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I. The Perfusion Unit of the Philippine Heart Center adopts the following Essentials and Guidelines for Perfusion Practice of the American Society of Extracorporeal Circulation as basic guidelines in the conduct of Perfusionist in their performance of their duties and functions.

Essential 1. An accurate perfusion record must be maintained according to an established protocol.

Essential 2. The perfusionist shall employ a checklist(s) according to an established protocol.

Essential 3. Extracorporeal circulation shall be conducted by a knowledgeable and competent perfusionist.

Essential 4. The perfusionist shall monitor the anticoagulation status of the patient according to an established protocol.

Essential 5. Appropriate gas exchange shall be maintained during extracorporeal circulation according to an established protocol.

Essential 6. The perfusionist shall maintain an appropriate blood flow rate during extracorporeal circulation according to an established protocol.

Essential 7. The perfusionist shall maintain an appropriate blood pressure during extracorporeal circulation according to an established protocol.

Essential 8. During extracorporeal circulation, the perfusionist must maintain a safe operational volume in the extracorporeal circuit according to an established protocol.
Essential 9. Appropriate monitoring devices shall be employed.

Essential 10. The perfusionist shall make a reasonable effort at cost containment.

Essential 11. The perfusionist must assure that properly maintained equipment is used in the conduct of extracorporeal circulation.

II. Perfusion Record

The following data shall be included in the perfusion record of patients undergoing cardiopulmonary bypass:

1. The perfusion record should include the following patient information:
   A. Hospital ID
   B. Gender
   A. Height
   D. Weight
   E. Body Surface Area (BSA)
   F. Allergens
   G. Blood Type
   H. Pre-op Laboratory Data
   I. Diagnosis and History

2. Additional procedure information should include:
   A. Date
   B. Procedure
   A. Perfusionist(s)
   D. Surgeon(s)
   E. Anesthesia Personnel
   F. Comments/Events

3. The following disposable lot numbers should be recorded:
   A. Oxygenator
   B. Cardiotomy Reservoir
   A. Tubing Pack/Arterial Filter
   D. Cardioplegia set
   E. Ultrafiltration set
   F. Cell washing set
   G. Centrifugal pump head and flow probe.

4. The following should be recorded at the perfusion data sheet during CPB at 10 min. interval
   A. Blood flow rates
B. Arterial blood pressure
   A. Central Venous/ Pulmonary artery pressure

5. At least one of the following patient temperatures which may include:
   A. Bladder
   B. Esophageal
   A. Rectal
   D. Nasopharyngeal
   E. Tympanic

6. Additional Temperature may include:
   A. Venous blood
   B. Arterial blood
   A. Cardioplegic solution
   D. Myocardium
   E. Water bath(s)
   F. Oxygenator gases including flow rate and concentration

7. Output fluid volumes including:
   A. Urine output
   B. Ultrafiltrate

8. The following should be determined and recorded every 30 minutes
   A. Arterial / Venous blood gases
   B. Venous oxygen saturation
   A. Potassium concentration
   D. Ionized calcium concentration
   E. Sodium concentration
   F. Activated Clotting Times (ACT) and/or Protamine assay results.

9. The perfusion record should be signed by the primary perfusionist and retained as part of the patient’s medical record. Additional copies of the perfusion record may be retained in the Perfusion Unit and/or patient database.

10. Patient parameters that are monitored/measured during the conduct of cardiopulmonary bypass should be documented.

III. General Guideline on Perfusionist designation, assignment of cases, and responsibility during conduct of Cardiopulmonary Bypass.

1. Only members of the perfusion staff shall operate the heart and lung machine.

2. Designated perfusionists in a particular section (congenital and pediatric, valvular and ischemic, vascular and miscellaneous) shall be followed as much as possible in assigning perfusionists to cases.
3. Assistant perfusionist or circulators should always be available in all cases.

4. Trainees are not allowed to handle perfusion without the presence of duty staff perfusionist, and without the consent of attending surgeon.

