Troubleshooting Beyond the Basics
Arrow International
Intra-Aortic Balloon Pumping
Troubleshooting Beyond the Basics

ACAT™ 1 Series pump
Document Specification

When making reference to or requesting additional copies of this document, please note the following Part Number: TBB-TG, Revision 7/99.
# Table of Contents

1. Program Schedule ................................. 1

2. Program Description .............................. 1

3. Program Objectives ............................... 1

4. Review of Principles of Counterpulsation .... 3

5. Preventative Maintenance ....................... 5

6. Possible “POWER ON” Problems/Remedies ... 7

7. Troubleshooting Tools ............................ 9

8. Possible Patient Connections Problems/Remedies ... 23

9. Possible Problems with Helium Delivery ....... 37

10. Triggering the Arrow International Balloon Pumps ... 53

11. Troubleshooting ACAT™ 1 SERIES/KAAT II/KAAT II PLUS® and M7000 Balloon Pumps ... 83

12. Post Test ........................................ 85

13. Answers to Troubleshooting Exercises ....... 87

14. Answers to Post Test ............................. 97

15. Program Evaluation ............................... 99

16. Miscellaneous .................................
   Use of the IABP during Cardiac Resuscitation ................................................................. 101
   Four Hour Program........................................................................................................... 103
   IABP Timing Algorithm .................................................................................................... 105
   Troubleshooting Algorithm: High Baseline....................................................................... 107
   Troubleshooting Algorithm: Plateau Rounding .................................................................. 109
   Quick Reference .............................................................................................................. 111
   Recommended IABP Triggers ........................................................................................... 113
   Intra-Aortic Balloon Pumping Reference List .................................................................... 115

Permission is granted to photocopy this manual for educational purposes only - not for resale.
1. Four Hour Program: Troubleshooting Beyond the Basics Program Schedule

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 - 8:10</td>
<td>Registration and Welcome</td>
<td>9:10 - 9:40</td>
<td>Potential Problems with Helium Delivery</td>
</tr>
<tr>
<td>8:10 - 8:20</td>
<td>Preventative Maintenance</td>
<td>9:40 - 10:00</td>
<td>Triggering Options</td>
</tr>
<tr>
<td>8:20 - 8:30</td>
<td>Possible “Power On” Problems/Remedies</td>
<td>10:00 - 10:15</td>
<td>Break</td>
</tr>
<tr>
<td>8:30 - 8:50</td>
<td>Troubleshooting Tools</td>
<td>10:15 - 11:15</td>
<td>Triggering Exercises</td>
</tr>
<tr>
<td>8:50 - 9:10</td>
<td>Possible Patient Connection Problems/ Remedies</td>
<td>11:15 - 12:15</td>
<td>Pump Operation and Set-Up</td>
</tr>
</tbody>
</table>

2. Program Description

This program has been developed for the clinician with previous IABP experience. Emphasis will be on advanced troubleshooting on Arrow International Intra-Aortic Balloon Pumps through case studies for the expert user.

3. Program Objectives

Following the lecture, case study presentations and group discussion, the participant will be able to:

1. Identify three (3) methods used to interface with the Arrow IABP System and rationale for each.
2. List the seven (7) trigger choices on the Arrow IABP, trigger acquisition requirements for each and appropriate troubleshooting for trigger-related alarm situations.
3. Discuss the differences between Real timing and Conventional timing in irregular rhythms.
4. Identify two (2) abnormal Balloon Pressure Waveforms and list their associated alarm condition, along with appropriate troubleshooting to correct the alarm condition.
5. Demonstrate proper setup and operation of the IABP.
The IABP is a volume displacement device which is placed in the descending thoracic aorta, 1 to 2 cm. below the left subclavian artery origin. It displaces blood volume in an omni-directional fashion. The principle of counterpulsation states that the IAB is inflated during diastole and deflated during systole, resulting in the following changes:

**Inflation**

The IAB is inflated immediately upon closure of the aortic valve. Aortic volume and pressure are increased through displacement principles causing:

1. Increased coronary perfusion pressure
2. Increased O2 supply (both coronary and peripheral)
3. Increased systemic perfusion pressure
4. Increased baroreceptor response
5. Decreased sympathetic stimulation - ↓SVR, ↑LV function, ↓heart rate.

**Deflation**

The IAB is rapidly deflated just prior to systole during isovolumetric contraction (IVC), and remains deflated during systole. This deflation creates a “potential space” in the aorta, reducing aortic volume and pressure causing:

1. Afterload reduction (MVO₂)
2. Reduction in assisted peak systolic pressure (APSP, LV work)
3. Increased cardiac output (C.O.)
4. Improved ejection fraction and forward flow.
5. Preventative Maintenance

A. Routine Operational Checks (when IABP is not in use)

1. Confirm that AC power has been connected.
   For pumps with a power indicator light, light should be on. For other pumps look to see that power cord is plugged in.
   IABP should be plugged into a power outlet at all times to maintain full charge on the battery.

2. Check Cold-Trap bottle.
   On A\textsuperscript{CAT}™ 1 Series, cold-trap bottle is located behind helium tank. To access: raise black lever up, tilt helium tank up, then gently remove cold-trap bottle from alcove and unscrew from lid.
   On KAAT II PLUS\textsuperscript{®} and KAAT II pumps the cold trap bottle is located in bottom front compartment (compartiment below connections).
   On M7000 it is located in the bottom of the compartment where the helium tank is located.
   Empty any condensation in the bottle.

3. Turn power on and observe screen.
   Alpha numeric lettering should be legible and lines should be straight. If screen is garbled:
   a. Turn power off.
   b. Wait 3 seconds.
      On A\textsuperscript{CAT}™ 1 Series and KAAT series pumps check cable connection between control module and pump.
   c. Turn pump back on.

   A\textsuperscript{CAT}™ 1 Series connections are on the back of the control module and on the floor of the helium tank compartment.
   KAAT II and KAAT II PLUS\textsuperscript{®} connection is on left side of control module and in back well on pump.

4. To check battery charger, note battery voltage level.
   Voltage should be 14.1V ± .1V when pump is receiving AC power.
   On A\textsuperscript{CAT}™ 1 Series press HOME, then press key below SHOW STATUS.
   On KAAT II and KAAT II PLUS\textsuperscript{®} press F3, then voltage will be displayed on screen.
5. Preventative Maintenance

5. Check helium tank status.
   For disposable tanks, make sure the tank is screwed in. Tank should be changed when helium is less than 100 PSI. (KAAT II, KAAT II PLUS®, and ACAT ™ 1 Series, helium bar graph is red)
   For refillable tanks, make sure tank is properly connected and turn tank on. Tank should be changed if helium is less than 300 PSI.
   Note where spare tanks are stored in your institution.

6. Internal Leak Test
   a. Place pump in Internal Trigger mode.
   b. Turn off alarms.
   c. Place finger tightly over helium port on pump IAB connector.
   d. Press Pump On
   e. Observe baseline of BPW for 1-2 minutes for evidence of a leak. Baseline should be staying above zero.

7. Check patient cables.
   Make sure that you have all of the cables that you need to connect between the patient and the pump. Inspect the cables for any frayed spots. Replace damaged cables.

8. Check for loose parts on the pump. Check power cord, and on KAAT series check communication cables, for frayed spots.

9. Document any problems and be sure that they get repaired in a timely fashion.

Figure 1a - ACAT ™ 1 Series pump
A. Verify That Power Source is Active

1. A/C power cord is connected to outlet and connected in the power receptacle of the pump.

   For ACAT™ 1 Series, when pump is operating under A/C power, the green power indicator light should be ON. Under SHOW STATUS, battery status should read CHARGING.

   When pump is operating under A/C power, status message should read “CHARGING BATTERY: LO”, “CHARGING BATTERY”, or “CHARGING BATTERY: HI”.

   If reading “ON BATTERY” then A/C fuse and/or charger circuit board should be checked. In addition, for pumps with power indicator light, the light will be off.

2. When pump is running on battery power, the status message will read “ON BATTERY”. Note: When switching from A/C to battery and vice versa, it takes a few seconds for status message to change.

