

2016

INTRA AORTIC BALLOON COUNTERPULSATION LEARNING PACKAGE



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[WSLHD 2/26/2016](#)

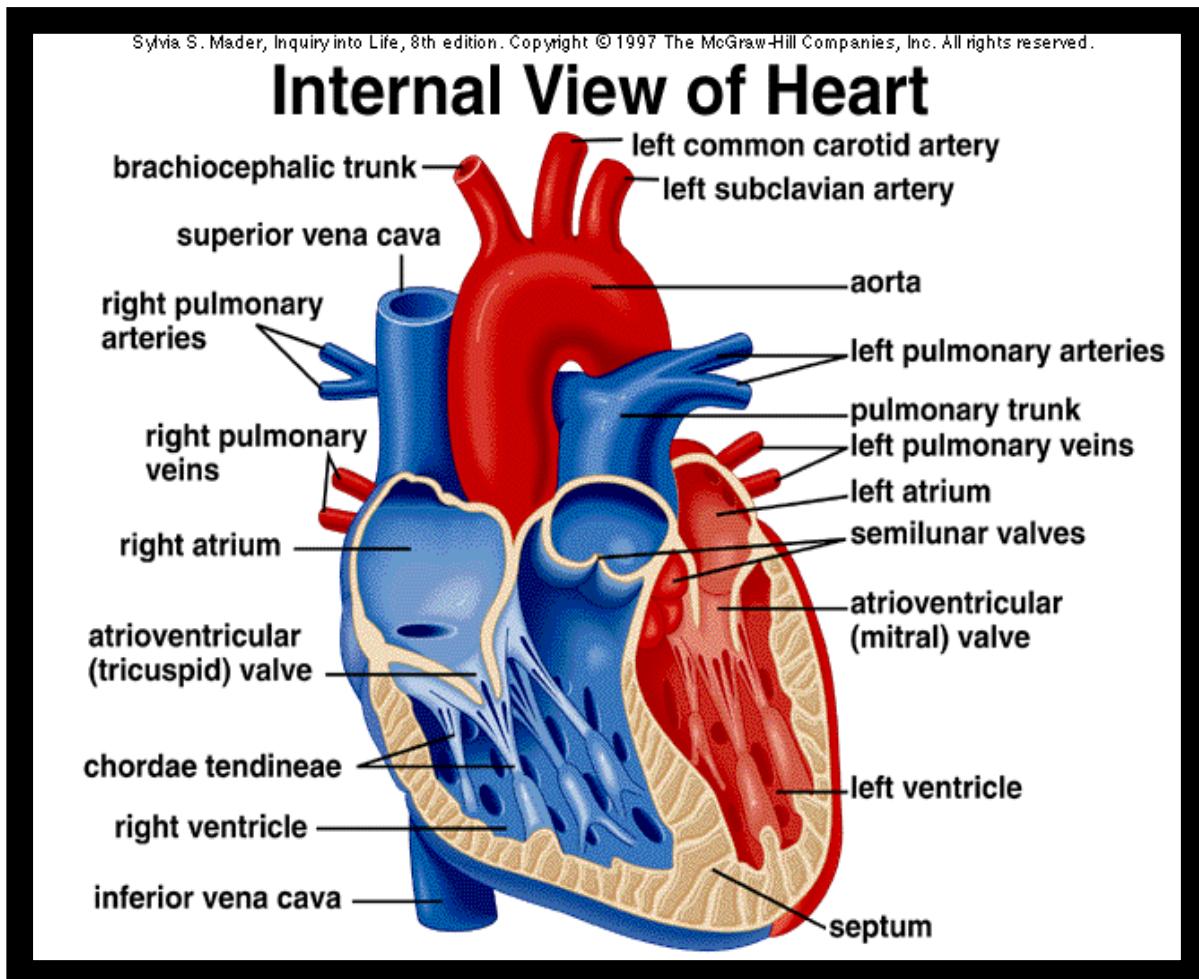
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ANATOMY & PHYSIOLOGY

- Heart is the centre of the cardiovascular system.
- It is a muscular organ located between the lungs in the mediastinum.
- The adult heart is about the size of a closed fist.
- The blood vessels form a network of tubes that carry the blood from the heart to the tissues of the body and then return it to the heart



