ACAT®1 PLUS
Intra-Aortic Balloon Pump
Timing, Triggering, and Troubleshooting
Arrow International
ACAT®1 PLUS Intra-Aortic Balloon Pump
Timing, Triggering and Troubleshooting

The Arrow ACAT®1 PLUS Intra-Aortic Balloon Pump
Document Specification

When making reference to or requesting additional copies of this document, please note the following Part Number: A2H-TG, Revision 1.

Caution: U.S. Federal Law limits this device to sale by or on order of a physician. Contents of unopened, undamaged package are sterile. Disposable. Refer to package insert for current warnings, indications, contraindications, precautions, and instructions for use.
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1. Two Hour Program Schedule: ACAT®1 PLUS IABP

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<th>Time</th>
<th>Session Title</th>
<th>Time</th>
<th>Session Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 – 8:05</td>
<td>Registration and Welcome</td>
<td>9:20 – 9:35</td>
<td>Review of Common Alarm Situations</td>
</tr>
<tr>
<td>8:05 – 8:30</td>
<td>Trigger Acquisition and Criteria</td>
<td>9:35 – 9:50</td>
<td>Set-up and Operation</td>
</tr>
<tr>
<td>8:30 – 9:00</td>
<td>Timing</td>
<td>9:50 – 10:00</td>
<td>Post test and Evaluation</td>
</tr>
<tr>
<td>9:00 – 9:20</td>
<td>Utilizing the Balloon Pressure Waveform in Troubleshooting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Program Description

The primary focus of this two hour session is the technical aspects, operation and troubleshooting of the ACAT®1 PLUS Intra-Aortic Balloon Pump (IABP). Participants should have previous IABP experience and a sound working knowledge of the anatomy, physiology and theory of IABP therapy.

3. Program Objectives

1. Identify improper timing and appropriate corrective action.
2. Identify the most appropriate trigger signal selection for a given patient situation.
3. Identify the alterations that would occur in the balloon pressure waveform for two alarm conditions.
4. Demonstrate the set-up and operation of the IABP, utilizing the skills checklist.
4. Patient Connections

1. ECG

2. ECG Cables
   a. Skin Leads Cable
      1. Must have SKIN selected on keypad
      2. For 3-lead cable choose I, II or III
      3. For 5-lead cable choose I, II, III, aVR, aVL, aVF or V
      4. Lead selected is highlighted in white
   b. Phono to Phono Cable
      1. Must have MONITOR selected on keypad
      2. For monitor cables, actual lead choice is made at the monitor
4. Patient Connections

3. Arterial Pressure

4. AP Cables
   a. Transducer Cable
      • Must have XDUCER selected
   b. Phono to Phono Cable
      • Must have MONITOR selected
5. Balloon

a. Use a 30cc, 40cc or 50cc balloon

b. Push balloon connector in firmly, right side up or upside down - it does not matter

c. Balloon volume is displayed above the helium bargraph display.
5. Start Up

1. Power On
   a. Applies power to the system
5. Start-Up

2. Check:

3. Remember

   a. The white overlay lines on the ECG and the Flashing Heart Symbol means the pump can see the Trigger that has been selected.

   b. The console cannot pump without a Trigger. If no trigger, check to see if Trigger signal is present, check signal size, or change Trigger.
4. Initiate Pumping

a. Press STANDBY to activate 4 beat purge.

b. Then press ON to begin counterpulsation.

Alternately:

a. Press ON to purge once, fill, and initiate counterpulsation.
5. Heart Pump Setup

An easy way to remember and complete the steps of setting up the ACAT®1 PLUS is to use the word HEART. Each letter stands for a step of set-up. Use of this method reduces the chance of incorrectly setting up the pump.

<table>
<thead>
<tr>
<th>LETTER</th>
<th>SET UP STEPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>Plug in pump and Power ON</td>
</tr>
<tr>
<td></td>
<td>Check HE Display</td>
</tr>
<tr>
<td></td>
<td>BLUE: OK</td>
</tr>
<tr>
<td></td>
<td>RED: OK but have an extra tank with the pump</td>
</tr>
<tr>
<td></td>
<td>BLACK: Tank is OFF or empty. Turn tank ON or replace.</td>
</tr>
<tr>
<td>E</td>
<td>ECG Set-up</td>
</tr>
<tr>
<td></td>
<td>Connect skin ECG cable or remote connection from bedside monitor</td>
</tr>
<tr>
<td></td>
<td>Select or Verify ECG Source</td>
</tr>
<tr>
<td></td>
<td>Select Lead</td>
</tr>
<tr>
<td>A</td>
<td>Arterial Pressure Set-up (Optional)</td>
</tr>
<tr>
<td></td>
<td>Connect transducer or remote connection from bedside monitor</td>
</tr>
<tr>
<td></td>
<td>Select or Verify AP Source</td>
</tr>
<tr>
<td></td>
<td>Zero transducer</td>
</tr>
<tr>
<td>RT</td>
<td>Reliable Trigger</td>
</tr>
<tr>
<td></td>
<td>Check for WHITE overlay on ECG trace.</td>
</tr>
<tr>
<td></td>
<td>This should appear on every other ECG if assist ratio is 1:2.</td>
</tr>
<tr>
<td></td>
<td>Otherwise, the WHITE overlay should match the assist ratio.</td>
</tr>
<tr>
<td></td>
<td>The WHITE overlay should be between the R waves.</td>
</tr>
<tr>
<td>RT</td>
<td>Relative Timing</td>
</tr>
<tr>
<td></td>
<td>Check the WHITE overlay on the AP.</td>
</tr>
<tr>
<td></td>
<td>It will appear on every beat when the pump is OFF.</td>
</tr>
<tr>
<td></td>
<td>Set inflation (beginning of WHITE overlay) at the dichrotic notch the deflation (end of the WHITE overlay) just prior to the next systolic upstroke.</td>
</tr>
</tbody>
</table>