   2 hour minimum battery for transport on ACAT™ 1 Series (4 hours optional)

   3 hour minimum battery for transport on KAAT II and KAAT II PLUS®

   90 minute battery for transport on M7000

3. If power switch is in the ON position but the switch and the screen do not illuminate then have BioMed check pump. Problem could be the main fuse or a short on a circuit board.

B. Check Cable Connector on KAAT Series Pumps

   If power switch is in ON position and illuminated but screen does not illuminate, turn power off. Check cable connections. Turn power on. If screen still does not illuminate have BioMed check pump.

C. Computer “lock-up”: may alarm SYSTEM ERROR

1. Depress RESET key. If that does not clear alarm, then:

2. Turn power off - count to three- turn power on (individual patient settings are maintained for 5 minutes)

3. More likely to happen when more then one control key is depressed at same time.

4. May be avoidable through preventative maintenance.
6. Possible “POWER ON” Problems/Remedies

Figure 1b
7. Troubleshooting Tools

A. Visual Inspection of Patient and Pump

1. Note where IABP, IV pumps, ventilator, etc. are located in the room.
2. How is the patient connected to the IABP? (direct or slaved signals)
3. What is the arterial pressure monitoring site? (IAB central lumen, radial, femoral)
4. What settings are currently selected on the IABP? (ie trigger, ECG lead, etc.)
5. Check information on screen (ie. helium tank level, battery status, alarm status, IAB volume, etc.). If helium supply is getting low, where is your backup tank?
6. Observe hemodynamic values on IABP screen. Do they correlate with the patient picture? Do they correlate with the bedside monitor. If not, Zero and check that AUTO CAL is ON.
7. Observe the ECG tracing on the IABP.
   a. Is the lead fairly unipolar?
   b. Is the gain ok? If not:
      On KAAT II and KAAT II PLUS® press AUTO GAIN. Biphasic QRS complexes may require the use of manual gain to guarantee a reliable trigger.
   c. Is the ECG free from artifact?
   d. Does the ECG on the pump demonstrate trigger acceptance? Trigger acceptance is shown by flashing heart by HR on all pumps and white bands on KAAT II, KAAT II PLUS® and ACAT™ I Series, blue bands on M7000, in the same ratio as the selected assist ratio.
8. Inspect groin site dressing, patient positioning, ie: HOB no higher than 30°, leg straight. Is leg restrained?
7. Troubleshooting Tools

B. Augmented Arterial Pressure Waveform

- **PAEDP** - Patient Aortic End Diastolic Pressure
- **AVO** - Aortic Valve Opening
- **PSP** - Peak Systolic Pressure
- **PDP** - Peak Diastolic Pressure
- **BAEDP** - Balloon Aortic End Diastolic Pressure
- **APSP** - Assisted Peak Systolic Pressure
- **DN** - Dicrotic Notch

**Timing**

1. **Inflation**
   
   a. Inflate just prior to DN which should result in PDP > PSP.

**Inflation Timing Errors**

Note: Inflation has occurred more than 40msec before Dicrotic Notch.

Note: Dicrotic Notch is exposed.

Remember: There are factors that can cause the PDP not to be greater than the PSP besides timing errors:

1. Patient SV greater than IAB volume
2. IAB too small
3. Severe Hypovolemia
4. Low SVR
5. Improperly positioned IAB
6. Patient’s arterial pressure
   a. Mean pressures < 40mmHg: IAB effect will be limited due to limited volume and decreased aortic diameter.
   b. Mean pressures 40-100mmHg: The IAB produces an average of 10 to 25mmHg augmentation.
   c. Mean pressures > 100mmHg: IAB effect is reduced relative to the patient’s pressure. This appears to be due to autoregulation of blood flow which maintains a constant blood flow in high and low perfusion states.

b. Deflation
   2. BAEDP < PAEDP
   3. APSP < PSP

Deflation Timing Errors

Figure 5. Early Deflation. Figure 6. Late Deflation

Note: APSP = PSP
Note: BAEDP > PAEDP

Remember: there are factors besides timing errors that can cause poor afterload reduction
1. IAB volume too low or too small for aorta
2. Compliant aortic walls
3. Improper IAB position
7. Troubleshooting Tools

Timing Exercises (Optional)

(a) Figure 7
Timing ____________________________
Hemodynamic Effect ________________________

(b) Figure 8
Timing ____________________________
Hemodynamic Effect ________________________

(c) Figure 9
Timing ____________________________
Hemodynamic Effect ________________________

(d) Figure 10
Timing ____________________________
Hemodynamic Effect ________________________

(e) Figure 11
Timing ____________________________
Hemodynamic Effect ________________________
C. Balloon Pressure Waveform

![Balloon Pressure Waveform Diagram]

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

Figure 12

**Balloon Pressure Waveform Description**

During a cycle of inflation/deflation, helium is rapidly moved in and out of the balloon. The environment within the balloon and the surrounding forces that effect balloon behavior all contribute to a predictable pattern of gas pressure during the inflate/deflate cycle. The gas pressure characteristics are converted into a waveform that is sensitive to the behavior of the gas. This transduced waveform can tell us much about the interaction of the balloon within the patient’s aorta. A thorough understanding of the balloon pressure curve is also important for efficient troubleshooting of the console.

1. Normal Morphology

The balloon pressure waveform has a normal shape and also has some variations that are considered normal or expected in a given clinical situation. An understanding of a normal waveform is necessary to enable identification of abnormal waveforms, unsafe operating states and to speed the troubleshooting process in the event of an alarm.
Figure 13 shows the normal shape of the balloon pressure waveform. On the Arrow International IABP the balloon pressure curve is shown in blue below the arterial pressure tracing. In a normal state the baseline of the balloon pressure curve rests between -0 to +2.5mmHg (2). On inflation there is a rapid upstroke of the waveform (3). At peak inflation there is an over shoot or artifact that is caused by gas pressure in the pneumatic line (4). The waveform then settles to a plateau (5). The deflation cycle is seen as a rapid descent of the waveform (6). At the completion of deflation there is another artifact or undershoot of the balloon pressure waveform (7). The cause is the same as that for the peak inflation artifact but the gas is traveling in the reverse. The balloon pressure waveform baseline should then return to a range of -0 to +2.5mmHg (8). It is difficult to measure exactly where balloon baseline pressure is because of the monitor screen scale. The computer accurately monitors the balloon pressure baseline.

Two very important characteristics to be made about the shape of the balloon pressure waveform are:

a. The width of the balloon pressure waveform is the duration in which the balloon is active during the cardiac cycle.

b. The balloon plateau pressure reflects arterial pressure within the aorta. Therefore, the balloon plateau pressure on the balloon pressure waveform should be within ±20mmHg of the PDP.

2. Variations of Normal

The most frequent changes seen in balloon pressure waveform shape are due to changes both in the cardiac cycle length and in aortic pressure.
3. Variation due to Heart Rate

The example in Figure 14 shows the difference in the balloon pressure waveform based on different patient heart rates. This would be expected given that timing was set optimally. Since the balloon remains inflated only during the diastolic period, it would be expected that heart rates with a longer diastolic phase (bradycardia) would have a wider balloon pressure waveform. Heart rates with a short diastolic phase (tachycardia) will have narrow balloon pressure waveforms.

![Figure 14. The Effects of Heart Rate on Balloon Pressure Waveform](image)

A. Tachycardia  
B. Bradycardia

If the heart rate is erratic, such as in atrial fibrillation or there are frequent premature complexes, the balloon pressure waveform will have varying widths as seen in Figure 15.

![Figure 15. Changing Balloon Pressure Waveform Width due to an Irregular Diastolic Phase](image)
4. Variations due to Aortic Pressure

The height of the balloon pressure waveform reflects the driving pressure necessary to complete full inflation. If the pressure within the aorta is relatively low then the drive pressure requirements are not as great and therefore the pressure in the balloon is also relatively low. Figure 16 shows the effects of aortic pressure on the balloon curve.

![Figure 16. The effect of Aortic Pressure on the Balloon Pressure Waveform]

| A. Hypertensive | B. Hypotensive |

Curve A occurs during hypertension and Curve B is typical of a hypotensive state.

A short balloon pressure waveform with a large peak inflation artifact may also be seen when the balloon volume is set very low. Increasing the volume setting to normal levels will return the balloon pressure curve to the expected height.

Occasionally a balloon pressure waveform will have a very small or absent peak deflation artifact. This occurs in mainly two conditions—hypertension and pumping of pediatric patients. In the hypertensive patient, the peak deflation artifact is lost but it is very cyclical. As the pressure rises the artifact disappears and when the pressure is controlled and reduced, the artifact reappears. Figure 17 shows an absent peak deflation artifact.

![Figure 17. Absent Peak Deflation Artifact.]
The normal variant shapes of the balloon pressure waveform should coincide with the patient’s clinical presentation. If the patient’s heart rate is 65 and the balloon pressure waveform is very narrow, then check the accuracy of timing as this finding is not appropriate. If the balloon pressure waveform width is erratic and the patient’s rhythm is very regular, check to see if the trigger is clear and appropriate (see Triggering the Console). Height of the balloon pressure waveform not congruent with patient pressure should clue the operator to check the gas supply (if the curve is low) or check the integrity of the balloon connecting tubing for kinks or leaks (see Console Troubleshooting.)

5. Balloon Pressure Waveform Superimposed on AP

**Figure 18**

**BPW HEIGHT:** Reflects the pressure in the aorta, therefore the plateau pressure on the BPW should be within a few mm Hg of the PDP. (±20mmHg)

**BPW WIDTH:** Is approximately the duration in which the balloon is active during the cardiac cycle.
7. Troubleshooting Tools

D. Information on the Screen

Figure 19 - Front panel of ACAT ™ 1 Series control/display module and KAAT II PLUS.
7. Troubleshooting Tools

E. Recorder Strips

1. Preset

Figure 20

2. Dual Waveform Options

Figure 21

Figure 22

Figure 23 (ACAT™ 1 Series Only)

These demonstrate just some of the possibilities.
7. Troubleshooting Tools

3. Single Waveform Options

![Figure 24](image)

4. Sweep Speed Option

![Figure 25](image)

5. Alarm Condition Recording

![Figure 26](image)

F. Twenty-four hour per day troubleshooting assistance is also available through the Arrow International 24 Hour Intra-Aortic Balloon Product Hotline by calling 1-800-447-IABP in the U.S. and Canada, or 617-389-8628 Worldwide.
7. Troubleshooting Tools

ACAT ™ 1 Series Recorder Menu

AUTO PRINT CYCLE TIME: OFF

| ECG | AP | BPW | 25mm/sec | TIME | TIME- | HOME |

1. Select HOME
2. Select RECORDER SETUP
3. Select desired waveforms

M7000, KAAT II and KAAT II PLUS®

<table>
<thead>
<tr>
<th>RECORD</th>
<th>ECG</th>
<th>AP</th>
<th>BPW</th>
<th>25/50 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON/ OFF</td>
<td>F1</td>
<td>F2</td>
<td>F3</td>
<td>F4</td>
</tr>
</tbody>
</table>

Figure 27
A. ECG - Not Clearly Visible on Screen

1. Select appropriate ECG lead for ECG cable in use.
   a. Skin Lead cable - Direct
      ECG Lead Select should be in Lead I, II, or III on pump.
      On ACAT™ 1 Series, if using 5-lead cable - I, II, III, AVR, AVL, AVF or V
   b. Phono - Nicolay cable - Slaved
      ECG Lead Select should be in Lead II (II/PN) on pump.
   c. Phono - Phono cable - Slaved
      ECG Lead Select should be in Monitor on pump.
   d. Criteria for selecting ECG lead to be monitored on the IABP is:
      • most uniphasic lead
      • lead with good amplitude for the R wave while minimizing amplitude of the T and P waves
      • artifact free

   Remember, when ECG is slaved from the bedside monitor to the IABP (whether using the Phono-Nicolay or Phono-Phono cable) the choice of actual ECG lead displayed on the pump is made at the bedside monitor.

2. Check Connections
   a. Electrodes to skin
   b. Lead wires to trunk cable
   c. Trunk cable to monitor or IABP
   d. Slave cable from monitor to IABP

3. Adjust ECG gain to maximize R wave but minimize P and T waves.
   a. For ACAT™ 1 Series, if in AUTO gain, gain will automatically be resized if patient ECG amplitude varies. If AUTO does not maximize the height of all of the R-waves, press ECG SELECT, then select MANUAL gain and use the arrow keys to adjust.
   
   b. For KAAT II PLUS®, KAAT II, and M7000, push AUTO GAIN on key pad. If AUTO GAIN does not maximize the height of all of the R waves then select ECG GAIN in the VARIABLE ADJUST section of the key pad and use the arrow keys.
   
   c. Adjusting gain is almost always necessary when switching between the SKIN LEAD cable and slave cable.
8. Possible Patient Connections Problems/Remedies

Figure 28a - ACAT™ 1 Series

Figure 28b - KAAT II PLUS®
8. Possible Patient Connections Problems/Remedies

4. Cable connected through pin-type Nicolay green input required for triggering in VPACE and APACE trigger mode and ESIS.

   a. Skin lead cable is preferable to Phono-Nicolay cable particularly in the operating room.

NOTE: For newer ACAT™ 1 Series units, use of Phono-Nicolay cable is not required for pacer triggering.
8. Possible Patient Connections Problems/Remedies

Figure 30a - ACAT ™1 Series Function Controls

Figure 30b - KAAT II Function Control Keypad
Possible Patient Connections Problems/Remedies

B. ECG “Hook-Up” Exercises

Exercise (1)

1. Your patient has just returned to the CCU from the Cath Lab after angioplasty. An IAB was inserted during the procedure to assure enough coronary perfusion pressure to maintain patency of the newly opened vessel. The Cath Lab staff transported the patient to the unit on a portable monitor which was used to slave the ECG to the pump via a PHONO input. The patient is known to have a demand pacemaker, so you connect the Phono-Nicolay cable between the monitor and the pump to slave in the patient information. The tech leaves the room. The patient’s ECG on the monitor begins to demonstrate short bursts of V-Tach as you fumble to make the connections to the pump. Once the cable is securely connected, you press PUMP ON and the following strip is generated with an alarm of PURGE FAILURE.

![ECG Pattern](image)

Figure 31

The alarm message on the screen reads: Check for leaks, helium supply connections, and loss of Trigger.

What action do you take?
8. Possible Patient Connections Problems/ Remedies

Exercise (2)

2. Two days later the patient develops signs of recurrent ischemia, and is now on his way back to the Cath Lab for a repeat angioplasty. You connect the transport monitor to the pump via a Phono to Phono cable as you had observed the tech had done it 2 days prior. In the elevator you notice that pumping sounds irregular. You run a strip off the pump that looks like this. No alarm has sounded yet.

![Figure 32](image)

What problem do you detect? How can it be remedied?
Exercise (3)

3. The second angioplasty fails and the patient is taken to the OR for emergency CABG. After surgery he is taken to the SICU on the balloon pump by the Anesthesiologist. The patient is connected to the pump with three lead SKIN cable and the pump is reportedly working well. (For ACAT™ 1 Series only: The pump is in MANUAL gain). You connect the standard Phono-Nicolay cable between the monitor and the pump in order to be able to remove one set of skin leads from the patient’s chest. The moment you walk over to take report from the Anesthesiologist, the pump alarms and generates a purge failure alarm strip. You then prompt the recorder to obtain the following:

![Figure 33](image)

The doctor reports that the pump had been doing fine in the PATTERN trigger mode. The alarm reads ECG Trigger Loss.

What is your assessment of the problem?

What actions do you take?
Your troubleshooting was a success, and the next strip you take is only to document the benefits of the IAB for your record. Congratulations!

Figure 34
Figure 35a - ACAT™ 1 Series

Figure 35b - KAAT II

Figure 35c - KAAT II Plus®
8. Possible Patient Connections Problems/Remedies

C. Arterial Pressure Waveform—Not clearly visible on screen of ACAT™ 1 Series.

1. Select appropriate AP source.
   a. XDUCER is the preset, and is for use when AP trace comes directly to IABP from the transducer.
   b. MONITOR is used when “slaving” AP to the pump via the phono-to-phono cable.
   c. If the wrong AP source is chosen, there will not be any waveform displayed on the screen.