Chambers of the Heart

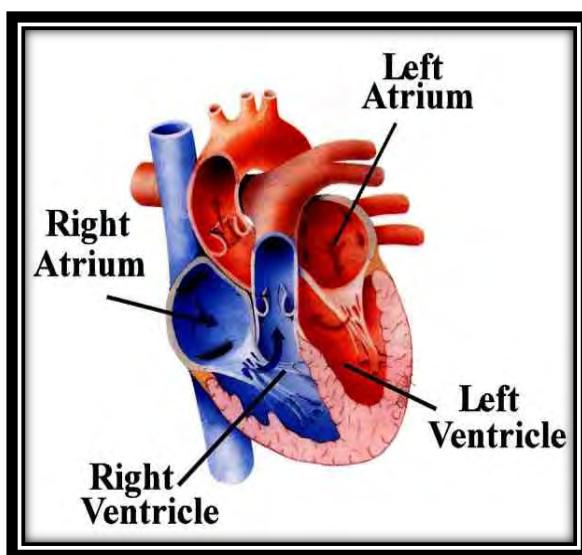
The heart has four chambers

Right and Left Atrium

- Are the smaller upper chambers of the heart
- The left atrium receives blood from the lungs
- The right atrium receives blood from the rest of the body
- The atrium allows approx 75% of blood flow directly from atria into ventricles prior to atria contracting.
- Atrial contraction adds 25% of filling to the ventricles; this is referred to as atrial kick.

Right and Left Ventricle

- larger lower chambers of the heart
- separated by the interventricular septum
- right ventricle pumps blood to the lungs
- left ventricle pumps blood to the rest of the body
- ventricles have thicker walls than the atria so they can work harder by pumping blood out to the body



Heart valves

The heart also has 4 valves. They prevent the blood from flowing backwards.

Atrioventricular Valves are the valves that lie between the atria and the ventricles

1. Tricuspid Valve
 - Is between the right atrium and the right ventricle
 - Consists of three flaps or cusps which are fibrous tissue
2. Mitral Valve
 - Lies between the left atrium and left ventricle
 - Consists of two cusps

Semilunar Valves are the two valves located between the pulmonary artery and the aorta that prevent blood from flowing back into the heart.

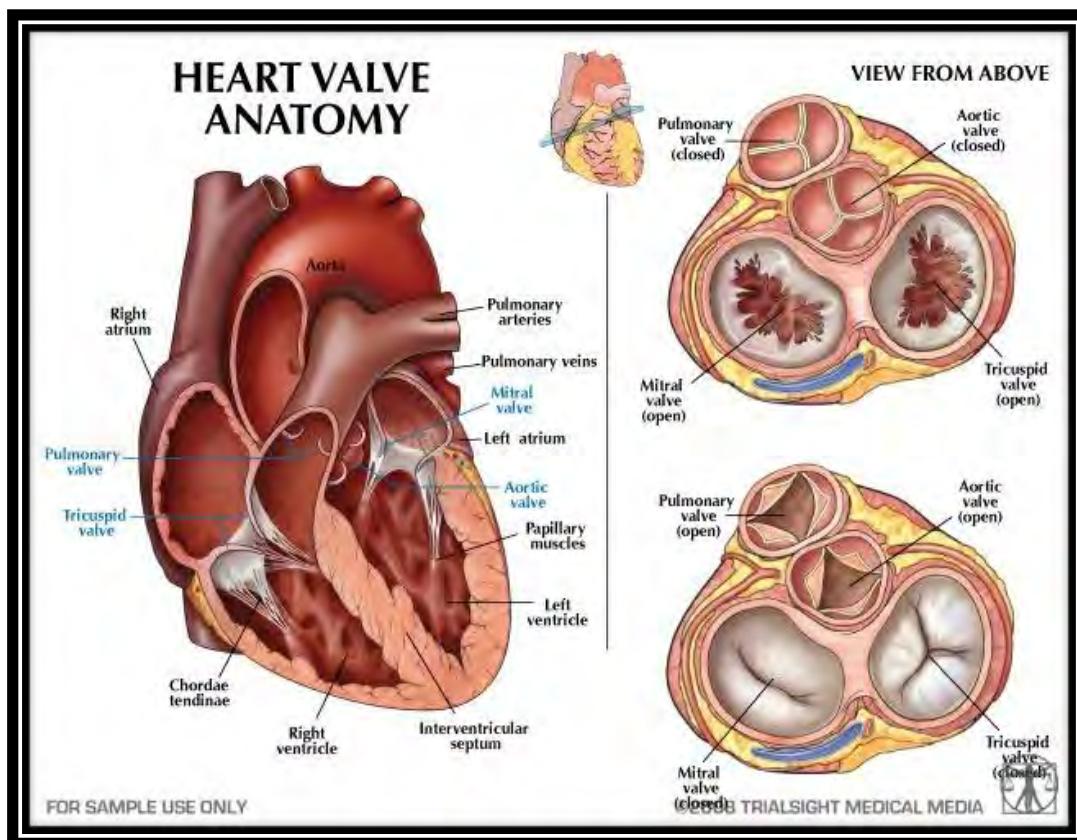
- Both valves consist of three semi lunar cusps.
- Permit blood flow in one direction from ventricles into the arteries.