Once these steps are complete, the pump is ready to start.

Connect the IAB and verify the volume setting.

Press PUMP ON to begin pumping.

Follow recommendations for timing and triggering described in this manual.
Information on the function of most keys can be obtained by pressing HELP, then pressing the key. For additional information, refer to the Operator’s Manual.

1. ECG Select

   a. ECG SELECT provides selection for LEAD, input source, gain mode and level.
      1. To change input source, press ECG SELECT twice.
      2. To change lead, press ECG SELECT once. Press key under desired LEAD label. To switch gain mode, press key under desired label. DECREASE/INCREASE GAIN keys can be used with AUTO or MANUAL GAIN. If AUTO is selected, the GAIN change is only valid until the lead is changed.
6. Control and Function Keys

2. AP Select and AP Alarm (1.28 or higher software only)

a. AP SELECT provides selection for source SCALE, ZERO, and CAL.

1. To change input source, press AP SELECT twice.

2. To adjust SCALE, ZERO or CAL, press AP SELECT once, then:
   • To change AP scale, press AP SCALING.
   • To zero, open transducer to air and press ZERO.

b. Setting AP ALARM (1.28 or higher)

1. Press AP SELECT

2. Press AP ALARM OFF. This will turn the alarm ON.

3. Select AP parameter for alarm. MAP or PDP.

4. Set alarm limit. Alarm limit can be adjusted in 5 mmHg increments.
   4.1. MAP pre-set alarm limit: 70 mmHg
   4.2. PDP pre-set alarm limit: 100 mmHg
3. Cursor

a. Moves horizontal cursor on AP and BPW. Move cursor to desired assessment point. Value is displayed above cursor on the right hand side.
6. Control and Function Keys

4. **Inflate** – Adjusts inflation point.
   a. Inflation occurs earlier when the left arrow is depressed and later when the right arrow is depressed. Allows the operator to optimize timing by monitoring the hemodynamic changes produced on the AP waveform.

   1. Move the inflation point to the right until you can clearly see the dicrotic notch on the arterial pressure waveform.
   2. Slowly move the inflation point to the left until the dicrotic notch (40ms in front of AVC/DN) is no longer visible.
   3. Check PDP/DA.
      Generally PDP/DA should be > APSP.
      If not, additional assessment of the patient or IABP may be required.

5. **Deflate** – Adjusts deflation point.
   a. Deflation occurs earlier when the left arrow is depressed and later when the right arrow is depressed. Allows the operator to optimize timing by monitoring the hemodynamic changes produced on the AP waveform.

   1. Move the deflation point to the left to see its effect on the AP waveform.
      Note the rise in the APSP and the plateau of the BAEDP/AEDP.
   2. Move the deflation point to the right to lower the APSP while simultaneously keeping the BAEDP/AEDP lower than the PAEDP/UEDP.
   3. Return the ASSIST RATIO to 1:1.
6. Control and Function Keys

6. Pump Status

a. **ON**
   Starts pumping.
   If pressed before STNDBY, pumping starts after one purge cycle and the pneumatic system fills with helium to 2.5mmHg.

b. **STNDBY**
   If pump is on, immediately stops pumping but does not vent the pneumatic system. If pump is off, completes a four beat purge cycle and pressurizes the pneumatic system with helium to 2.5mmHg. If pump left in STNDBY > 3 minutes an alarm will be issued.

c. **OFF**
   Immediately stops pumping, deflates the balloon and vents the pneumatic system to atmosphere.
   Six alarms automatically stop the pump.

7. Trigger Modes

a. **Preset trigger.** For normal QRS complex. Uses height, width and slope of positive or negative QRS complexes. Width must be between 25 and 135 msec. Rejects pacer spikes.

b. **For any type of QRS complex and changing QRS shapes.** Uses height and slope only of positive or negative QRS complexes. May be preferred for HR > 140. Rejects pacer spikes.

c. **For irregular cardiac rhythms.** Uses height and slope only of positive or negative QRS complexes with REAL TIME (R-Wave) deflation. Rejects pacer spikes.

d. **Uses V-pacer spikes to trigger.** MUST BE 100% PACED. For V and AV sequential pacers.

e. **Uses A-pacer spikes to trigger.** MUST BE 100% PACED. For Atrial pacers only.

f. **Uses AP waveform to trigger.** Recommended when ECG is not available or too noisy. NOT RECOMMENDED FOR IRREGULAR RHYTHMS.

g. **Uses IABP internal signal for triggering.** Used when no ECG or AP signal is available. ASYNCHRONOUS TO PATIENT CARDIAC ACTIVITY. Press INT twice to confirm.
8. Assist Ratio

1:1 Initiates one inflation-deflation cycle for each cardiac cycle. Generally used after timing has been optimized.

1:2 Initiates one inflation-deflation cycle for every second cardiac cycle. Generally used to initiate counterpulsation, optimize timing, and to wean patient from IABP support. Is the preset assist ratio on power up.

1:4 Initiates one inflation-deflation cycle for every fourth cardiac cycle. Generally used to wean patient from IABP support.

1:8 Initiates one inflation-deflation cycle for every eighth cardiac cycle. Generally used to wean patient from IABP support.

9. Balloon Volume

a. When the IAB is plugged into the pump, the volume will automatically be set at full balloon size.

To change volume:

1. Press pump OFF to change volume.
   (with 1.28 or higher software, pump may remain in ON position to change volume)

2. Press BALLOON VOLUME key.

3. Select INCREASE/DECREASE until desired volume is displayed.
   Press FULL VOLUME to return to volume based on balloon connector.

Balloon Volume (1.28 or higher Software)

The ACAT®1 SERIES 1.28 or higher software allows the user to set the precise volume to be delivered to the IAB in 0.5 cc increments. Volume can be changed while the pump is OFF or during pumping. If IAB volume is changed while pumping, the pump will pause for 1 or 2 beats to reset the volume and then resume pumping at the new volume setting.
6. Control and Function Keys

Changing IABP Delivered Volume

Change Volume:
1. Press BALLOON VOLUME key.
2. INCREASE or DECREASE the volume to the desired setting.
3. Press APPLY to change volume. NOTE: Pump will reset volume in 1 or 2 beats and resume pumping.
4. If volume change was made in error, press CANCEL or wait 30 seconds for multifunction keys to time out.

When < DECREASE or > INCREASE keys are pressed, the APPLY and CANCEL keys will be displayed

Recorder
a. Starts and stops recorder.
b. To change recorder settings:
   1. Press HOME
   2. Press RECORDER SETUP
   3. Select desired waveforms or set recorder automatic print interval.

Control and Function Keys
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6. Control and Function Keys

11. Alarm Control

   a. RESET
      Silences the audible alarm tone and clears the alarm message. If pumping was interrupted, the alarm message is not cleared until STNDBY or ON is pressed. If there is more than one alarm condition, one message is cleared at a time.

   b. ON/OFF
      Turns pneumatic alarms audio, recording, drain and refill on or off. To select alarm time off, press key under desired setting. Alarm message will be displayed. Time remaining for alarms off is displayed above AP Scale. Press ON/OFF again to reanimate gas surveillance alarms.

12. Home

   a. AP SCALING
      Selects AP Scale for display and recorder

   b. RECORDER SETUP
      Selects waveforms to be recorded. Time interval for automatic recordings may be set.

   c. WEANING SETUP
      Allows user to select volume, assist ratio and timer for weaning.

   d. SHOW STATUS
      This key will display a summary of all current operational settings as well as selected information which is tracked by the ACAT®1 PLUS.

   e. AUDIO SETUP
      Allows the user to set the key volume and turn it on/off and independently set alarm volume.

   f. HEMODYNAMICS
      Automatically calculates: PDP - PSP   PDP - EDP

   g. CLOCK SETUP
      Allows the user to set the time and date for the pump.
New Functions (1.28 and higher)

a. Hemodynamic Calculations and Charting Hemodynamic Values

To stabilize AP values for charting and show Unassisted AP values if available:

1. Press HOME
2. Press HEMODYNAMICS key
3. AP values will freeze for 30 seconds and if assist ratio is 1:2 or lower the unassisted values will appear in YELLOW, below the assisted AP values.
4. Press HEMODYNAMICS key again to unfreeze or wait 30 seconds.

13. Weaning Setup/Start

a. To begin weaning:
   1. Press HOME
   2. Press WEANING
   3. Set Volume, assist ratio and time to desired settings.
   4. Press START to implement weaning.

b. WEANING STEP COMPLETE:
   When the timer expires for a weaning step, a Class 3 alert will be displayed:
   WEANING STEP COMPLETE
   EVALUATE HEMODYNAMICS AND CONTINUE
   WEANING OR RESUME FULL IABP SUPPORT

Current IAB volume and assist ratio from the weaning setup will be used for pumping until another weaning setup is selected or until pumping is discontinued.
c. WEANING AND INTERNAL TRIGGER MODE

Weaning cannot be set when INTERNAL trigger mode is selected. The user must change to another trigger mode if the weaning mode is required.

If you are in weaning and the INTERNAL trigger mode is selected and confirmed by pressing the INTERNAL key twice, weaning will be suspended and the INTERNAL mode will be selected.

d. CANCELING WEANING

To cancel a current weaning session:
1. Change assist ratio. IAB volume will return to FULL VOLUME at the new assist ratio.
2. Change IAB volume. Assist ratio will return to 1:1 at new IAB volume.
3. Press 100%V @ 1:1 key to initiate FULL VOLUME at 1:1 assist ratio.

14. Flash Card (1.28 or higher Software)

The ACAT®1 SERIES has the ability to customize the start up settings of the pump using a Flash Card. This Flash Card may be changed by the clinician to suit individual or institutional preferences. The following section is a guide to the use and programming of the Flash Card.

a. STARTING THE SYSTEM USING FLASH CARD SETTINGS

1. Place Flashcard in receptacle
2. Power ON
3. Selected settings will be in use.
4. Verify message that Flashcard settings are in use.

b. RETURNING TO ACAT®1 PLUS PRESET START UP SETTINGS

If the user prefers to return to the ACAT®1 PLUS Preset start up settings:
1. Press HOME
2. Press SHOW STATS
3. Press PRESET SETTINGS key x2.
6. Control and Function Keys

c. Preset start-up settings are:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Setting Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump</td>
<td>OFF</td>
</tr>
<tr>
<td>Assist Ratio</td>
<td>1:2</td>
</tr>
<tr>
<td>ECG</td>
<td>Skin, Lead II, Autogain ON</td>
</tr>
<tr>
<td>AP</td>
<td>Transducer, Scale 50 - 150 mmHg</td>
</tr>
<tr>
<td>Trigger Mode</td>
<td>Pattern</td>
</tr>
<tr>
<td>Timing settings</td>
<td>Inflation 50% and Deflation 85% (Pattern trigger)</td>
</tr>
<tr>
<td>Alarms</td>
<td>ON</td>
</tr>
<tr>
<td>Balloon Volume</td>
<td>Full volume based on IAB connector</td>
</tr>
<tr>
<td>Recorder</td>
<td>ECG/AP @ 25 mm/sec.</td>
</tr>
<tr>
<td>Cursor</td>
<td>Top of Arterial pressure waveform</td>
</tr>
<tr>
<td>AP Alarm</td>
<td>OFF</td>
</tr>
</tbody>
</table>

d. SAVING SETTINGS TO THE FLASH CARD

Verify that the Flash Card is NOT write protected. (A small switch is located on the end of the Flash Card opposite the connector. See the reverse side of the Flash Card for write protect position.)

1. Place Flash card in receptacle

2. Select start-up settings using the keys on the keypad and HOME multifunction keys.

3. When all settings are complete, Press HOME

4. Press SHOW STATS

5. Press SAVE TO FLASH key x2. Settings will now be saved.
6. Control and Function Keys
7. Alarms

An alarm may cause the pump to stop pumping. The pump will display a message on the screen to assist in troubleshooting.

Once the condition is corrected, to resume pumping:

1. Press alarm RESET (until the reset LED is off) It may take several key presses if there are multiple alarms.
2. Press pump ON

If the alarm reappears consistently, refer to the Operator’s Manual for further information. Or call the Arrow IABP support line at: 800-447-IABP

1. Class 1 Alarms (Automatic Response)

   The following Class 1 automatic response alarms cause the ACAT® 1 PLUS to:
   1. Stop pumping (PUMP OFF key illuminates)
   2. Deflate the balloon
   3. Open the vent valve
   4. Initiate the audio alarm
   5. Display an alarm message
   6. Freeze the waveform display
   7. Print approximately the last ten seconds of balloon and AP waveforms on the strip chart recorder

   Note: Alarms must be reset prior to initiating counterpulsation. The LED illuminated on the RESET key indicates alarm to be reset. Depress the key until the LED goes out.

### ALARM | POSSIBLE CAUSE | CORRECTIVE ACTION
--- | --- | ---
Possible Helium Loss | Leak in tubing or connections | Perform Leak Test and repair tubing as needed
 | Kinked Catheter | Find kink and straighten out the catheter. Be sure that the IAB membrane has fully exited the insertion sheath.
 | Balloon connector not properly seated | Reconnect the balloon connector to console
 | Blood in catheter tubing | Remove balloon immediately and insert a new IAB catheter WARNING: Any evidence of blood leakage within the IAB assembly warrants immediate IAB removal
Large Helium Loss Detected | Leak at catheter connection or tubing between console and catheter insertion point | Check all connection points for leaks and correct as required.
 | Other Helium leak | Perform Leak Test and repair as necessary
## Class 1 Alarms (Automatic Response) – continued

<table>
<thead>
<tr>
<th>ALARM</th>
<th>POSSIBLE CAUSE</th>
<th>CORRECTIVE ACTION</th>
</tr>
</thead>
</table>
| Unable to Refill  
Version 1.28 or higher software  
(Replaces HE Loss 1 alarm) | Low HE tank pressure  
Timing settings are too wide for current heart rate and/or rhythm  
Fill valves not functioning correctly  
Tubing disconnection  
Very large HE leak | Verify HE tank is ON and has adequate HE supply.  
If HE tank pressure is less than 100 psi or HE tank display is RED, change tank.  
Adjust timing settings to proper timing.  
Change trigger mode to PEAK or AFIB.  
Change to another console.  
Call Field service.  
Check tubing for disconnects and reconnect.  
Check for blood in tubing, if blood is found, stop counterpulsation and remove IAB.  
Assess for large leak in tubing or connections.  
Repair as directed on page 9-20 of the ACAT™1 PLUS Operator’s Manual. |
7. Alarms

### Class 1 Alarms (Automatic Response) – continued

<table>
<thead>
<tr>
<th>ALARM</th>
<th>POSSIBLE CAUSE</th>
<th>CORRECTIVE ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purge Failure</td>
<td>Helium tank not inserted properly</td>
<td>Reinsert tank per instructions.</td>
</tr>
<tr>
<td></td>
<td>Helium tank empty</td>
<td>Replace with full helium tank</td>
</tr>
<tr>
<td></td>
<td>Quick connect not connected or loose</td>
<td>Tighten or connect Quick Connect.</td>
</tr>
<tr>
<td></td>
<td>Reliable trigger signal lost</td>
<td>Adjust ECG GAIN to reestablish triggering. Check electrode contacts. Change trigger mode. Check for broken electrical connections on electrodes and leads. Check to make sure the correct trigger source is selected. Select another trigger mode to obtain reliable triggering. Check the patient.</td>
</tr>
<tr>
<td></td>
<td>Balloon not connected to the console</td>
<td>Connect balloon to BALLOON CONNECTOR on patient interface panel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Baseline</td>
<td>Kinked catheter</td>
<td>Find kink and straighten out the catheter. Be sure that the IAB membrane has fully exited the insertion sheath.</td>
</tr>
<tr>
<td></td>
<td>Partially wrapped balloon</td>
<td>Notify physician: aspirate to check for blood then inject approximately 10cc of air greater than the balloon volume into the balloon connector and aspirate immediately.</td>
</tr>
<tr>
<td></td>
<td>Overfill</td>
<td>Call Arrow Service</td>
</tr>
<tr>
<td></td>
<td>IAB not exited sheath</td>
<td>Be sure that the IAB membrane has fully exited the insertion sheath. Check to be sure proximal end of IAB is not in sheath.</td>
</tr>
<tr>
<td>High Pressure</td>
<td>Kinked Catheter</td>
<td>Find kink and straighten out the catheter.</td>
</tr>
<tr>
<td></td>
<td>Partially wrapped balloon</td>
<td>Be sure that the IAB membrane has fully exited the insertion sheath. Notify physician: aspirate to check for blood then inject approximately 10cc of air greater than the balloon volume into the balloon connector and aspirate immediately.</td>
</tr>
<tr>
<td></td>
<td>Balloon too large</td>
<td>Decrease IAB volume until the balloon pressure waveform returns to normal configuration. WARNING: The inflation volume should be no less than 2/3 of the balloon’s capacity.</td>
</tr>
<tr>
<td>System Error</td>
<td>Fault in System</td>
<td>Press the ALARM RESET control key: press the PUMP STNDBY control key, then PUMP ON (correcting this alarm may require turning the power off and on to reset the microprocessor). All control key settings are retained in memory for five minutes and need not be reset. If the alarm recurs, call Arrow service.</td>
</tr>
</tbody>
</table>
## 7. Alarms

### 2. Class 2 Alarms (Automatic Response)

The following Class 2 automatic response alarms cause the ACAT® 1 PLUS to:

1. Stop pumping (PUMP STNDBY key illuminates, system not vented)
2. Deflate the balloon
3. Initiate the audio alarm
4. Display an alarm message

**NOTE:** Trigger loss alarms will automatically reset and pumping resumes when trigger is established.

<table>
<thead>
<tr>
<th>ALARM</th>
<th>POSSIBLE CAUSE</th>
<th>CORRECTIVE ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG Trigger Loss</td>
<td>No ECG Waveform displayed</td>
<td>Check patient rhythm. Check electrode placement and change if necessary.</td>
</tr>
<tr>
<td></td>
<td>Waveform erratic or noisy</td>
<td>Reapply electrode paste or replace disposable electrodes.</td>
</tr>
<tr>
<td></td>
<td>Low waveform amplitude</td>
<td>Select another lead (if using external monitor, use monitor’s controls to select a different lead).</td>
</tr>
<tr>
<td></td>
<td>Inappropriate trigger mode</td>
<td>Select another trigger mode (reassess timing).</td>
</tr>
<tr>
<td>ECG Lead Fault Detected</td>
<td>Poor electrode contact</td>
<td>Reapply electrode paste or replace disposable electrodes.</td>
</tr>
<tr>
<td></td>
<td>Loose cable connections</td>
<td>Check cable connections; repair if necessary. Replace ECG Cable.</td>
</tr>
<tr>
<td>Pressure Triggering Loss</td>
<td>No pressure waveform</td>
<td>Check patient’s state. Check all connections. Check pressure transducer, catheter and all connections for loose connections; repair if necessary. Make sure that correct pressure source is selected. Select another trigger mode (reassess timing).</td>
</tr>
<tr>
<td>STANDBY longer than 3 minutes</td>
<td>Pump was left in STANDBY status for longer than 3 minutes</td>
<td>Press PUMP ON to resume pumping. Press PUMP OFF to stop pumping. Press ALARMS RESET to continue STANDBY for additional 3 minutes (may repeat). Press PUMP STNDBY twice within 30 seconds to bypass this alarm.</td>
</tr>
<tr>
<td>STANDBY alarm off</td>
<td>Pump was left in STANDBY status and STANDBY alarm was bypassed</td>
<td>Press PUMP ON to resume pumping. Press PUMP OFF to stop pumping. NOTE: This alarm does not have audio tone.</td>
</tr>
</tbody>
</table>
3. Class 3 Alarms (Automatic Response)

The following Class 3 (information only) alarms alert you to less serious conditions. You should check on the condition, but immediate action may not be required. Class 3 alarms cause the ACAT®1 PLUS to:

1. Initiate the audio alarm
2. Display a visual alarm message on the display.

<table>
<thead>
<tr>
<th>ALARM</th>
<th>POSSIBLE CAUSE</th>
<th>CORRECTIVE ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deflation &gt; 100%</td>
<td>Deflation set beyond 100% of R-R interval</td>
<td>Check timing in relation to AP waveforms; adjust if necessary.</td>
</tr>
<tr>
<td>Drain Failure</td>
<td>Condensate collection bottle full or tubing is kinked</td>
<td>Empty condensate collection bottle. Straighten tubing.</td>
</tr>
<tr>
<td></td>
<td>Drain valve failed to open or system purge not performed</td>
<td>Initiate purge cycle by pressing PUMP OFF, then PUMP STANDBY; wait 5 seconds for purge, then press PUMP ON to restart pumping. Call Arrow for service.</td>
</tr>
<tr>
<td>Battery life less than 20, 10, 5 minutes</td>
<td>Battery will be completely discharged in 20, 10, 5 minutes</td>
<td>Connect system to AC power as soon as possible to charge batteries</td>
</tr>
<tr>
<td>System running on batteries</td>
<td>System accidentally or intentionally disconnected from AC power</td>
<td>Reconnect system to AC power as soon as possible. Arrange for alternate AC power source if failure expected to exceed battery life.</td>
</tr>
<tr>
<td></td>
<td>AC power failure</td>
<td></td>
</tr>
<tr>
<td>Battery Inoperative</td>
<td>The system will not run in battery mode due to the faulty circuit breaker</td>
<td>Do not disconnect the system from the AC power source. Check the DC circuit breaker located in the helium compartment.</td>
</tr>
<tr>
<td>Timing Error</td>
<td>Insufficient time to deflate before next inflation cycle</td>
<td>Check timing in relation to AP waveform; adjust as necessary</td>
</tr>
<tr>
<td>ECG waveform detected in internal trigger</td>
<td>Patient has ECG complex</td>
<td>Verify ECG, change trigger mode</td>
</tr>
<tr>
<td>Low Helium Supply</td>
<td>Helium tank pressure less than 100psi. Helium tank inserted improperly</td>
<td>Install a full helium tank. Remove and replace helium tank per instructions</td>
</tr>
<tr>
<td>Low battery for static RAM</td>
<td>The internal RAM battery needs to be replaced</td>
<td>Place service call</td>
</tr>
<tr>
<td>AP ALARM LIMIT (Version 1.28 or higher software)</td>
<td>AP disconnect</td>
<td>Check AP lines for disconnection, reconnect and refush</td>
</tr>
<tr>
<td></td>
<td>AP pressure has dropped</td>
<td>Assess patient condition and treat according to hospital protocol. Change AP alarm limit.</td>
</tr>
<tr>
<td></td>
<td>AP alarm limit set too high</td>
<td>Change AP alarm limit</td>
</tr>
<tr>
<td>WEANING STEP COMPLETE (Version 1.28 or higher software)</td>
<td>Weaning timer has expired</td>
<td>Assess patient hemodynamics and set next step of weaning. Press START WEANING. If hemodynamic status is unstable, resume full support by pressing the 100%SV @ 1:1 key X 2 or increasing IAB volume and/or assist ratio.</td>
</tr>
</tbody>
</table>

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4. Timing Guidelines

The Timing Three

1. Inflation
   GOAL: To produce a rapid rise in aortic pressure (optimize PDP/DA), thereby increasing O₂ supply to coronary circulation
   a. Inflate just prior to DN which should result in PDP/DA>PSP

2. Deflation
   GOAL: To reduce aortic end diastolic pressure (afterload), thereby decreasing MVO₂ while improving the CO (cardiac output).
   b. BAEDP/AEDP<PAEDP/UEDP
   c. APSP < PSP

Balloon Inflation and Deflation
Electrical and mechanical Relationship
Incorrect Timing States

1. Early Inflation

IAB is inflated well before actual DN. (aortic valve closure.)
Violates Rule 1 for inflation.
Result: Premature closure of aortic valve. Reduces stroke volume/CO.
Increase in LVED volume.

2. Late Inflation

DN is visible between points PSP and PDP/DA. Violates Rule 1 for inflation.
Result: PDP/DA less than optimum. Decreased perfusion pressure and volume to coronary arteries.

3. Early Deflation

APSP = PSP Violates Rule 3 for deflation. May see “U” shape at BAEDP/AEDP.
Result: No afterload reduction.