5. Perfusionist should always be available for emergency CPB cases.

6. On-call perfusionist should be within 30 minute radius from the hospital for an emergency CPB case.

IV. ACT Management During Cardiopulmonary Bypass

The following will serve as guideline for anticoagulation management during CPB:

1. The Hemochron ACT is the standard anticoagulation monitoring during CPB.

2. Pump heparinizing dose is 300 units/cc. of priming solution.

3. ACT determination shall be done 5 minutes after initiation of cardiopulmonary bypass and at 30 minutes interval thereafter.

4. Maintain a celite and kaolin ACT > 480 seconds. Heparin Maintenance is accomplished by administering the amount of heparin indicated by a heparin assay to maintain the heparin concentration designated by the heparin dose response for an ACT of > 480 seconds.

5. If the heparin loading dose results in an ACT <480 seconds, an additional bolus of heparin should be administered by the anesthesiologist. If the resulting ACT is still <480 seconds, the surgeon and Anesthesiologist should again be informed on the possible diagnosis of AT3 deficiency. If a diagnosis of AT3 deficiency is reached, then the appropriate amount of plasma should be ordered, and either administered before CPB by the anesthesiologist or added to the pump prime by the perfusionist. Additional heparin in the prime should be considered.

V. BLOOD FLOW RATE MANAGEMENT DURING CARDIOPULMONARY BYPASS

The Body Surface Area (B.S.A.) shall be used routinely in the computation for determining blood flow rate during Cardiopulmonary Bypass. The following table shall be adopted for blood flow index at various body temperatures.
Alternatively, the patient’s body weight may be used as a guide to determine blood flow at 37 degree body temperature.

<table>
<thead>
<tr>
<th>Blood Flow Rate by Kilogram Weight Patient Kilogram Weight</th>
<th>Blood Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3 kg</td>
<td>200 ml/kg/min</td>
</tr>
<tr>
<td>3 - 10 kg</td>
<td>150 ml/kg/min</td>
</tr>
<tr>
<td>10 - 15 kg</td>
<td>125 ml/kg/min</td>
</tr>
<tr>
<td>15 - 30 kg</td>
<td>100 ml/kg/min</td>
</tr>
<tr>
<td>&gt; 30 kg</td>
<td>75 ml/kg/min</td>
</tr>
<tr>
<td>&gt; 55 kg</td>
<td>65 ml/kg/min</td>
</tr>
</tbody>
</table>

The following parameters considered in the determination of flow rate:

A. Venous oxygen saturation
B. Body surface area
C. Arterial blood pressure
D. Temperature

A venous saturation of 70% as indicated in the in line venous saturation monitoring is considered optimum during cardiopulmonary bypass, especially during normothermia. A fall in venous saturation below this level may necessitate increase in blood flow rate, among other interventions.
VI. Minimum Operating Reservoir Level

1. The following minimum operating level according to circuit/oxygenator type should be observed prior to initiation of, and during the conduct of CPB.

   Neonate and infant circuit --- 100 ml  
   Children --- 200 ml  
   Adult --- 400 ml

2. During CPB appropriate volume should be maintained to allow for sufficient reaction time in the event of a decrease or loss of circulating volume.

3. If additional fluid is to be added, the hematocrit of the patient should be considered to determine whether blood or crystalloid should be used to increase reservoir volume.

VII. Safety Devices During CPB

1. The following safety devices should be employed during CPB at all times.
   a. Bubble detector
   b. Level sensor
   c. Anaesthetic Gas scavenge line
   d. Pressure alarm

2. The above devices, alarms, should be checked and functioning well during set up of CPB.

3. Any defective device and malfunction should be reported to the Chief Perfusionist, who shall make a written report to the Head of the unit for proper action.

VIII. Use of Terumo CDI 500.

1. The Terumo CDI 500 should be used in all cases to monitor in line arterial blood gas, venous saturation, and hematocrit during cardiopulmonary bypass.

2. Case priority usage should be observed in the following order in case of shortage of monitor:
   A. Deep hypothermia and circulatory arrest patients
   B. Neonates and infants
   A. Children who will undergo complex repair and long bypass
D. Big children

E. Adult

3. Every perfusionist should be familiar of the set up for the use of the machine.

IX. Current Circuit Selection Guide of The Perfusion Unit of PHC DSA

1. The following table shall be used as guide for selection of appropriate circuit, and pump boot:

**Tubing Pack Selection Guidelines For Bicaval Cannulation**

<table>
<thead>
<tr>
<th>Type</th>
<th>Neonatal</th>
<th>Infant</th>
<th>Pediatric</th>
<th>Small Adult</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td>&lt; m 800 ml/ min</td>
<td>&gt; m 800 &lt; 1,500 ml/ min</td>
<td>&gt; 1,500 &lt; 3,000 ml/ min</td>
<td>&gt; 3,000 &lt; 4,000 ml/ min</td>
<td>&gt; 4,000 ml/ min</td>
</tr>
</tbody>
</table>

The following table shall be used as reference for pump boot circuit size

**Pump Boot Selection Guidelines**

<table>
<thead>
<tr>
<th>Type</th>
<th>3/16 “</th>
<th>¼”</th>
<th>3/8”</th>
<th>½”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td>&lt; 700 ml/ min</td>
<td>&gt; 700 &lt; 1,300 ml/ min</td>
<td>&gt; 1,300 &lt; 2,700 ml/ min</td>
<td>&gt; 2,700 ml/ min</td>
</tr>
</tbody>
</table>

X. Arterial and Venous Cannula Selection Criteria

1. The following tables shall serve as guide for selection of arterial and venous cannula according to maximum flow rate.

**DLP Aortic Cannula Selection Criteria**

<table>
<thead>
<tr>
<th>DLP wire</th>
<th>Max Flow cc/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Fr</td>
<td>400</td>
</tr>
<tr>
<td>8 Fr</td>
<td>650</td>
</tr>
<tr>
<td>10 Fr</td>
<td>1,100</td>
</tr>
<tr>
<td>12 Fr</td>
<td>2,200</td>
</tr>
<tr>
<td>14 Fr</td>
<td>2,900</td>
</tr>
<tr>
<td>DLP single Stage straight</td>
<td>Max Flow cc/ min</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>14 Fr</td>
<td>300</td>
</tr>
<tr>
<td>16 Fr</td>
<td>450</td>
</tr>
<tr>
<td>18 Fr</td>
<td>800</td>
</tr>
<tr>
<td>18 Fr</td>
<td>1,000</td>
</tr>
<tr>
<td>20 Fr</td>
<td>1,200</td>
</tr>
<tr>
<td>22 Fr</td>
<td>1,600</td>
</tr>
<tr>
<td>22 Fr</td>
<td>1,800</td>
</tr>
<tr>
<td>24 Fr</td>
<td>2,200</td>
</tr>
<tr>
<td>28 Fr</td>
<td>2,800</td>
</tr>
<tr>
<td>30 Fr</td>
<td>3,100</td>
</tr>
<tr>
<td>32 Fr</td>
<td>3,500</td>
</tr>
<tr>
<td>32 Fr</td>
<td>4,000</td>
</tr>
<tr>
<td>34 Fr</td>
<td>4,400</td>
</tr>
<tr>
<td>36 Fr</td>
<td>5,000</td>
</tr>
<tr>
<td>38 Fr</td>
<td>5,500</td>
</tr>
<tr>
<td>40 Fr</td>
<td>6,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bi-caval Angled DLP or Angled Edwards</th>
<th>Max Flow cc/ min</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Fr 12 Fr</td>
<td>500</td>
</tr>
<tr>
<td>12 Fr 14 Fr</td>
<td>750</td>
</tr>
<tr>
<td>12 Fr 16 Fr</td>
<td>1,000</td>
</tr>
<tr>
<td>14 Fr 14 Fr</td>
<td>1,000</td>
</tr>
<tr>
<td>14 Fr 16 Fr</td>
<td>1,200</td>
</tr>
<tr>
<td>16 Fr 16 Fr</td>
<td>1,500</td>
</tr>
<tr>
<td>18 Fr 18 Fr</td>
<td>1,800</td>
</tr>
<tr>
<td>18 Fr 20 Fr</td>
<td>2,500</td>
</tr>
<tr>
<td>20 Fr 20 Fr</td>
<td>2,800</td>
</tr>
<tr>
<td>20 Fr 24 Fr</td>
<td>3,200</td>
</tr>
<tr>
<td>24 Fr 24 Fr</td>
<td>4,000</td>
</tr>
<tr>
<td>24 Fr 28 Fr</td>
<td>5,000</td>
</tr>
<tr>
<td>28 Fr 28 Fr</td>
<td>6,000</td>
</tr>
</tbody>
</table>