2. Check connections, check stopcocks, ensure fluid in flush system, verify pressure bag to 300mmHg pressure, ensure no air bubbles in arterial pressure line.

3. Zero the waveform.
   a. Press AP SELECT once.
   b. Open stopcock to air, off to patient.
   c. Press ZERO.
   d. CAL is only to be used with reusable transducers. Pump is automatically calibrated for disposable transducers on power up.

4. Choose AP scale that will best accommodate the waveform.
   a. 100/0
   b. 100/25
   c. 150/0
   d. 150/50 (preset)
   e. 200/0
   f. 200/50
   g. 250/50
D. Arterial Pressure Waveform— not clearly visible on screen of KAAT II or M-7000.

1. Pump will automatically display arterial pressure waveform from either source (monitor or transducer).
   a. If both arterial pressure sources are connected, the pump will display the transducer source (i.e. Direct input overrides slaved input).

2. Zero and Calibrate the Waveform
   a. Open transducer to air.
   b. Depress the Zero key on your monitor (if AP waveform slaved).
   c. Press Zero in Cal section of keypad on the pump.
   d. Observe that Auto light is on in the Cal section.

3. Choose a Display from the Variable Adjust section of keypad.
   a. Available scales 0-100, 0-150, 0-200

E. Arterial Pressure KAAT II PLUS®.

1. Same as KAAT II for setup, patient connection, and calibration.

2. Display scales available:
   a. 50/0  d. 150/50  g. 200/0
   b. 100/25  e. 150/0  h. 250/50
   c. 100/0  f. 200/50  i. 250/0

F. Pressure Differences Between IABP and Bedside Monitor.

The Arrow IABP displays pressure on a beat-to-beat basis. This allows the clinician to evaluate the differences between the assisted and unassisted pressures, as well as the amount of augmentation. The IABP can differentiate between IAB augmentation in diastole (PDP) and systole because of mechanical action of pneumatics.

Bedside monitors are designed to provide the clinician with trends for making treatment decisions. They use some method (number of beats or period of time) to average pressures. Also monitors have no method to differentiate IAB augmentation from other pressures. The amount of difference between IABP and monitor pressures is dependent on the amount of beat-to-beat variance and is seen most dramatically in systole because of IAB augmentation.
8. Possible Patient Connections Problems/Remedies

G. Arterial Pressure Exercises - Applicable for KAAT II PLUS® only

Exercise (4)

You are caring for two patients in a semi-private room in the SICU. While you are doing an assessment on one of your patients, the residents make rounds on your other patient who happens to be on a balloon pump. They call across the room to you to find out what his pressures have been running. You respond. You notice one of the newer residents standing at the pump with his back to you. Satisfied with your patient’s progress, the team moves on to the next room. You complete your nursing care for patient #1 and move across the room to assess the other. On attempting to evaluate the IABP timing, you are faced with the waveform below.

![Waveform Image]

Figure 36

Can you tell if the pump is receiving an AP signal?

What is wrong with the AP display?
Exercise (5)

You are called into the CCU to assist the doctor in inserting an IAB into an unstable MI patient. While you are busy prepping the patient and the balloon a new nurse unfamiliar with the pump gets the IABP turned on and the ECG and arterial pressure cables connected to the pump. You notice that she is pushing several buttons on the pump. When asked she says that she is just getting the pump ready to start when the IAB is connected. Once the balloon is inserted you hand the end of the catheter to her and ask her to connect it to the pump and start pumping while you are busy hooking up the art line tubing and transducer to the catheter. You then move over to the pump to fine tune the timing. On looking at the pump you notice the following:

![Figure 37](image)

You make sure that the art line is connected to the balloon and the pump and that it is patent. The waveform still looks the same.

For KAAT II AND KAAT II PLUS®:

You then notice that the AUTO light in the CAL section of the control module is not lit and that AP SENSITIVITY is selected in the VARIABLE ADJUST section.

What do you do?

For ACAT™ 1 Series:

You decide to see if she made any changes under CAL, so you open the stopcock to air and off to patient, press CAL, and note that the sensitivity is at 90mmHg.

What do you do?
8. Possible Patient Connections Problems/Remedies

Exercise (6)
What is wrong? How do you fix it?

![Figure 38](image)

Exercise (7)
Which would be the better arterial line to use for timing?

![Figure 39](image)
A. Automated Features of the ACAT™ 1 Series, KAAT II Plus®, KAAT II, M-7000
1. Purge of IAB in synchrony with the patient’s cardiac cycle
2. Preset safe timing at the onset of pumping
3. Ongoing balloon refill
4. Continuous display of balloon pressure waveform
5. Alarms on—gas transition and all others
6. Preset parameters for each function
7. Continuous removal of condensation from the system
8. Transfer of power source (AC/DC) without interruption of pumping
9. Automatic alarm specific troubleshooting information
10. Automatic alarm print out

B. Additional Automated Features of the ACAT™ 1 Series:
1. Automatic reset of Class 2 and some Class 3 alarms
2. 3- or 5-lead ECG cables with automatic recognition of the cable type and correct lead selections for each cable displayed automatically
3. Continuous Auto Gain
B. PURGE FAILURE - a commonly encountered alarm when turning Pump On

1. Alarm message reads:
   Check for: Leaks
   Helium Supply Connections
   Loss of Trigger

2. Class 1 Alarm occurs whenever the system fails to purge within 8 seconds of pressing either Standby or On keys.

NORMAL BALLOON PRESSURE DURING PURGE CYCLE (Stand-by Mode)

The following is the normal sequence of mechanical (pneumatic) events during a purge cycle.

1. Bellows moves to “Home” (deflated position) ([based on IAB size or volume setting]). This produces a downward stroke.
2. Bellows moves to confirm home position. Which produces a rapid up and down BPW.
3. Fill valve opens and helium enters bellows from tank. BPW baseline rises.
4. When the BPW baseline is at +2.5mmHg, and a valid trigger is present, four inflate/deflate cycles will occur, synchronized to the trigger signal.

3. Purge Failure due to no trigger source.
   a) Look to see if trigger signal is present. If the video bar at the bottom of the screen is green, an ECG must be present. If the video bar is red, the arterial pressure waveform must be present.
   b) Observe if there is an acceptable trigger present:
      1) White or blue bands on ECG in same ratio as the assist ratio
      2) Flashing heart by HR
      3) An accurate numeric display for HR
      4) Make sure the selected Trigger is available for the pump 100% of the time
9. Possible Problems with Helium Delivery

Purge Failure due to Trigger loss.
Note: Fill pressure is correct but no inflation/deflation action

4. Purge Failure due to lack of Helium Supply

Verify that Helium tank is open/engaged, contains Helium, and that there are no kinks in the tubing connecting the tank to the pneumatics inside the pump. Also make sure that the IAB is intact, i.e., that the connecting tubing is connected to the IAB.

Purge Failure due to lack of Helium Supply
Note: BPW pressure never exceeds the zero baseline, but initial bellows movement is normal.

5. Purge failure due to no IAB connector.

Verify that the IAB is connected to the pump.

Purge Failure due to no IAB connected
Note: Very small bellows movement. If no IAB connector is present the home position is set to 5cc which produces a very small change in the pressure.
6. Purge failure due to mechanical failure.
   Generally produces system error alarm and cannot be corrected by the clinician.

Figure 44

Purge Failure due to mechanical failure
Note: Distortion of BPW baseline without inflation/deflation action
C. HIGH PRESSURE - Can be encountered after a successful purge

1. Alarm message reads:
   Check for:  Kinked catheter
               Partially wrapped balloon
               Balloon too large

2. Class 1 Alarm occurs when the balloon line pressure exceeds +250mmHg during pumping. The measurements are taken at the end of inflation.

3. Check for kinks.
   a. External
      1) Plastic connecting tubing
      2) Suture too tight around IAB catheter or sheath
   b. Internal
      1) Balloon too high - in the arch
      2) Balloon too low or in opposite femoral artery
      3) Balloon in intimal wall of the aorta
      4) Balloon has not fully exited insertion sheath
9. Possible Problems with Helium Delivery

Sample patient strip indicative of proximal portion of balloon caught in sheath or suture material tightly wrapped around balloon catheter. Note:
1. Widened Peak Inflation Artifact
2. Widened Peak Deflation Artifact
3. Reduced diastolic augmentation

![Sample patient strip](image)

Figure 46

Helium loss alarms usually occur at full IAB volume and assist ratio of 1:1. Alarms may decrease in frequency or cease if IAB volume or assist ratio is decreased.