4. Late Deflation

BAEDP/AEDP > PAEDP/UEDP Violates Rule 2 for deflation.
Result: Increased workload of left ventricle. Increased MVO\(^2\). Decreased CO.
7. Alarms

5. Recommended IABP Triggers

<table>
<thead>
<tr>
<th>RHYTHM</th>
<th>PATTERN R-wave criteria: 25-135msec.</th>
<th>PEAK Wide Complex QRS</th>
<th>AFIB Varying R-R Automatic R-wave deflation</th>
<th>V-PACE(^1) 100% Paced</th>
<th>A-PACE(^1) 100% Paced</th>
<th>AP [Consistent BP]</th>
<th>INT Rate 80 automatic Range 40-120</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSR</td>
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<tr>
<td>CAUTERY INTERFERENCE</td>
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<tr>
<td>NSR With premature</td>
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<td>(atrial)(^2)</td>
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<td>beats</td>
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<td>NSR With pauses</td>
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<td>Atrial Flutter</td>
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<tr>
<td>Atrial Pacing</td>
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<td>demand</td>
<td>demand</td>
<td>100% Paced</td>
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<tr>
<td>Ventricular Pacing</td>
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<td>A-V Pacing</td>
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<td>RBBB, LBBB</td>
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<tr>
<td>Ventricular Tachycardia</td>
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<td>CPR</td>
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<tr>
<td>Bypass- Pulsatile Flow System Test</td>
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</tbody>
</table>

\(^1\) Note: No capture beat needed for trigger.
\(^2\) Depends on type and number of premature beats.
\(^3\) For significant irregularity use Peak.
\(^4\) If real time timing desired.
\(^5\) May be preferred for HR > 140 bpm.
6. Balloon Pressure Waveform

1. Description
   The Balloon Pressure Waveform (BPW) represents helium movement from the console to the IAB catheter. It is shown as a calibrated, continuous waveform which allows objective assessment of the safety and effectiveness of counterpulsation.

2. BPW Height
   Reflects the pressure in the aorta, therefore the plateau pressure on the BPW should be within ±20mmHg of the DA/PDP.

3. BPW Width
   Is approximately the duration in which the balloon is inflated.

1. Zero Baseline
2. Balloon Pressure Baseline
3. Rapid Inflation
4. Peak Inflation Artifact
5. Plateau Pressure
6. Rapid Deflation
7. Deflation Artifact
8. Return to Baseline
9. Duration of Balloon Cycle
7. Alarms

Balloon Pressure Waveform (continued)

<table>
<thead>
<tr>
<th>Purge Failure</th>
<th>Low Plateau Pressure</th>
<th>Squared or Rounded Plateau Pressure</th>
<th>Wide Inflation and/or Deflation Artifact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check for:</td>
<td>Check for:</td>
<td>Check for:</td>
<td>Check for:</td>
</tr>
<tr>
<td>• Loss of trigger</td>
<td>• Leaks</td>
<td>• Volume setting too low</td>
<td>• Proximal portion of IAB in sheath</td>
</tr>
<tr>
<td></td>
<td>• Low helium</td>
<td>• Balloon too small for patient</td>
<td>• Suture too tight around catheter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Balloon too low in aorta</td>
<td>• Partial obstruction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Low systemic vascular resistance</td>
<td>• Partial kink</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Slow catheter or He shuttle speed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Very tortuous vessels</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Baseline Elevated</th>
<th>Baseline Below Zero</th>
<th>Possible Helium Loss</th>
<th>High Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check for:</td>
<td>Check for:</td>
<td>Check for:</td>
<td>Check for:</td>
</tr>
<tr>
<td>• Kinked catheter</td>
<td>• Blood in catheter tubing</td>
<td>• Partially wrapped balloon</td>
<td>• Partially wrapped balloon</td>
</tr>
<tr>
<td>• Partially wrapped balloon</td>
<td>• Possible leak in connections or tubing</td>
<td>• Kink in catheter or tubing</td>
<td>• Kink in catheter or tubing</td>
</tr>
<tr>
<td>• IAB in sheath</td>
<td>• Kinked catheter</td>
<td>• Balloon too large for aorta</td>
<td>• Balloon too large for aorta</td>
</tr>
<tr>
<td>• IAB too low in aorta</td>
<td>• Ectopic beats</td>
<td>• Balloon position too high or too low</td>
<td>• Balloon position too high or too low</td>
</tr>
<tr>
<td>• IAB too large</td>
<td></td>
<td>• Balloon in sheath</td>
<td>• Balloon in sheath</td>
</tr>
<tr>
<td>• Overfill</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wide deflation artifact may cause Possible Helium Loss Alarm in 1:1 assist.
## Skills Checklist

Name_____________________________________________________________________________

Date _____________________________________________________________________________

Instructor_________________________________________________________________________