3. Aortic Valve

- found at the base of the aorta and the left ventricle

4. Pulmonary Valve

- lies between the right ventricle and the pulmonary artery



Cardiac cycle

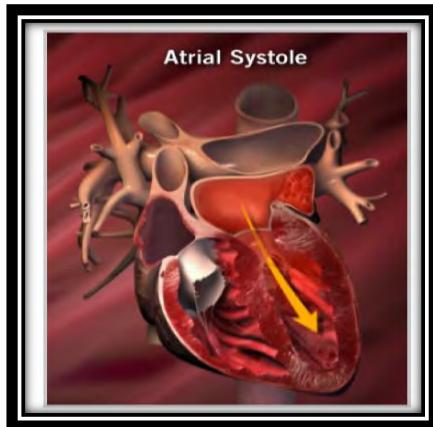
This term refers to all or any of the events related to the flow of blood pressure that occurs from one heartbeat to the next. (Guyton A.C & Hall J.E. 2006)

- In a normal heart beat, the two atria contract (systole) simultaneously while the two ventricles relax (diastole).
- Then when the two ventricles contract, the two atria relax.
- Every single beat of the heart involves 5 phases;
 1. Atrial systole (contraction)
 2. Isovolumetric contraction
 3. Ventricular systole/ejection
 4. Isovolumetric relaxation (diastole)
 5. Ventricular filling

ATRIAL SYSTOLE

- Is the contraction of the heart muscle of the left and right atria

- Electrical systole is the electrical activity that stimulates the myocardium to make the atria contract
- As atria contract the blood pressure in each atrium increases forcing additional blood into the ventricles
- AV valves open and blood flows from atria to ventricles
- The additional flow of blood is known as atrial kick
- 70% of blood flows passively down into the ventricles
- Atrial kick is absent if there is loss of the normal electrical conduction such as AF, and heart blocks
- Atrial contraction follows the P wave of the ECG



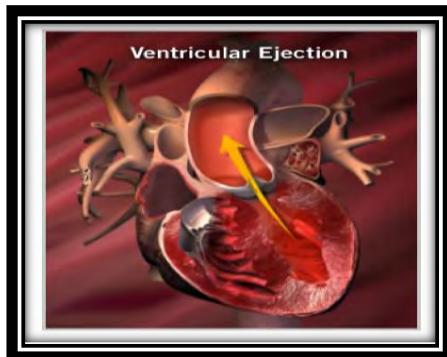
VENTRICULAR SYSTOLE

- Is the contraction of the muscles of the left and right ventricles
- As the ventricular pressure rises, the AV valves close, mitral before tricuspid and this can be heard as the first heart sound.
- An additional 0.02-0.03secs is required for the ventricle to build up sufficient pressure to push the aortic and pulmonary valves open against the pressures in the aorta and pulmonary artery.
- During this time, contraction is occurring in the ventricles with no emptying, and is known as **Isovolumetric contraction**