![Helium loss alarms](image)

Figure 47

Changes in peak inflation and deflation artifacts after pulling sheath back to allow full and rapid inflation and deflation, with resultant increase in PDP and improved reduction of BAEDP.

4. Verify balloon is unwrapped
   a. Check fluoroscopy - IAB outline visible
   b. Without fluoroscopy
      1) Attempt to pump again (x2 PRN)
      2) If unsuccessful, disconnect IAB connector at pump
      3) Aspirate with a large slip tip syringe to check for blood
      4) Manually inflate/deflate rapidly several times with air (inject 10cc of air greater than the total balloon volume capacity, ie 50cc for a 40cc IAB)
      5) Assure proper IAB placement via CXR/Fluoroscopy.
5. The balloon may also be too tight in the aorta.
   a. In the absence of aortograms or angiography to determine the exact aortic diameter, the following guidelines may be used:
      >6ft. = 50cc
      5ft. 4in. - 6ft. = 40cc
      <5ft. 4in. = 30cc
   b. Decrease the amount of helium going to the balloon
      1) Inflation volume keys in Variable Adjust Section of KAAT II PLUS®, KAAT II and M-7000 keypad. On ACAT™ 1 Series inflation volume keys will come up at bottom of screen once BALLOON VOLUME (or VOLUME CONTROL) key is pressed.
      2) Depress the Pump Off key to release helium contained in bellows
      3) Decrease the volume 1-2cc at a time
      4) Press Pump On
      5) Observe the balloon pressure waveform for changes
      6) This maneuver is usually done with a doctor’s order/consent

   Note: It is not recommended to decrease the inflation volume greater than 2/3 the capacity of the IAB
   
   50cc → 33cc minimum     40cc → 27cc minimum
   30cc → 20cc minimum

   Figure 48
   Plateau Pressure >250mmHg
9. Possible Problems with Helium Delivery

Inflation Volume Decreased 2cc

Figure 49  Plateau Pressure = 230 mmHg

Figure 50  Plateau Pressure = 190 mmHg

Decrease Inflation Volume 2 more cc = 6cc total

Figure 51  Plateau Pressure = 140 mmHg
9. Possible Problems with Helium Delivery

Exercise (8)
What are the possible causes of the High Pressure Alarm?

Figure 52
9. Possible Problems with Helium Delivery

D. HELIUM LOSS ALARMS - two major types

1. Large Helium Leak
   a. Alarm message reads:
      Check balloon connections, catheter and vent hole
      possible internal balloon leak
   b. Class 1 Alarm that will occur anytime during pumping if the balloon
      pressure falls below 5mmHg. This is checked just prior to the onset of
      deflation (i.e. during the inflation plateau)
   c. May indicate balloon rupture - check for blood in tubing
   d. Large leak in balloon connections. Check all connecting points along the
      catheter and IAB connecting tubing down to the insertion at the pump for
      any leaks. If all connections appear tight, no leak is apparent, a leak test
      can be performed.

Figure 53

Helium Loss Alarms  
46
2. Possible Helium Loss
   a. Class I Alarm
   b. Alarm Message Reads:
      Check for: Possible leak in tubing or connections
      Blood in catheter tubing
      Kinked catheter
      Ectopic beats
   c. Notation of Helium Loss 1, 2, or 3 made on strip recording
   d. May be visible in a drop of the balloon pressure baseline
      or
      May not be clearly visible during the 5 second recording of the alarm situation
   e. Three distinct modes of measuring Possible Helium Loss
      1) Helium Loss 1 - System could not refill to 2.5mmHg within 8 beats
      2) Helium Loss 2 - System attempted a second refill within one minute of last refill
9. Possible Problems with Helium Delivery

3) Helium Loss 3 - The baseline is below -10mmHg just prior to inflation for two consecutive beats

Figure 56

f. A Helium Loss caused by a kink in the catheter usually looks like this:

Figure 57
3. The Leak Test

If a helium leak is suspected, but no obvious cause has been found (i.e., no blood in the tubing, etc), a leak test may be performed.

Necessary materials: pair of rubber-shod hemostats
spare balloon connector
pair of scissors

a. Press PUMP OFF.

b. For ACAT™ 1 Series, press Alarms ON/OFF key, then select how many minutes you want alarms off. For KAAT II PLUS®, KAAT II or M7000 press the ALARMS OFF control key twice to disable the helium alarms for ten minutes.

c. Use a pair of rubber-shod hemostats or other clamping device to clamp the catheter tubing between the quick connect valve and the bifurcation. (Note: never clamp the balloon catheter itself). Press ON. Observe the balloon pressure waveform baseline for 1-2 minutes.

1) If the baseline does not fall, the leak is probably on the patient side: either in the balloon itself or in the junction of the balloon connecting tubing to the bifurcation. Check connections. Consider stopping the pump, removing the balloon catheter and inserting another catheter.

![Figure 58](Image)

Leak probably between clamp and patient

2) If the baseline falls, there is probably no leak in the balloon or at this connection, but a leak exists somewhere between the clamp and the internal pneumatics.

![Figure 59](Image)

Leak probably between clamp and pump
9. Possible Problems with Helium Delivery

  d. If baseline did fall, press PUMP OFF control key. Place the hemostat on the connecting tubing as it exits the balloon connector plug at the pump. Press ON. Observe the balloon pressure baseline.

1) If the baseline stays stable now, you have isolated the leak to be somewhere in the connecting tubing. Isolate small portions of the tubing at a time with your clamp (working from patient toward pump.)

   a) If the leak is at the quick connect (male/female connection where tubing attaches to catheter), cut off quick connect and attach the two pieces of tubing with a connector (such as NG tubing connector).

   b) If leak is in the tubing either replace or repair tubing. To repair tubing wrap area of leak with bonewax or non-porous tape.

2) If the baseline falls, the leak must be at either the balloon connector or inside the pump. Try disconnecting the connector plug, cut off 1/4” of tubing, and replace with spare connector (appropriate size for that particular balloon). Repeat test here.

  e. If the baseline continues to fall, disconnect the balloon connector from the pump. Place your finger tightly over the center hole of the balloon connection port on the pump. Press ON. Observe the balloon pressure baseline.

1) If the baseline falls, repeat this portion of the test making sure that your finger tightly occludes the helium from exiting the port. If the baseline continues to fall, it may be assumed that the leak is somewhere inside the pump. Arrow Service should be notified. A back-up pump should be used to replace the original.

  f. This procedure can be performed relatively quickly once the operator is familiar with it. If the patient cannot tolerate being off the pump for this period of time, check the pump for leak first.

  g. When problem is resolved, if the alarms are still disabled, press the ON control key to re-enable the alarms.

4. If persistent ectopy is the cause of the alarm:

   a. Select trigger modes that can best deal with irregularity: AFIB and PEAK.

   b. Always adjust timing when switching trigger modes.
Exercise (9)

What are some possible causes for this Helium Loss 3 Alarm?

