Clinical Guidelines†
Acute Normovolemic Hemodilution Guidelines for Cardiac Surgery‡
Department of Anesthesiology and Perioperative Medicine
Date: 12-30-2012

Is the patient at risk for blood loss of ≥ 1000 mLs?

- Yes
  - Will the patient have a Hb ≥ 10 g/dL following hemodilution correction?
    - Yes
      - Proceed to Acute Normovolemic Hemodilution Procedural Guidelines
    - No
      - Is the patient HD stable and not actively ischemic?
        - Yes
          - Proceed to Acute Normovolemic Hemodilution Procedural Guidelines
        - No
          - Proceed to Acute Normovolemic Hemodilution Procedural Guidelines
      - No
        - Proceed to Acute Normovolemic Hemodilution Procedural Guidelines
  - No
    - Avoid these Guidelines

Hb: Hemoglobin concentration; HD: Hemodynamically stable; GFR: Glomerular filtration rate
Acute Normovolemic Hemodilution (ANH) Procedural Guidelines

Step 1: Arterial/Venous Access

Insure **arterial access** is available for blood collection using the larger bore noncompliant tubing with a stopcock **proximal to the distal end** (i.e. patient end) of the tubing. The tubing is stored in the anesthesia workroom on the top shelf just outside and left of Mel’s office. Use of the standard triple set up without the integrated stopcock will work but will significantly slow the collection process. At least an 18 gauge peripheral IV is recommended to permit adequate volume replacement as the blood is taken off.

![Integrated proximal stopcock](image1.png)

Step 2: Monitoring

Employ standard cardiac surgical monitoring procedures including the use of **cerebral oximetry** prior to performing this procedure. During collection of the ANH blood a non-invasive blood pressure cuff is used to monitor systemic blood pressure. The use of cerebral oximetry is expected to be a “first alert” indicator of ANH induced cerebral oxygen tissue imbalance that may accompany this procedure and is thus strongly recommended. The importance of establishing baseline cerebral oximetry values prior to ANH cannot be over emphasized.
Step 3: IBW/EBV Calculations

Determine the patient’s height:__________inches
Determine patient’s actual body weight:________kg
Calculate the patient’s Ideal Body Weight (IBW)

\[ IBW = 50 \text{ kg (or 45.5 kg for females)} + 2.3 \text{ kg for each inch > 60 inches} \]

<table>
<thead>
<tr>
<th>Example:</th>
<th>90 kg male (actual body weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>70 inches (height)</td>
</tr>
<tr>
<td></td>
<td>IBW = 50 kg + (2.3 kg x 10) = 73 kg</td>
</tr>
</tbody>
</table>

Calculate the patient’s Estimated Blood Volume (EBV)___________mLs

\[ EBV = (75 \text{ mLs/kg of IBW in males or 70 mLs/kg of IBW in females}) \]

<table>
<thead>
<tr>
<th>Example:</th>
<th>73 kg male (IBW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EBV = 75 mLs/kg \cdot 73 kg = 5,475 mLs</td>
</tr>
</tbody>
</table>

---

Step 4: ANH\textsubscript{vol} Calculation

Determine the patient’s current Hb:_________mg/dL
Determine the patient’s target Hb:__________mg/dL

Calculate the amount of blood to remove to achieve the target Hb (ANH\textsubscript{vol})

\[
\text{ANH}_{\text{vol}} = [\text{EBV}] \cdot \left(\frac{\text{Hb}_{\text{current}} - \text{Hb}_{\text{target}}}{\text{(Hb}_{\text{current}} + \text{Hb}_{\text{target}})/2}\right)
\]

<table>
<thead>
<tr>
<th>Example:</th>
<th>73 kg male (IBW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hb\textsubscript{current} = 13.7 mg/dL</td>
</tr>
<tr>
<td></td>
<td>Hb\textsubscript{target} = 11.7 mg/dL</td>
</tr>
</tbody>
</table>

\[
\text{ANH}_{\text{vol}} = (5,475 \text{ mLs}) \cdot \left(\frac{(13.7 - 11.7 = 2)/((13.7 + 11.7 = 24.7)/2 = 12.7} = 0.157\right) \\
\text{ANH}_{\text{vol}} = 5,475 \cdot 0.157 \\
\text{ANH}_{\text{vol}} = 859 \text{ mLs} = (859 \text{ mLs x 1.06 g/mL = 910 g of whole blood})
\]

Note: 1 mL of whole blood is equivalent to 1.06 grams of whole blood

\[
1 \text{ mL} = 1.06 \text{ gram}
\]
**Step 5: ANH\textsubscript{vol} to Replacement Volume Ratios**

Once the desired amount of ANH\textsubscript{vol} to be removed has been calculated and the physiologic monitors are in use the process of acute normovolemic hemodilution (ANH) can begin. While ANH could theoretically be performed in an awake patient it is recommended to do so while the patient is anesthetized to reduce cerebral metabolic oxygen demand and to unload the heart.

