INTRA-AORTIC BALLOON PUMPING IN CARDIAC SURGERY

DR.K.ASHOK
IABP is a mechanical assist device that is used to improve the ventricular performance of the failing heart.

- Facilitates
  Increase in myocardial O2 supply.
  Decrease in myocardial O2 demand.
IAB is a cylindrical polyethylene balloon positioned in the aorta, 2cms distal to the left subclavian artery and counterpulsates.
COUNTERPULSATION

- IABP works by volume displacement and pressure changes caused by rapidly shuttling Helium gas in and out of the balloon.

- A computer-controlled mechanism inflates and deflates the balloon at precisely timed intervals.
HISTORICAL MILESTONES

• 1952: Realization that coronary perfusion mainly occurs during diastole

• 1958: Harken suggested removal of blood via the femoral artery during systole and replacing it rapidly in diastole as a treatment for LV failure.
HISTORICAL MILESTONES

1962  Kantrowitz and Moulopoulos - prototype

1967  1st successful Rx of cardiogenic shock

1969  The first commercially available IABP

1976  David Bregman - first use in heart surgery

1979  First double lumen surgical IAB catheter

1980  First Percutaneous IAB catheter
PROTOTYPE PUMP
PRESENT PUMPS
INSERTION TECHNIQUES

- Percutaneous
  - Femoral
  - Brachial
  - Axillary

- Surgical insertion
  - Femoral cut down
  - Trans-thoracic
BALLOON PLACEMENT
• The IAB Should be selected according to the following chart

**Clinical Reference Sizing Chart**

- **50 cc**: Approx. Height – Over 6’ (183 cm)
- **40 cc**: Approx. Height – From 5’4” - 6’ (163 cm - 183 cm)
- **34 cc**: Approx. Height – From 5’-5’4” (152 cm - 163 cm)
- **25 cc**: Approx. Height – Less than 5’ (152 cm)
PRIMARY EFFECTS OF IABP

Supply = Demand

IAB Inflation

IAB Deflation

$MVO_2$
**Diastole:**

- IAB Inflation

- Increase myocardial O$_2$ delivery
- Increased coronary collateral circulation
- Increased systemic perfusion pressure

**Systole:**

- IAB Deflation

- Decreases afterload and preload
- Decrease myocardial O$_2$ consumption
- Increase cardiac output
SURGICAL INDICATIONS

- Pre-operative severe LV dysfunction
- Post surgical LCOS
- Refractory ventricular arrhythmias
- Inability to wean from CPB
- Acute ventricular septal rupture / Acute MR
- Bridging device for Cardiac Transplant
CARDIOGENIC SHOCK
• Pre-Shock Syndrome
• Extensive MI
• Refractor y arrhythmias
• Cardiac Contusion

MEDICAL INDICATIONS

• Support for
  • Coronary Angio
  • PCI
  • Thrombolysis
  • High risk interventions
LV Dysfunction

Vasoconstriction
- Na & H₂O retention

Revascularization

Coronary occlusion

Ischemia

↓ Contractile mass

↓ Arterial pressure

↓ Coronary flow

↓ Ischemia

↑ Sympathetic tone

↑ RAS

Inotropes

IABP Therapy
CONTRAINDICATIONS

- Aortic Insufficiency
- Dissecting Aortic Aneursym
- Severe atherosclerosis
- End-stage terminal disease
- Abdominal Aortic Aneurysms, not resected
TIMING

- IABP timing is the key to a successful outcome.
- The wrong timing is damaging.
HOW IS PROPER TIMING ACHIEVED?

• Always performed using the arterial pressure waveform as the guide
A = One complete cardiac cycle
B = Unassisted aortic end diastolic pressure
C = Unassisted systolic pressure
D = Diastolic Augmentation
E = Reduced aortic end diastolic pressure
F = Reduced systolic pressure

Increased Coronary Artery Perfusion

Reduced Myocardial O₂ Demand
CORRECT INFLATION

AORTIC VALVE CLOSURE

Just prior to dicrotic notch
CORRECT DEFLATION

PAEDP

AORTIC VALVE OPEN
TRIGGERING

• The computer in the IAB console needs a stimulus to cycle the pneumatic system which inflates and deflates the balloon.

• TRIGGERS
  • R wave of the ECG
  • Arterial pressure waveform
  • Pacing spikes
ECG PATTERN

• This is the preset trigger mode.
• The computer analyzes the height, width and slope of a positively or negatively deflected QRS complex.
FOR GOOD, CONSISTENT TRIGGERING IT IS IMPORTANT TO PROVIDE THE PUMP WITH A GOOD ECG SIGNAL

**Good Choices** –
Unidirectional QRS with minimal artifact

**Poor Choices** –
Biphasic QRS, tall T or P waves, wandering baseline, artifact present
Arterial Pressure

The computer uses the systolic upstroke of the arterial pressure waveform as the trigger signal.

This mode is an option when an ECG is unavailable or distorted.
The balloon inflates and deflates at a preset rate regardless of the patient’s cardiac activity.

This mode is only to be used when there is no cardiac output and no ECG.