Figure 60
9. Possible Problems with Helium Delivery

E. High Baseline Alarm

1. Rare
2. Class 1 Alarm that will occur if the balloon baseline exceeds +25 mm Hg.
3. Alarm Message Reads:
   - Check for: Kinked catheter
   - Partially wrapped balloon
4. Assure that balloon is completely unwrapped (as discussed earlier)

F. The System reacts to Class 1 Alarms in the following manner:

1. Freezing the display screen
2. Deflating the balloon and going to the Pump Off mode
3. Opens the vent valve inside the pump to vent the helium
4. Sounds an audible tone
5. Displays a diagnostic message
6. Recorder prints the last 5 seconds of patient data for arterial pressure and balloon pressure

Note: Only Class 1 Alarms are off when Alarms Off key is pressed. Alarms automatically default On after the selected period of time has elapsed.
10. Triggering the Arrow International Balloon Pumps

A. There are three Class 2 Alarms all related to triggering
B. The system reacts to Class 2 Alarms in the following manner:
   1. Stops the pump and goes to the Pump Standby mode
   2. Deflates the balloon
   3. Keeps the vent valve closed
   4. Sounds an audible tone
   5. Displays a diagnostic message
   6. For ACAT™ 1 Series: pump will automatically resume pumping once a trigger is established

Note: These alarms cannot be disabled

1. ECG Trigger Loss
2. Pressure Trigger Loss
3. Loose Lead Detected

C. Indications of Trigger Acceptance
   (as discussed on Page 38)

D. Establishing a Reliable Trigger Signal
   1. In most instances ECG is the preferred signal because it has the greatest reliability
   2. Computer looks at P - QRS - T complexes, Pacer Spikes, or AP wave
   3. Back to the basics regarding proper skin prep and electrode placements
   4. Three ways of “looking at” ECG; 4 other options for challenging patients
10. Triggering the Arrow International Balloon Pumps

A. ECG Pattern
   1. Preset Parameter
   2. Computer analyzes positively or negatively deflected QRS complexes
   3. Automatic Pacer Spike Rejection
   4. Most discriminating due to 3 separate identification criteria
      a. Height of R wave
      b. Width of QRS complex
      c. Slope of the R wave
   5. Prefers regularity in the rhythm and unipolar QRS complex
   6. Limited by
      a. Low amplitude R wave
      b. Wide QRS (> .135 seconds)
      c. Irregular rhythms
7. Trigger Exercise

Exercise (10)

a. The following rhythm is creating Purge Failure and ECG Trigger Loss Alarms. What do you suspect is the problem? What actions should you take to remedy the situation?
Exercise (11)

b. What evidence now appears to assure you that the Trigger is now reliably present?

Figure 63
B. ECG Peak Trigger Mode

1. Computer analyzes positively or negatively deflected QRS complexes
2. Automatic Pacer Spike Rejection
3. Identification criteria
   a. Height of the R wave
   b. Slope of the R wave
4. Trigger mode of choice with widened QRS
   a. Bundle branch block
   b. Supra-ventricular rhythms with aberrant conduction
   c. V-Paced or A-V Paced
   d. Ventricular origin rhythms
5. Prefers regularity and unipolar QRS complex
6. Limited by
   a. May not screen out tall P or T waves
   b. Movement artifact may also meet identification criteria
   c. Irregularity
7. Trigger Exercise
   Exercise (12)
   a. Identify the problem with the following strip and suggest corrective action.
C. A-FIB Trigger Mode

1. Computer analyzes R wave same as Peak
2. Automatic pacer spike rejection
3. Automatic R wave deflation
4. Operator sets inflation timing: pump sets deflation timing
5. Trigger of choice with irregular R-R intervals
   a. Atrial fibrillation
   b. SVT with early or aberrant conduction beats
   c. Sinus rhythm with multiple ectopic beats

Figure 65  Note good afterload reduction

Figure 66  Note variable width BPW
10. Triggering the Arrow International Balloon Pumps

6. Limited by
   a. Late inflation

   ![Figure 67](image)

   b. Patient's response may be less than optimal at rapid rates (140-200)

   1) The theory of real timing is that if the IAB is actively deflating during
      the pre-ejection phase and mechanical systole, the deflation action will
      pull (or assist in the evacuation of) blood from the left ventricle, increasing
      CO and unloading. The generally accepted “safe” condition is that the IAB
      must be at least 50% deflated at the beginning of mechanical systole. R-wave
      deflation may result in this dynamic or may also result in the IAB being fully
      deflated before mechanical systole begins. It may also result in late deflation
      or having the IAB more that 50% inflated at the start of mechanical systole,
      which could result in ↑MVO₂ and ↓CO.

   2) Timing characteristics:
      Correct: Elevated BAEDP with normal dp/dt upstroke
               Hemodynamics should show improvement in LVSWI and Cl
      Late: Elevated BAEDP with decreased dp/dt
             Slow dp/dt and/or very depressed APSP

   ![Figure 68](image)
D. V-PACE Trigger Mode

1. Computer analyzes ventricular pacer spike
2. Requires 100% paced rhythm
3. Option available in the absence of a suitable R wave
4. Appropriate for ventricular or A-V sequentially paced rhythms
5. Must use ECG lead I, II, III

6. Limited by
   a. Invalid with ESIS ON on KAAT
   b. Demand pacemakers (when demand is not 100%)

Can resume pumping if Trigger becomes available again within 8 seconds otherwise will initiate ECG TRIGGER LOSS Alarm
E. A-PACE Trigger Mode

1. Computer analyzes atrial pacer spike
2. Requires 100% paced rhythm
3. Option available in the absence of a suitable R wave
4. Appropriate for atrial paced rhythms only
5. Must use ECG lead I, II, III

Figure 71

6. Limited by
   a. Demand pacemakers (when demand is not 100%)

Figure 72

Intermittent Atrial Pacing in PEAK Trigger Mode (or Pattern)
7. Trigger Exercise

Exercise (13)

You are called to the bedside to assist another nurse who reports an inability to time the IABP effectively. What is the problem?

Figure 73
F. Arterial Pressure (ART PRES or AP) Trigger Mode

1. Computer analyzes systolic upstroke of AP wave
2. Requires regular, artifact free pressure tracing
3. Identification criteria
   a. Slope of upstroke of AP wave
   b. Requires regular peak to peak interval (requires regular peak height)
   c. Requires correct deflation timing (late deflation may interfere with AP upstroke)
4. Option available where ECG is unavailable or distorted
   a. ECG electrode patch change during a bath
   b. Broken ECG cable
   c. “Noisy” ECG due to electro-cautery in OR, extreme shivering, or seizure activity
   d. Extremely low voltage QRS
   e. During CPR with functional A-line

5. Limited by
   a. Irregularity - caused by irregular rhythm, respiratory variations in tracing due to mechanical ventilation, irregular rate or depth chest compressions
   b. Late deflation
G. Internal Trigger Mode

1. Electronically generated from within the console, therefore asynchronous
2. Rate selection variable (40-120)
3. Confirmation required – Depress Internal twice on M-7000, KAAT II and KAAT II PLUS®
4. "Warning: Internal trigger selected" appears over ECG trace
5. Option available in the absence of organized myocardial activity
   a. On cardio-pulmonary bypass
   b. Cardiac Arrest – to prevent balloon from being dormant, no hemodynamic benefits
      1) Pump Off
      2) Select Internal Trigger Mode
      3) Decrease ratio to 1:8
      4) Pump On
      5) Continue CPR
6. Choose another trigger mode as soon as organized myocardial contractions resume, increase ratio to 1:1.
7. Limited by:
   a. Failure to Confirm

   If you forget to Confirm Internal Trigger Mode, the pump actually remains in the last chosen trigger mode, and will usually generate a Purge Failure Alarm due to lack of trigger with which to synchronize.

   After Confirmation, a Warning message appears over the ECG and Internal Trigger is denoted on the recorder strip.
H. More Exercises

Exercise (14)

1. The following strip is observed while in ECG Pattern mode with an alarm of ECG Trigger Loss. If the pump had been in the OFF position, an alarm of Purge Failure would occur when an attempt to initiate pumping was made. What is the most likely cause? How can you get the pump to resume pumping?

![Figure 78](image.jpg)

Exercise (15)

2. You are consulted to help set the timing in the following patient. You note that the selected trigger mode is ECG Pattern.

What do you suspect is the problem? How can you get the pump to work more effectively?

![Figure 79](image.jpg)
Exercise (16)

3. You are taking care of an elderly woman who has a partially ruptured papillary muscle following an MI. A 40cc IAB was inserted for support along with low dose Dobutamine and Neosynephrine. For several hours the patient responds well. Suddenly her blood pressure bottoms out necessitating a large increase in vasopressor support. Now the IABP is alarming frequently with a message of HIGH PRESSURE. What might be the cause of the alarms?

Figure 80
Exercise (17)

4. Name 2 trigger modes that could produce reliable pumping for this patient.

Figure 81

Exercise (18)

5. What is this patient's rhythm? Which trigger modes would you consider using?

Figure 82
10. Triggering the Arrow International Balloon Pumps

Exercise (19)

6. Would arterial pressure trigger be a wise choice here? What could cause this? What actions would you take to troubleshoot the art line to reduce artifact?

![Figure 83]

Exercise (20)

7. What patient condition would you suspect based on the arterial pressure recording? What would you do about the ECG trace/trigger?

![Figure 84]
10. Triggering the Arrow International Balloon Pumps

Exercise (21)

8. The following was reported to be the intra-operative recordings of ECG and AP waveforms through P hono inputs from a loaner monitor. What is the problem and what would you do?

Figure 85

Exercise (22)

9. The following strip was obtained on a patient you are admitting from the cath lab following a temporary pacemaker insertion. What would be the most reliable method for connecting this patient to the IABP? Once the patient is connected, what trigger mode would you select? Why?

Figure 86
10. Triggering the Arrow International Balloon Pumps

Exercise (23)

10. Analyze this strip in terms of augmentation and triggering. What trigger mode was selected? How do you know?

![Figure 87](image)

Exercise (24)

11. Analyze this strip and select a trigger mode.

![Figure 88](image)
Exercise (25)

12. Analyze this strip and select a trigger mode.

![Figure 89]

Exercise (26)

13. Analyze this strip and select a trigger mode.

![Figure 90]
Exercise (27)

14. You are admitting a patient post op CABG. The IABP has been inserted to get the patient off CPB. The pump seems to be triggering consistently, however, something does not look right. What is the problem with the following strip? What trigger mode do you think is currently selected? What trigger mode(s) would you use?

---

Figure 91

Exercise (28)

15. You are caring for a patient after the insertion of a temporary pacemaker. What trigger mode(s) would you use with the following strip. What would you consider doing if the patient was not 100% paced?

---

Figure 92
10. Triggering the Arrow International Balloon Pumps

Exercise (29)

16. What possible trigger modes could you use to produce the following strip?

![Figure 93](image)

Figure 93

Exercise (30)

17. List the possible reasons for the augmentation in the following strip.

![Figure 94](image)

Figure 94
10. Triggering the Arrow International Balloon Pumps

Exercise (31)

18. Analyze the following strip taken from a patient 1 hour after admission from surgery for an MVR.
   Is there a timing problem? Triggering problem?

Figure 95
Exercise (32)

19. The following strip was obtained on a patient with severe cardiomyopathy awaiting transplant with the IAB in place on a 1:2 assist ratio. What is the problem? What trigger mode(s) might be more effective?

Figure 96
Exercise (33)

20. The pump is working fine in a 1:2 assist ratio. But whenever you change the assist to 1:1, it immediately alarms with a message of POSSIBLE HELIUM LOSS. What do you think is going on?

![Figure 97](image)

Exercise (34)

21. Your patient has been 100% AV paced since surgery. The patient has been steadily improving over the last several hours. The trigger mode that is currently selected is PEAK. On assessing the timing during your normal hourly check you notice the following:

![Figure 98](image)

What do you think is the problem? What should you do to fix it?
Exercise (35)

22. The patient had an IAB inserted in the CVL earlier today. On assessing timing you notice the following:

What do you think is happening to cause the arterial line waveform to give this picture? What do you need to do?

Exercise (36)

23. This patient had a CABG today. Two atrial and two ventricular temporary pacing wires were inserted during surgery in case of need to pace post-operatively. Initially the patient was in NSR. Three hours post-operatively his heart rate slowed, and temporary AV sequential pacing was initiated since this patient was known to be dependent on his atrial kick. What is wrong with the ECG? What timing error can you appreciate even though the pump is in 1:1? Why is the augmentation poor?
Exercise (37)

24. You are managing the IAB pump in the OR on a 57 year old male having coronary artery bypass surgery. The procedure is being done without going onto the bypass machine. You have been pumping with the balloon pump on an assist ratio of 1:1 for 3 hours. The alarms have been off for the procedure and the pump has been functioning well. You now are beginning to observe the message of HELIUM LOSS on the screen. This is the rhythm strip.

![Rhythm strip](image1)

There is no blood noted in the gas line. Also there are no kinks observed. What is your assessment and what action do you take? Just pressing the RESET does not correct this alarm message.

Exercise (38)

25. The patient is 100% atrially paced. The MA on the pacer is set at 20. Currently the pump is in AP trigger. Every time you try to pump in PATTERN or PEAK the pump double triggers. Why? What can you do to correct this?

![Rhythm strip](image2)
Use of the IABP During Cardiac Resuscitation

In the event of cardiac arrest in a patient on the IABP, the loss of the ECG and Arterial pressure wave will result in a loss of the trigger signal to the IABP. This will generally cause a TRIGGER LOSS alarm and stop counterpulsation. It is strongly recommended that one of the following options be instituted to minimize patient risk of thrombus formation.

1. If counterpulsation is to be continued and synchronized to the CPR effort, then ARTERIAL TRIGGER should be selected*. If the CPR generates sufficient blood pressure, then in most cases, the IABP will pump and may improve perfusion. In the event that the CPR cannot generate a consistent and reliable trigger, then additional steps should be taken as follows.

2. A trigger signal generated by the IABP is available through the use of the INTERNAL TRIGGER mode. To select INTERNAL, the INTERNAL TRIGGER key must be depressed TWICE. This is done to prevent inadvertent selection of INTERNAL. In most cases, clinicians may decrease the assist interval or decrease the volume of the IAB. This trigger will maintain movement of the IAB and therefore reduce the risk of thrombus formation.

WARNING: The use of INTERNAL TRIGGER will produce asynchronous counterpulsation and therefore should never be used in the event that the patient has an ECG or Arterial pressure source available. Once the ECG or Arterial signal has been reestablished, the trigger mode must be changed from INTERNAL to an acceptable patient trigger.

3. If the IABP is not used in one of the above methods and the IABP is turned OFF, the IAB should be manually inflated with approximately 40cc of room air via the IAB connector. Manual inflation should be done 4 to 5 times every thirty minutes that counterpulsation is discontinued.

NOTE: Some clinicians have reported the successful use of the ECG TRIGGER by placing an ECG electrode close to the CPR site. The mechanical motion of the ECG Electrode may produce enough voltage on the ECG waveform to be used. If this maneuver is attempted, the PEAK TRIGGER mode should be used.

Eight Hour Program: Troubleshooting Beyond the Basics Program Schedule

<table>
<thead>
<tr>
<th>Morning</th>
<th>Afternoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 – 8:15 Registration</td>
<td>11:15 – 12:00 Potential Problems with Helium Delivery</td>
</tr>
<tr>
<td>8:15 – 8:30 Review of Principles of Counterpulsation</td>
<td>12:00 – 1:00 Lunch</td>
</tr>
<tr>
<td>8:30 – 9:00 Preventative Maintenance</td>
<td>1:00 – 2:00 Potential Problems with Helium Delivery (continued)</td>
</tr>
<tr>
<td>9:00 – 9:20 Possible “Power On” Problems/Remedies</td>
<td>2:00 – 2:30 Triggering Options</td>
</tr>
<tr>
<td>9:20 – 10:00 Troubleshooting Tools</td>
<td>2:30 – 2:45 Break</td>
</tr>
<tr>
<td>10:00 – 10:15 Break</td>
<td>2:45 – 4:00 Hands-On</td>
</tr>
<tr>
<td>10:15 – 11:15 Possible Patient Connection Problems/ Remedies</td>
<td>4:00 – 4:10 Post Test and Evaluations</td>
</tr>
</tbody>
</table>

Program Description

This program has been developed for the clinician with previous IABP experience. Emphasis will be on advanced troubleshooting on Arrow International Intra-Aortic Balloon Pumps through case studies for the expert user.

Program Objectives

Following the lecture, case study presentations and group discussion, the participant will be able to:

1. Identify three (3) methods used to interface with the Arrow IABP System and rationale for each.
2. List the seven (7) trigger choices on the Arrow IABP, trigger acquisition requirements for each and appropriate troubleshooting for trigger-related alarm situations.
3. Discuss the differences between Real timing and Conventional timing in irregular rhythms.
4. Identify two (2) abnormal Balloon Pressure Waveforms and list their associated alarm condition, along with appropriate troubleshooting to correct the alarm condition.
5. Demonstrate proper setup and operation of the IABP.
IABP Timing Algorithm

Identify assisted/unassisted pressure landmarks

Is there a dicrotic notch?