Replacing the ANH\textsubscript{vol} that is drawn off can be done with either crystalloids, colloids or a combination of both. For **colloid replacement** (5% albumin) only a ratio of $1 : 1$ for whole blood volume drawn off to colloid volume replaced is needed. For **crystalloid replacement** a volume of $1 : 1.5$-$2$ for whole blood volume drawn off to crystalloid replaced is recommended. In either case attention to tissue oxygen balance and hemodynamic stability is required throughout the entire procedure. The replacement volume should be returned at approximately the same rate that the ANH\textsubscript{vol} is being removed, especially in patients with severe valvular pathology to avoid hemodynamic instability.

\[
\begin{align*}
1 & \leftrightarrow 1 \\
& \leftrightarrow 1.5-2
\end{align*}
\]

**Step 6: ANH\textsubscript{vol} Removal Setup Detail**

Obtain the high fidelity digital scale stored in the perfusion room behind the computers. Place the scale on the bottom shelf a stainless steel rolling line cart directly next to the site of blood collection. Plug in the scale and push the ON/ZERO button as indicated. Next, push the ON/ZERO button again. Once the scale is reading 0.0 g it is ready for the CPDA collection bag. CPDA collection bags are located in the Perfusion room on the top shelf of the 1\textsuperscript{st} roller shelf to the right in a silver foil bag.
Label the bag with a patient sticker, date, time, patient’s blood type and number #1 if it is the first bag withdrawn (#2 for second bag, and so on…). This is important as the most hemodilute bag is given back first (i.e. the bag which has the highest number) with the best whole blood given last (i.e. bag #1).

**BEFORE** starting the collection process close off the **small blue clamp** and break the **crush point** in the collection bag’s tubing to allow the blood into the CPDA bag.

Now place the collection bag on the digital scale and press the **TARE** button as indicated below.
**Step 8: Initiating ANH\textsubscript{vol} Collection**

Start the collection process by uncapping the large bore needle of the collection system and plugging it into a blunt cap connector affixed to the proximal stopcock of the arterial line non-compliant tubing after swabbing the port with an alcohol wipe to optimize asepsis. Turning the stopcock starts the flow of blood. Take care not to push the needle down into the inner portion of the stockcock as this may result in damage to the needle and/or stockcock if it is mistakenly turned during this process.

Generally no more than 450 mLs (477 g) will fit easily into the bag without it becoming pressurized and thus slowing the filling process and potentially causing clotting in the collection system tubing. Agitate the bag once every few minutes to insure the citrate solution is mixing with the collected blood to prevent clotting.

**Step 9: Storing the ANH\textsubscript{vol} Collection**

The ANH\textsubscript{vol} is stored in the OR it is collected in at room temperature in a safe location and is well labeled with the patient’s identifying information and the number indicating the order in which the blood was collected (see Step #6). Storing the blood in a cooler or refrigerator will worsen the platelet storage lesion and will impact the ability of the platelets to function optimally when re-transfused.
Step 10: Returning the $\text{ANH}_{\text{vol}}$ Collection

Give the $\text{ANH}_{\text{vol}}$ bag with the highest number first (i.e. the bag collected last) regardless of whether it is given during or post-CPB. When possible return the blood after protamine administration. Do not wash the blood through the Fresenius cell saver device for any reason. Do not use a fluid warmer or a pressure bag to return the $\text{ANH}_{\text{vol}}$ bag as this may activate the platelets.
Clinical guidelines are based on the best and most recent available data and are made available to promote best clinical practices and to an extent to standardize our approach to managing various clinical issues that are encountered by all CASECAG staff. Standardizing our approach to some of our practices is expected to reduce medical errors in the clinical environment, increase work flow for the trainees and optimize our clinical outcomes.

These clinical guidelines are intended to reduce the incidence of both bleeding and allogeneic transfusion following CPB related cardiac surgery. Use of acute normovolemic hemodilution is considered a Class IIb Recommendation with Level of Evidence B by the Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists. The complete risk to benefit analysis is well treated in the manuscript authored by Dr.’s A. Shander and T. Rijhwani.

1: While use of venous access to perform ANH is an accepted practice in some centers it is more likely to result in clotting of the collected sample which is to be avoided at all costs to prevent any decrease in the concentration of hemostatic elements of the collected blood. Vacuum based syringing and pressurized injection of the ANH collection blood into the CPDA bag should be strictly avoided as the shear stress associated with this practice will likely activate the platelets and render them inactive upon re-transfusion.

2: Cerebral oximetry use in cardiac surgery has been observed to be a “first alert” indicator of adverse physiological events. Using standard monitoring techniques such as heart rate, blood pressure and EKG changes to assess overall stability is also necessary but will likely follow changes in tissue oxygen balance if the ANH is significantly contributing to decreased tissue oxygen delivery.

References: