissue edema, discuss other pharmacologic therapy with surgeon and anesthesiologist (such as Thiopental or methylprednisolone).

    k. Hyperbaric chamber therapy may also be used if prescribed by The Surgeon.

7. Consider reporting this event to your institution's incident reporting structure.

CLINICAL ASSESSMENT/SCREENING:

A. Contraindications: Some cannulation sites or patient anatomy may cause more difficulty in applying emergent retrograde cerebral perfusion, however immediate measures to reverse the massive air embolism must be taken.

RELATED DOCUMENTS:

A. Retrograde Cerebral Perfusion Clinical Protocol

REFERENCES:
1. Mongero L, Beck J. On Bypass: Advanced Perfusion Techniques. Totowa, NJ: Humana Press, 2008.
2. Gravlee GP, Davis RF, Stammers AH, Ungerleider RM. Cardiopulmonary Bypass Principles and Practice. 3 rd ed. Philadelphia, PA: Wolters Kluwer, 2008: 412.
3. Ghosh S, Falter F, Perrino AC. Cardiopulmonary Bypass. 2nd ed. Cambridge, UK: Cambridge Press, 2015.
4. Bojar RM, Manual of Perioperative Care in Adult Cardiac Surgery. 5th ed. West Sussex, UK: Wiley-Blackwell, 2011.
5. Van der Zee MP, Koene BM, Mariani MA. Fatal air embolism during cardiopulmonary bypass: analysis of an incident and prevention measures. Interactive Cardiovascular and Thoracic Surgery. 2014; 19:875-877.
6. Brenner WI. A Battle plan in the event of massive air embolism during open heart surgery. JECT. 1985; 17(4):133-137.
7. Guy TS, Kelly MP, Cason B, Tseng E. Retrograde cerebral perfusion and delayed hyperbaric oxygen for massive air embolism during cardiac surgery. Interactive Cardiovascular and Thoracic Surgery. 2009; 8:382-383.
8. Quintero OL, Giraldo JC, Sandoval NF. Successful management of massive air embolism during cardiopulmonary bypass using multimodal neuroprotection strategies. Seminars in Cardiothoracic and Vascular Anesthesia. 2019; 23(3)324-332.

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*

   Date Reviewed:

   Signatures:

                                     Date:
_____|_____
<Insert Name, Title>

                                     Date:
_____|_____
<Insert Name, Title>

                                     Date:
_____|_____
<Insert Name, Chief Medical Officer *>*

                                     Date:
_____|_____
<Insert Name, Chief Nursing Executive>