YES

NO

Late Inflation

Does the inflation point just cover the dicrotic notch?

YES

NO

Optimal Inflation

Early Deflation

Is APSP = PSP? Is there a “U” at end diastole?

YES

NO

Early Inflation

Is BAEDP < PAEDP?

YES

Deflation is Optimal

NO

Late Deflation

Developed by Andrea Bowman, RN, BSN, CCRN, CCU Staff Nurse at Good Samaritan Hospital, Portland, Oregon
Troubleshooting Algorithm: High Baseline

Note: You may want to turn alarms off momentarily while troubleshooting.

**RESTART PUMP ON.**
Is the baseline fill pressure at 2.5 mg Hg?

- **NO**, it begins pumping at a higher baseline.
- **Internal transducer needs calibrating. Call Arrow.**

**YES, but the baseline quickly rises.**

- **Check for kinks:**
  - connecting tube
  - sutures around sheath/catheter

**YES, internal kink found.**
If augmentation & hemodynamic effects are poor, it may be advisable to insert a new IAB.

- **NO external kinks.**
  Check for internal kinks via CXR (a/p, lateral) or fluoroscopy.

- **NO internal kinks found.**
  Call Arrow.
Troubleshooting Algorithm: Plateau Rounding

Is the patient hypertensive?

NO, pressure is less than 135mm Hg.

YES, BPW will return to normal when the BP is lowered.

Turn pump off. Decrease IAB volume 2cc at a time. Check BPW after each decrease for return of the peak inflation artifact.

NO, BPW remains rounded.

YES, catheter is too large for the patient. Run at reduced volume (no less than 2/3 of the balloon's capacity volume). Consider replacing IAB with smaller size.

Check for kinks in the connecting tubing and internally.

NO, tubing/catheter unimpeded.

YES, correct and resume pumping.

Perform leak test procedure. Is there a leak?

NO, leak detected.

YES, correct the leak if outside of console. If inside, call Arrow.

Is the IAB completely unwrapped?

IAB shows up very well under fluoro. Observe diastolic augmentation.

YES, IAB appears to be fully unwrapped.

NO, IAB not fully unwrapped. Repurge using the standby mode, resume pumping and recheck. Manually inflate with syringe (at connection) at 10cc greater than IAB volume. If balloon will not unwrap and augmentation is poor, insert a new catheter and contact Arrow.

Call Arrow.

Note: You may want to turn alarms off momentarily while troubleshooting.
Quick Reference

To Start Pump:

1. Patient Connections
2. Power On
3. Pump On

Preset Parameters:

1. Assist Ratio 1:2
2. Trigger Source Pattern (ECG)
3. ECG Source Lead II (Skin), Monitor/Slave (P-N Cable)
4. AP Source Transducer (Direct)
5. Balloon Volume Volume Automatically Set When Balloon Connected
6. Calibration Auto
7. Timing Safe Timing
8. Alarms On

Automatic Features:

1. Automatic Purging at Start-Up — Provides rapid initiation of counterpulsation
2. Automatic Helium Refill Without Interruption in Pumping — Based on a beat-to-beat analysis of IAB pressure waveform
3. Automatic Water Vapor Removal Without Interruption in Pumping
4. Automatic Preset Parameters — For safe and rapid initiation of counterpulsation
5. Automatic Calibration — Arterial pressure, ECG size, and BPW
6. Automatic Timing — Will monitor and adjust timing changes based upon beat to beat changes in heart rate
7. Automatic Alarm Specific Troubleshooting Information
8. Automatic Alarm Printout

(The following features apply to ACAT™1 only.)
9. Continuous Autogain
10. Automatic Reset of Class 2 and some Class 3 Alarms
11. Automatic Signal Recognition -3 or 5 Lead ECG Cables with Automatic Recognition of the Cable Type and Correct Lead Selections for each cable
## Recommended IABP Triggers*

<table>
<thead>
<tr>
<th>Rhythm</th>
<th>Pattern</th>
<th>Peak</th>
<th>ARB</th>
<th>V-Pace(^1)</th>
<th>A-Pace(^2)</th>
<th>AP</th>
<th>INT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R-Wave criteria:</td>
<td>Wide Complex</td>
<td>Varying R-R</td>
<td>100% Paced</td>
<td>100% Paced</td>
<td>(Consistent BP)</td>
<td>Rate 80 automatic Range 40-120</td>
</tr>
<tr>
<td></td>
<td>25-135 msec.</td>
<td>QR S</td>
<td>Automatic R-Wave deflation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSR</td>
<td>*</td>
<td>*</td>
<td>*(^4)</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>S Brady</td>
<td>*</td>
<td>*</td>
<td>*(^4)</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>S Tachy</td>
<td>*</td>
<td>*(^5)</td>
<td>*(^4)</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Cautery Interference</td>
<td></td>
<td></td>
<td>*(^6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSR with Premature Beats</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(atrial)(^2)</td>
<td>(vent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSR with Pauses</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>if severe</td>
</tr>
<tr>
<td>PAT/SVT</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrial Flutter</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>if irregular</td>
</tr>
<tr>
<td>Atrial Fibrillation</td>
<td>*(^3)</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrial Pacing</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>demand</td>
<td>demand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100% paced</td>
</tr>
<tr>
<td>Ventricular Pacing</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>demand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100% paced</td>
</tr>
<tr>
<td>A-V Pacing</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>demand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100% paced</td>
</tr>
<tr>
<td>RBBB, LBBB</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>CPR</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>first choice</td>
</tr>
<tr>
<td>Bypass-Pulsatile flow System Test</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Applies to KAAT Series and ACAT™1 SERIES IABP.

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.
**Triggering Modes**

The seven trigger modes on the Arrow International IABP console are explained below:

**ECG Pattern**
The pre-set (default) trigger mode. The computer analyzes the height, width, and slope of a positively or negatively deflected QRS complex. The width of the R wave must be between 25-135msec.

**ECG Peak**
The computer analyzes the height and slope of a positively or negatively deflected QRS complex. The trigger mode of choice for wide complex rhythms. Preferred trigger for heart rate >140.

**A-Fib**
The computer analyzes the QRS complex in the same manner as in the peak mode. The balloon will automatically be deflated whenever an R wave is sensed. The trigger mode of choice for rhythms with varying R to R intervals.

• Rejection of pacer spikes and artifact is automatic in ECG Pattern, Peak and A-Fib.

**V Pace**
The computer uses the ventricular spike as the trigger signal. Used with ventricular or AV paced rhythms. It is ESSENTIAL that the patient’s rhythm is 100% paced.

**A Pace**
The computer uses the atrial pacing spike as the trigger signal. This mode can only be used with 100% atrial paced rhythms.

**Arterial Pressure**
The computer uses the systolic upstroke of an arterial pressure waveform as the trigger signal. An option for clinical situations where an ECG is unavailable or distorted.

**Internal**
The balloon inflates and deflates at a preset rate regardless of the patient’s cardiac activity. Used in situations where there is no cardiac output and no ECG. Must be confirmed by an additional keystroke.

**During Cardiac Resuscitation**
If counterpulsation is to be continued and synchronized to the CPR effort, then Arterial Pressure should be selected. In the event that the CPR cannot generate a consistent and reliable trigger, Internal may be utilized.
Intra-Aortic Balloon Pumping
Reference List


Berne RM, Levy MN.  Cardiovascular Physiology. 6th ed. St. Louis, MO: Mosby Year Book; 1992


Gawlinski A.  Saving the cardiogenic shock patient. Nursing 1989:34-42


Intra-Aortic Balloon Pumping
Reference List (continued)


Palmer P. Advanced hemodynamic assessment. DCCN. May-June 1982;1(3):139-144


Quaal SJ. Comprehensive Intra-Aortic Balloon Pumping. 2nd ed. St. Louis, MO: CV Mosby CO;1993

Shoulders-Odom B. Managing the challenge of IABP therapy. Crit Care Nurse. 1990;11(2):60-76