2. Surgeon’s preference should be considered as priority in the selection of cannulae size and design.

3. Perfusionist should be able to recommend the appropriate size of cannulae for a particular maximum flow rate, and size of patient.
XI. Current Oxygenator Selection Criteria at the Philippine Heart Center, DSA Perfusion Unit

1. The following table shall be used as reference for selection of appropriate oxygenator type according to corresponding flow rate.

<table>
<thead>
<tr>
<th>Oxygenator Type</th>
<th>Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dideco Liliput D901</td>
<td>maximum 800ml/min</td>
</tr>
<tr>
<td>Capiox Baby RX</td>
<td>800ml/min to 1500 ml/min</td>
</tr>
<tr>
<td>Jostra Quadrox.i Pedia</td>
<td>1500 ml/min to 2800 ml/min</td>
</tr>
<tr>
<td>Capiox RX15</td>
<td>2.8 to 4.0 l/min</td>
</tr>
<tr>
<td>Adult- Dideco Compactflo Evo</td>
<td>4 to 7 l/min</td>
</tr>
<tr>
<td>Jostra Quadrox.i Adult</td>
<td></td>
</tr>
</tbody>
</table>

2. This criteria is made for the proper utilization and stock maintenance of oxygenators, and not necessarily on the flow rate range of the oxygenator.

XII. Hematocrit Management During Cardiopulmonary Bypass Procedures in Adult Patients

1. The following statements will serve as management guide for hematocrit management during pump.

2. In all cases, the following calculations should be done.

   A. Hematocrit without blood prime
   B. Blood needed to raise hematocrit to 25%
   A. Blood needed to raise hematocrit to 30%

3. Blood shall not be added to the prime without the concurrence or prior instruction of attending surgeon

4. A hematocrit of 25% is considered as best during most cardiopulmonary bypass procedures in adult patients

5. A hematocrit of 21% is preferred than addition of blood into the prime.

6. If the calculated hematocrit is below 21%, the attending surgeon should be consulted and his consent secured prior to addition of blood into the prime. Alternatively retrograde priming may be done but only upon the approval of the attending surgeon.

7. Estimation of blood volume and calculation of blood prime shall be done using the formula and table as used for pediatric patients.
XIII. Perfusion Time-Out Prior To Surgical Procedure Under Cardiopulmonary Bypass For All Patients

1. The perfusionist assigned to a CPB case shall call a time-out prior to start of the surgical procedure specifically after the circuits have been set-up on a draped patient.

2. The perfusionist shall confirm the identity of the patient, and the surgical procedure to be performed.

3. He shall state the maximum flow rate, oxygenator and circuit used for the patient. He shall state the ideal cannula sizes prepared for the patient.

4. He shall state the calculated hematocrit without blood prime and shall get the consent of the attending surgeon if blood should be added.

5. He shall state the target temperature and confirm with the surgeon.

6. He shall state the base cardioplegia concentration, ratio of blood to cardioplegia, temperature of cardioplegia, frequency of delivery and concur with the attending surgeons.

XIV. Current Standard Priming Composition for CPB at the Philippine Heart Center

1. Plasmalyte 148 - volume as specified for safe minimum operating level.

2. Albumin 25% (50 CC vial) - for patients 25 kgs and below - one vial for every 300 ml of priming volume. (Confirm with surgeon if albumin used is more than 2 vials, or if priming volume is more than 600 ml)