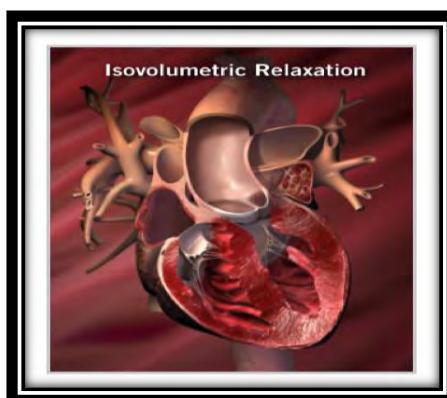


VENTRICULAR EJECTION

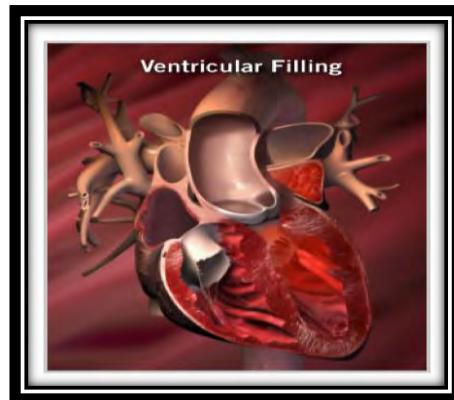
- Begins when the intraventricular pressure exceeds that of the aorta and pulmonary arteries and the semi lunar valves open, aortic before pulmonary.
- Immediately blood flows out of the ventricles, 70% occurs in the first third period of ejection (rapid ejection) and 30% during next two thirds (slow ejection)

**ISOVOLUMETRIC VENTRICULAR RELAXATION**

- At the end of this period the ventricles relax and the pressure falls below that of the aorta and the pulmonary arteries.
- The semi lunar valves now close and this constitutes the second heart sound.
- All the valves in the heart are closed and the intraventricular pressures fall.
- The opening of the AV valves terminates this when the pressure in the atria exceeds that in the ventricles.
- The stored atrial blood then flows into the ventricles.
- Ventricular depolarisation and subsequent contraction occur at 0.12-0.20 seconds (P-R interval on ECG) after similar events in the atrium.

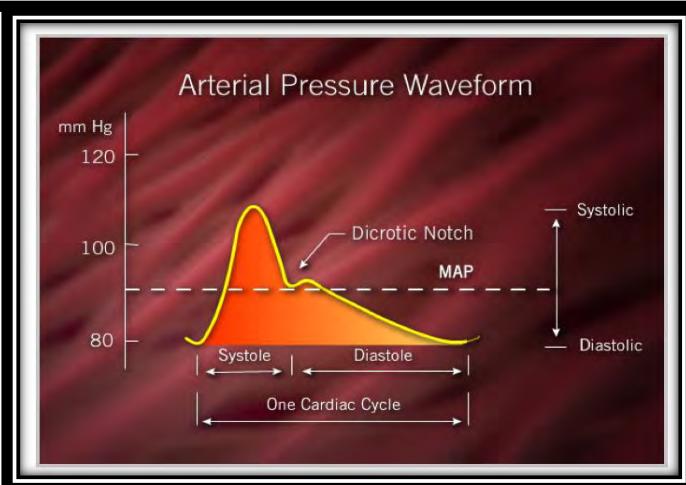
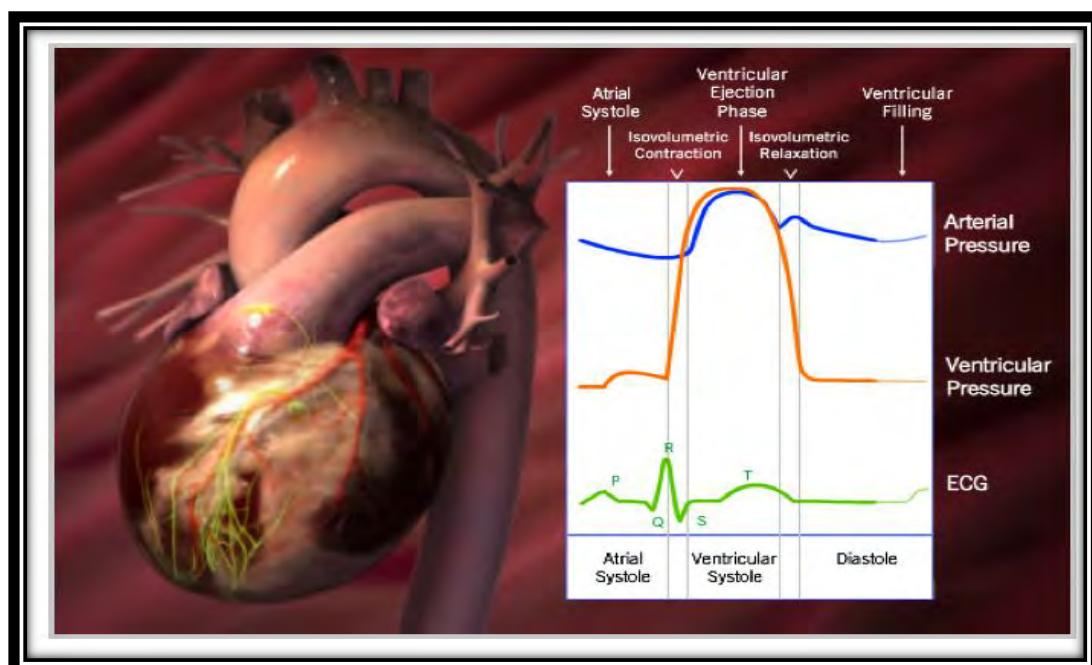
**VENTRICULAR FILLING**