<table>
<thead>
<tr>
<th>Skill</th>
<th>DEMO DATE</th>
<th>INITIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Initial Set Up</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Power Up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Connect Patient ECG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Skin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Phono-Phono</td>
<td></td>
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</tr>
<tr>
<td>C. Adjust ECG Gain, if Necessary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Connect Arterial Pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Phono-Phono</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Transducer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Initiate 4 Beat Purge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Initiate Pumping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>Timing, Identify And Correct</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Early Inflation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Late Inflation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Early Deflation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Late Deflation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>Change Assist Interval</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <strong>Recorder</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Program:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waveform 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waveform 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date/Time</td>
<td></td>
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</tr>
<tr>
<td>B. Change Paper</td>
<td></td>
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</tr>
<tr>
<td>5. <strong>Zero Arterial Pressure Transducer</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8. Skills Checklist

<table>
<thead>
<tr>
<th>Skill– (continued)</th>
<th>DEMO DATE</th>
<th>INITIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Change Arterial Pressure Scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Activate Appropriate Trigger For:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Clear ECG, QRS Normal, Rate 90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Clear ECG, QRS Wide, Rate 110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Noisy ECG With Excessive Interference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. A.V. Sequential Pacemaker-Fixed Rate</td>
<td></td>
<td></td>
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<tr>
<td>E. Atrial Pacemaker-Fixed Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Rapid, Irregular Rhythm</td>
<td></td>
<td></td>
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<tr>
<td>G. Cardiopulmonary Bypass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Alarms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Assure Alarms On. If Not, Turn On</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Reset Alarms When Activated And Resume Pumping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Change Helium Tank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Initiate Battery Operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Empty Water Drain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Adjust Balloon Volume</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Assess IAB Sizing Relative to Patient’s PDP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. Self-Evaluation Tool

___ 1. The landmark on the arterial pressure waveform used to time the inflation point is
   A. The dicrotic notch
   B. The systolic peak
   C. The end diastolic pressure
   D. Diastolic augmentation

___ 2. A physiological effect of early inflation of the balloon may be
   A. Potential premature closure of the aortic valve
   B. Suboptimal diastolic augmentation
   C. Potential retrograde coronary and carotid blood flow
   D. Potential renal artery hypoperfusion

___ 3. The waveform characteristics of late inflation includes
   A. Inflation prior to the dicrotic notch
   B. Diastolic augmentation encroaches into systole
   C. Rate of rise of assisted systole is prolonged
   D. Inflation of the balloon after the dicrotic notch

___ 4. A trigger is defined as
   A. Adjustment of inflation and deflation
   B. Pressure exerted to inflate IAB
   C. Event that purges console automatically
   D. Signal to identify the onset of the next cardiac cycle

___ 5. The trigger of choice on the ACAT®1 PLUS pump is
   A. AP (arterial pressure)
   B. Peak
   C. A Pace
   D. Pattern
10. Self-Evaluation Tool

___ 6. Your patient is 100% A-V paced. What is your first trigger choice?
   A. AP (arterial pressure)
   B. Pattern
   C. Peak
   D. V Pace

___ 7. The following represents a cause of a HELIUM LOSS alarm
   A. Kinked line
   B. IAB abrasion
   C. IAB malpositioned
   D. All of the above

Answers:

1. A
2. A
3. D
4. D
5. D or B
6. C
7. D
Intra-Aortic Balloon Pumping

Reference List

Theory of Counterpulsation

Berne RM, Levy MN. Cardiovascular Physiology, Sixth Edition St. Louis, MO: Mosby Year Book; 1992


Indications For Use


Intra-Aortic Balloon Pumping
Reference List (continued)


Intra-Aortic Balloon Pumping

Reference List (continued)

Complications Associated With Counterpulsation


Fiber Optics in Balloon Pump Therapy


Intra-Aortic Balloon Pumping
Reference List (continued)


Insertion Techniques


Nursing


Beaver KE. Intra-Aortic Balloon Pump Therapy in the Cardiac Catheterization Lab Part I. *Cath-Lab Digest* 3(2)(July/August 1995)

Beaver, KE Intra-Aortic Balloon Pump Therapy in the Cardiac Catheterization Lab Part II. *Cath-Lab Digest* 3(4)(March/April 1995)


Intra-Aortic Balloon Pumping
Reference List (continued)


Transport


**9. Program/Speaker Evaluation Tool**

Arrow International  
ACAT®1 PLUS Intra-Aortic Balloon Pump  
Timing, Triggering and Troubleshooting  

Please help us evaluate this program so that we may better meet the needs of future participants. Check the appropriate box.

Instructor:  
______________________________

Date:  
______________________________

Hospital:  
______________________________

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<tr>
<th>Program Evaluation</th>
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<tbody>
<tr>
<td>1. Program met the stated objectives</td>
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<td>2. Content covered topic adequately</td>
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<td>3. Rate overall quality of this program</td>
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<td>4. Rate overall quality of speaker(s)</td>
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<td>5. Rate the program facilities</td>
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<tr>
<td>6. How well did this program meet your personal objectives?</td>
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<td>7. I can incorporate program content into my practice</td>
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<td>2. Audiovisual – Contributed to Presentation</td>
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<td>3. Content – Relevance of Content to Objectives</td>
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<td>4. Presentation – Speaker Qualified and Held Interest</td>
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<td>5. Effectiveness – Speaker was Organized and Effective</td>
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<td>6. Practice – Validate/Change Practice</td>
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</table>

Comments:  
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