Preset rate is 80 bpm; can be varied between 40 to 120.
### SIGNS OF IMPROVED CLINICAL CONDITION

<table>
<thead>
<tr>
<th>Condition</th>
<th>Inflation</th>
<th>Deflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased cardiac output, 0.5 – 1 L/min</td>
<td></td>
<td></td>
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<tr>
<td>Increased urine output</td>
<td></td>
<td></td>
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<tr>
<td>Decreased preload</td>
<td></td>
<td></td>
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<tr>
<td>Decreased pulmonary congestion</td>
<td></td>
<td></td>
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<tr>
<td>Improved mentation</td>
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<td></td>
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<tr>
<td>Decreased heart rate</td>
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<td></td>
</tr>
<tr>
<td>Decreased lactic acidosis</td>
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<td></td>
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<tr>
<td>Increased pulse pressure</td>
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</tbody>
</table>
PATIENT CARE

- Heparinisation
- Serial activated clotting time
- Distal limb pulses - digital / doppler
- Distal limb colour, temperature and function.
- Serial platelet counts
- Higher antibiotics
# COMPLICATIONS

<table>
<thead>
<tr>
<th>VASCULAR</th>
<th>BALLOON related</th>
<th>MISCELLANEOUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial injury (perforation, dissection)</td>
<td>Perforation</td>
<td>Hemorrhage</td>
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<tr>
<td>Aortic perforation</td>
<td>Tear</td>
<td>Infection</td>
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<tr>
<td>Aortic dissection</td>
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<td></td>
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<tr>
<td>Femoral artery thrombosis</td>
<td>Rupture</td>
<td>Entrapment</td>
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<tr>
<td>Peripheral embolization</td>
<td>Incorrect positioning</td>
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</tr>
<tr>
<td>Femoral vein cannulation</td>
<td>Gas embolization</td>
<td></td>
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<tr>
<td>Limb ischemia</td>
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<td></td>
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<tr>
<td>Visceral ischemia</td>
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</tbody>
</table>
OBSERVATION OF EARLY SIGNS OF COMPLICATIONS
- Limb ischaemia / Infection
- Balloon malpositioning
- Bleeding / thrombus

ENSURING PROPER FUNCTIONING OF IABP
- Correct timing
- Consistent triggering
- Troubleshooting alarms

EVALUATION OF PATIENT’S RESPONSE
- Hemodynamic status
- Systemic perfusion
- Relief of symptoms

NURSING CARE
- EVALUATION OF PATIENT’S RESPONSE
- OBSERVATION OF EARLY SIGNS OF COMPLICATIONS
- ENSURING PROPER FUNCTIONING OF IABP
Our Experience at SRM

- Total number of cardiac cases: 351
- Total number of CABGs: 76
  - On pump: 67
  - Beating heart: 09
- IABP usage: 05
PREOPERATIVE LV FUNCTION (n=76)

- NORMAL: 41%
- MILD: 30%
- MODERATE: 20%
- SEVERE: 9%

NUMBER OF PATIENTS
SURGICAL DATA

- Average number of bypass grafts: 3
- Cardiopulmonary bypass time (mins)
  - Range: 110 - 249
  - Mean: 175
- Aortic cross clamp time (mins)
  - Range: 80 - 100
  - Mean: 85.6
INDICATIONS FOR IABP (n=5)

1. Low Cardiac Output
2. Refractory Arrhythmias
3. Myocardial Stunning
INOTROPIC SUPPORT

- Dopamine 5
- Dobutamine 3
- Adrenaline 3
- Noradrenaline 1

CARDIAC PACING

- Ventricular pacing 1
DURATION OF MECHANICAL SUPPORT

- Intra aortic balloon pump: 18 – 49 hrs
- Mechanical ventilation: 14 – 60 hrs
- Cardiac pacing: 4 hrs

OUTCOME

- Morbidity: None
- Mortality: One
• From its initial clinical use, over 40 years ago, to its current extensive use, IABP has developed into sophisticated, computer-assisted technology for mechanically aiding circulation.
• Only assist device which has not undergone any major technical change since invention.
  - Simplicity of the technology
  - Least invasive among the LVADs
  - Proven efficacy

• Early aggressive strategy improves surgical outcomes
OTHER ASSIST DEVICES
VENTRICULAR ASSIST DEVICE (VAD)

• A mechanical pump that is surgically attached to one of the heart’s ventricles to augment or replace native ventricular function.

• Are powered by external power sources that connect to the implanted pump via a percutaneous lead (driveline) that exits the body on the right abdomen.
VENTRICULAR ASSIST DEVICES

• **LVAD** - the device is surgically attached to the LV of the heart and to the aorta for LV support

• **RVAD** - the device is attached to the right atrium and to the pulmonary artery
THORATEC pVAD

- Short term use (up to 2 years)
  - bridge to recovery
  - bridge to transplant
  - hospital discharge possible
HEARTMATE XVE LVAS

- Internally implanted, electric pump
  - left heart support only
  - Medium- to long-term therapy (months to years)
  - bridge to transplant
  - destination therapy
TOTAL ARTIFICIAL HEART

A synthetic replacement for the heart remains one of the long-sought holy grails of modern medicine.
THANK YOU