- The initial filling of the ventricles is very rapid and the AV valves are wide open. However, in mid-diastole the valves move toward the closed position and then open again widely during atrial systole.



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Cardiac cycle & Electrical Events



Cardiac cycle represented on Arterial pressure waveform

- Dicrotic notch represents aortic valve closure

Coronary Circulation

The heart is supplied by two major coronary arteries, the right coronary artery and the left coronary artery.

The coronary arteries originate from the aorta immediately above the aortic valve.

Left coronary artery

- Arises from the left posterior aortic sinus as the Left main coronary artery and passes behind the base of the pulmonary artery. The left main coronary artery divides into the **Left Anterior Descending artery (LAD)** or the intraventricular artery and the **Left Circumflex artery (Cx)**.

Right coronary artery

- Arises from the anterior aortic sinus and courses through the right atrioventricular groove between the right atrium and right ventricle to the inferior part of the septum.

Circumflex Artery

- The circumflex (Cx) lies in the left AV groove between the left atrium and the left ventricle and supplies the vessels of the lateral wall of the left ventricle. These vessels are known as obtuse marginal's (M1, M2 etc) because they supply the lateral margin of the left ventricle and branch off with an obtuse angle.
- The circumflex artery also supplies branches to the left atrium.

Left coronary artery (LCA)

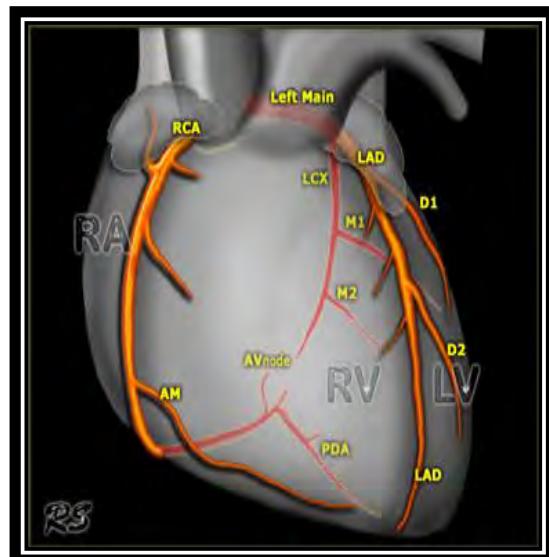
- Left anterior descending (LAD)
- Diagonal branches (D1,D2)

Circumflex (Cx)

- Marginal branches (M1,M2)

Right coronary artery

- Acute marginal branch (AM)
- AV node (branch)
- Posterior descending artery (PDA)



Overview of coronary arteries (Smithuis & Willems 2008)

- Most of the blood flow into coronary circulation happens during systole while the ventricle is relaxed
- Adequate diastolic pressure must be maintained to ensure perfusion of the coronary arteries and good myocardial oxygenation and or supply
- Heart rate, diastolic pressure (afterload) and filling (preload) all affect coronary artery perfusion and myocardial oxygen demand.

DETERMINANTS OF MYOCARDIAL OXYGEN SUPPLY AND DEMAND



The diagram illustrates the balance between myocardial oxygen supply and demand. A horizontal blue bar at the top is divided into two sections: "Supply" on the left and "Demand" on the right. In the center, between the two sections, is a yellow triangle containing the letters "MVO₂". This visualizes the concept that myocardial oxygen supply must equal myocardial oxygen demand for the heart to function adequately.