3. Mannitol - 1.25 ml per kg weight of patient

4. Heparin - 300 units per 100 ml of priming volume

5. Sodium Bicarbonate - 0.025 meq for every ml of priming volume

6. Solumedrol - 20 mg per kg patient weight.

7. Fresh Frozen Plasma - 2 units to be incorporated to CPB upon rewarming for infants and neonates.

8. Attending surgeon may modify priming solution as needed or according to individual preferences.
XV. Current Standard Priming Composition for Adult CPB of The Perfusion Unit PHC DSA

1. The following is the current priming composition for adult CPB.

   Priming Composition

   A. Plasmalyte  
   B. Mannitol – 5cc/kg  
   C. Plasma expander - Gelafusine or Voluven  
   D. NaHC03 - 50 meq  
   E. Heparin 30 mg / liter of priming  
   F. Solumedrol 500 mg  
   G. Blood - as needed to make hematocrit of 25% especially for long bypass time and complicated procedures. For simple short procedures (bypass less than 1 hour) a hematocrit of 21% may be acceptable. Confer with surgeon for preferred hematocrit and prior to addition of non-autologous blood.

2. Attending surgeon may modify composition of priming solution.

XVI. Current Standard Cardioplegic Solution for Adult CPB at the Philippine Heart Center

1. The following is the current standard PHC DSA Cardioplegia Composition for Adult

   A. Plasmalyte - 915 cc  
   B. KCl - 100 meq (50 cc)  
   C. NaHCO3 - 10 meq (10 cc)  
   D. Optional – Lidocaine 100 mg (Cariño, Chua Chiaco, Jr.), MgSO4

2. Preparation and delivery of the cardioplegia solution

   A. 85 cc. of fluid is aspirated from the 1 liter bag of Plasmalyte  
   B. The above additives are aspirated using individual syringes and properly labelled, then added to the Plasmalyte solution  
   C. The cardioplegia is given as 4:1 blood to cardioplegia ratio.  
   D. Dosage of cardioplegia is computed by the formula  
      BSA x 400 cc as initial dose. Maintenance dose is half of the Initial dose.  
   E. Cardioplegia is given at interval of 20-30 minutes (confer with surgeon).  
   F. Attending surgeon may modify composition, dosage and frequency of delivery.
XVII. Current Standard Conduct of CPB at the PHC for Adult Patients

The following procedures will be the current standard procedure for the set up, conduct, and patient management during CPB at the Philippine Heart Center.

1. Setting Up the Heart and Lung Machine
   A. A Calculated blood flow at a cardiac index of 2.5 L/min. is used to determine the size of the circuit.
      Blood Flow = BSA x 2.5 L/min
   B. Refer to circuit reference table for the appropriate size of circuit.
   C. Refer to oxygenator reference table for proper size and kind of oxygenator.
   D. Set up the circuit and CPB hardware. Ensure all safety and alarm systems are properly connected and functioning

2. Documentation
   A. After calculating the patient's BSA, flow rate, heparin dose, and post-dilutional hematocrit, the rest of the preoperative data and history should be recorded on the appropriate forms.
   B. Serial numbers for disposables and equipment should be noted, and the pre-bypass checklist completed.
   C. During bypass, documentation of the blood flow rate, arterial blood temperature, esophageal temperature, axillary or rectal temperature, mean arterial blood pressure, and central venous pressure (if available) must be made on the perfusion record at specified interval.
   D. Additional information is recorded in the "Events" column.

3. Priming the Circuit
   A. Flush the circuit with 100% CO2 through a sterile gas filter
   B. Prime of the circuit with Plasmalyte Solution. For all circuit prime constituents, refer to Prime Constituents protocol.
   C. The circuit is then debubbled and recirculated.

4. Procedure before blood product addition into the prime
   A. A post dilutional pump hematocrit may require that packed red cells (PRBCs) be added to the perfusion circuit. This decision is surgeon directed, and usually based on the complexity of the surgical procedure and preoperative condition of the patient.
   B. Blood products (fresh frozen plasma and PRBCs) should be kept in the blood refrigerator after being checked by the perfusionist and a physician.
C. Proper identification of the blood with the patient's name, birth date, hospital number, blood type, donor number, and expiration date is mandatory before addition to the pump.

D. This must be counterchecked by another member of the open heart team, and both signatures must be recorded on the transfusion form.