<ul style="list-style-type: none"> ▪ Coronary Artery Anatomy ▪ Diastolic Pressure ▪ Diastolic Time ▪ Oxygen Extraction <ul style="list-style-type: none"> ▪ Hemoglobin ▪ PaO₂ 	<ul style="list-style-type: none"> ▪ Heart Rate ▪ Afterload ▪ Preload ▪ Contractility
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Myocardial Oxygen Supply and Demand

Myocardial oxygen supply must balance myocardial oxygen demand for the heart to function adequately.

Factors that affect oxygen demands of the heart are

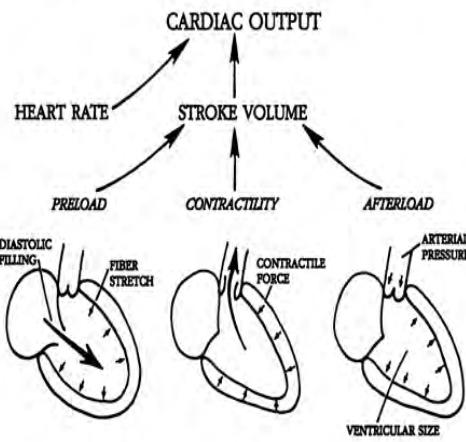
Heart rate

Preload

Afterload

Contractility

MEASUREMENT OF CARDIAC PERFORMANCE



The diagram shows the determinants of cardiac output. At the top, "CARDIAC OUTPUT" is shown with an upward-pointing arrow. Below it, "STROKE VOLUME" has two arrows pointing towards it from the left and right. An arrow points from "HEART RATE" to "STROKE VOLUME". Below "STROKE VOLUME", three factors are listed: "PRELOAD", "CONTRACTILITY", and "AFTERLOAD", each with an arrow pointing towards "STROKE VOLUME". Below these three factors are three anatomical illustrations of a heart in different states: "DIASTOLIC FILLING" (left), "CONTRACTILE FORCE" (middle), and "ARTERIAL PRESSURE" (right). Arrows point from each of these three illustrations to their respective factor labels ("PRELOAD", "CONTRACTILITY", and "AFTERLOAD").

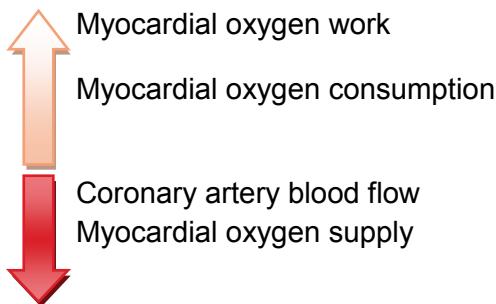
Cardiac Output = Heart Rate x Stroke Volume Normal = 4-6 L/Min.

Cardiac Index = $\frac{\text{Cardiac Output}}{\text{BSA}}$ Normal = 2.5-3.5 l/min/m²

Reprinted with permission from Pierce and Wilson, *Pathophysiology: Clinical Concepts of Disease Processes*, 1978, McGraw-Hill

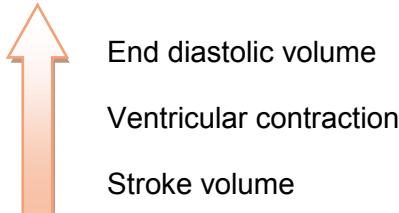
Heart rate:

- Increase in heart rate will

**Preload: (filling)**

- Is the pressure or stretching of the ventricle.
- It is the end-diastolic volume in the ventricle and serves as an estimation of average diastolic fibre length.

Left ventricular end diastolic volume will affect Left ventricular preload.



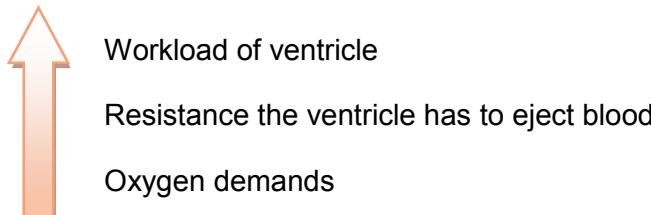
To a critical point (Starlings curve) then stroke volume decreases. This may lead to left ventricular failure.