E. One copy of the blood transfusion form is placed on the patient's chart, the other is returned to the blood bank.

5. Anticoagulation

A. A pre-bypass Kaolin Activated Clotting Time (ACT) is obtained before heparinization to determine the baseline coagulation before initiating bypass.

B. Dose of Heparin is calculated. Adequate heparinization is achieved when the ACT reaches 480 s.

C. On bypass, the ACT should be maintained for greater than 480 s with additional heparin administration when necessary.

D. An ACT should be monitored every 30 min on bypass, and more frequently during rewarming, when the ACT may decrease rapidly.

E. After termination of bypass, heparin is reversed with 1mg of Protamine given by the anaesthesiologist for every 100U of heparin that was administered during the bypass procedure.

F. Ten minutes after Protamine, an ACT and heparin level are performed to assure complete neutralization of the heparin and that the ACT has returned to within 10% of the pre-bypass baseline.

6. Cardioplegia
   (refer to the Cardioplegia protocol.)

7. Recovery of Pump Volume

A. At the end of bypass, modified ultrafiltration is done for almost all patient. This is done until all the blood remaining in the reservoir has been filtered out and transfused.

B. Blood from the circuit tubing may also be collected in a blood bag and transfused.

C. Use of Cell Saver is not routinely used.

8. Circuit Breakdown/Disposal

A. Once all lines have been disconnected from the patient and returned to the perfusionist, pump circuit disassembly may begin when directed by the surgeon.

B. The heater-cooler should remain connected and recirculating until instructed to discard the pump circuit, at which time the lines may be deprimed, valves closed, and cardioplegia system lines removed from the delivery set.
XVIII. Clinical Blood Gases/ Calcium and Electrolyte Management

1. An arterial and venous blood gas will be checked within the first 5 minutes of cardiopulmonary bypass.

2. Subsequent arterial and venous blood gases will be checked every 30 minutes while on cardiopulmonary bypass or whenever a relevant clinical change is encountered. Examples of relevant clinical changes are:
   A. cooling to circulatory arrest
   B. anticipated aortic cross clamp removal
   C. rewarming
   D. anticipated removal from Cardiopulmonary Bypass
   E. Computation of NaHCO3 for blood gas correction, as well as all electrolyte correction shall be done by the anaesthesiologist.

3. Calcium Management
   A. Maintain an ionized Ca++ level of approximately 0.8 mmol/L during CPB until 15-20 mins. after myocardial reperfusion.
   B. Correct the ionized Ca++ level to approximately 1.2 mmol/L 15-20 mins. after the myocardial reperfusion.

XIX. Patient Management During CPB

The following are suggested management strategies/checklists during various situations during CPB

1. Svo2 :
   a. Maintain Svo2>75%
   b. Low SvO2 Interventions include:
      1. Increase BFR.
      2. Increase isoflurane delivery.
      3. Consider muscle relaxant.
      4. Increase hematocrit: add PRBC. Avoid excessive transfusion of PRBC's and donor exposure during rewarming and following aortic crossclamp release when Svo2 drops in are transitory.
      5. Lower body temperature, if situation doesn’t allow increase in blood flow rate.

2. Mean Arterial Pressure (MAP)
   a. MAP Range During CPB: 35-50 mmHg (for pediatric patients) 50-80 mmHg (for adult patients)
   b. Low MAP Intervention Checklist
1. Verify closure of membrane recirculation line.
2. Compensate for blood steal whenever the arterial purge line is open and during cardioplegia delivery, hemofiltration, and aortic needle vent usage.
3. Consult anaesthesiologist if there is a need to lower isoflurane delivery
5. Increase BFR until either adequate MAP or the upper limit of BFR range is reached.
6. Administer phenylephrine only after consultation with the anaesthesiologist.

c. High MAP Intervention Checklist
   1. Administer isoflurane at 0.1 – 2%. Administration of isoflurane at > 2.0% has been linked to the uncoupling of cerebral autoregulation and should, therefore, probably be avoided. Refer to Anesthesiologist for management.
   2. Consult the anaesthesiologist as to whether opioid or muscle relaxant agents should be administered.
   3. Lower BFR if SvO2 > 75%.

3. CENTRAL VENOUS PRESSURE (CVP) MANAGEMENT

   A. During CPB, the CVP should be < 5 mmHg.
   B. An elevated CVP can result in hypoperfusion, hypervolemia, and edema, particularly when the MAP is low.
   C. Elevated CVP Intervention Checklist include the ff:
      1. Verify that the venous line is not occluded.
      2. Ask the anesthesiologist to check the patient for evidence of facial edema, the patency of the CVP monitoring line, and the zero and calibration of CVP transducer.
      3. Ask the surgeon to check the position of the venous cannulae.
   4. Hematocrit Management
      A. If the Terumo CDI is not in use, determine Hct every 30 minutes or depending on instruction of attending surgeon.
      B. Consult with surgeon desired Hct level, during pump, upon rewarming, and upon termination of bypass
      C. A hematocrit of 21% is mostly adequate for adult patients, especially if blood transfusion is avoided. A Hct of 25% is optimum.
      D. A hematocrit of 25-30% is considered best for majority of pediatric patients undergoing CPB.
      E. For short procedures like closure of ASD, VSD in children and older patients, a lower hematocrit may be preferable than addition of blood into the prime.
If the calculated hematocrit without blood prime is less than 25%, the attending surgeon should be informed and consulted, whether a higher hematocrit with blood prime is preferred. Alternatively, other modalities may be employed like circuit reduction, autologous priming, but only in consultation and with the consent of the attending surgeon.

XX. Management of Massive Gas Embolism During CPB

The Philippine Heart Center Perfusion Unit adopts the procedure for massive gas embolism as included in the Practice of Cardiac Anesthesia by Little, Brown; 1st Edition (1990), in the event of a massive gas embolization during CPB. The procedure is as follows:

1. Stop cardiopulmonary bypass (CPB) immediately.

2. Steep Trendelenberg position.

3. Remove aortic cannula vent air from aortic cannulation site.

4. De-air arterial cannula and pump line.

5. Institute hypothermic retrograde operator vena cava (SVC) perfusion by connecting arterial pump line to the SVC cannula with caval tape tightened. Blood at 20-24°C is injected into SVC at 1-2L/min or more, and air plus blood is drained from aortic cannulation site to the pump.

6. Carotid compression is performed intermittently during retrograde SVC perfusion to allow retrograde purging of air from the vertebral arteries.

7. Maintain retrograde SVC perfusion for at least 1-2 min. Continue for an additional 1-2 min if air continues to exit from aorta.

8. In extensive systemic air injection accidents in which emboli to splanchnic, renal, or femoral circulation are suspected, retrograde inferior vena cava perfusion may be performed after head de-arming procedures are completed. This is performed while the carotid arteries are clamped and the patient is in head-up position to facilitate removal of air through the aortic root vent, but prevent re-embolization of the brain.

9. When no additional air can be expelled, resume anterograde CPB, maintaining hypothermia at 20°C for at least 40-45 min. Lowering patient temperature is important because increased gas solubility helps to resorb bubbles and because decreased metabolic demands may limit ischemic damage before bubble resorption.
10. Induce hypertension with vasoconstrictor drugs. Hydrostatic pressure shrinks bubbles; also, bubbles occluding arterial bifurcations are pushed into one vessel, opening the other branch.

11. Express coronary air by massage and needle venting.

12. Steroids may be administered, although this is controversial; the usual dose of methylprednisolone is 30mg/kg.

13. Barbiturate coma should be considered if the myocardium will be able to tolerate the significant negative inotropy. Thiopental 10mg/kg loading dose plus 1-3 mg/kg/h infusion may be used empirically. If EEG monitoring is available, titration of barbiturate to an EEG burst/suppression (1 burst/min) pattern is preferable.

14. Patient is weaned from CPB.

15. Continue ventilating patient with 100% O₂ for at least 6 hrs. to maximize blood alveolar gradient for elimination of N₂.

16. Hyperbaric chamber can accelerate resorption of residual bubbles. However, the risk of moving a critically ill patient must be weighed against the potential benefits.