- The Frank-Starling mechanism can be explained on the basis of preload.
- As the heart fills with more blood than usual, there is an increase in the load experienced by each muscle fibre.
- This stretches the muscle fibres, increasing the affinity of troponin C to Ca²⁺ ions causing a greater number of cross-bridges to form within the muscle fibres.
- This increases the contractile force of the cardiac muscle, resulting in increased stroke volume.
- The preload that provides optimal cardiac output varies from each patient and is dependent on ventricular size.

Afterload: (resistance/BP)

- Is the impedance to left ventricular contraction, is assessed by measuring systemic vascular resistance (SVR). It is the degree of constriction or dilatation of the arterial circulation.

Increase in afterload will



Contractility:

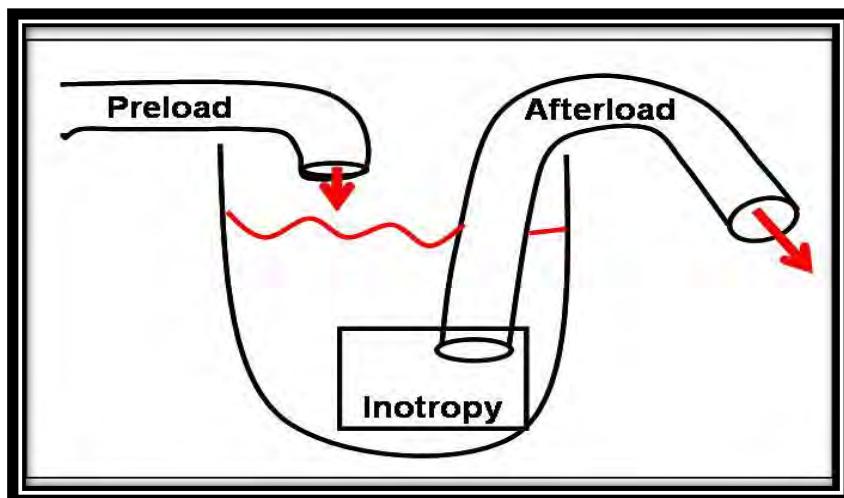
- Is the ability of the myocardial muscle fibres to shorten independent of preload and afterload.
- It is the ability of the heart to contract and the force at which it does so.

The force of contraction is determined by the concentration of calcium ions in the cells



Contractility by flooding cell with more calcium (beta agonist) or by keeping more calcium in the cell and not letting it escape.

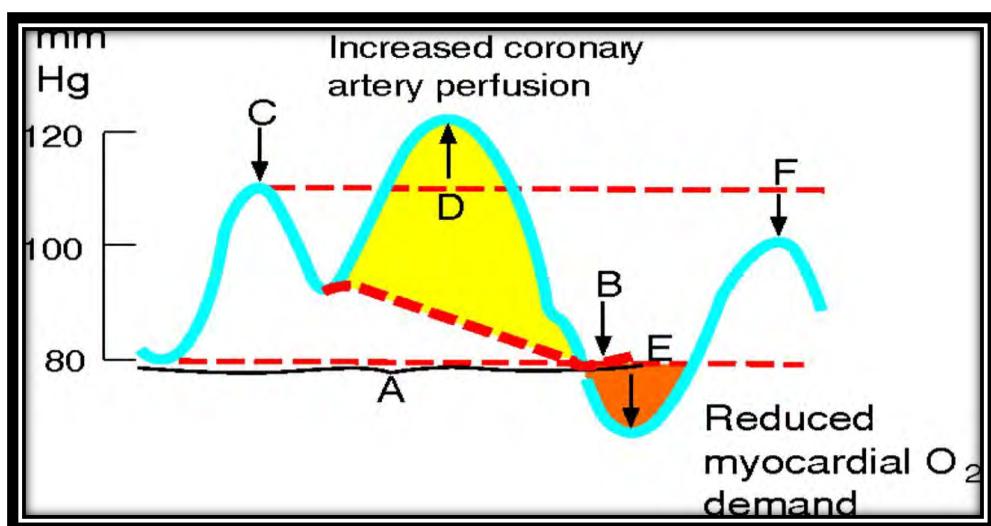
Contractility by using inotropic pharmacological agents, such as milronone, dobutamine and levosimendan. The choice of agent is individualised to the specific clinical situation.

**Summary**

Preload = tap filling the heart. The faster it turned on = more constriction ↑ preload

Contractility / Inotropy = Pump

Afterload = diameter of hose or resistance

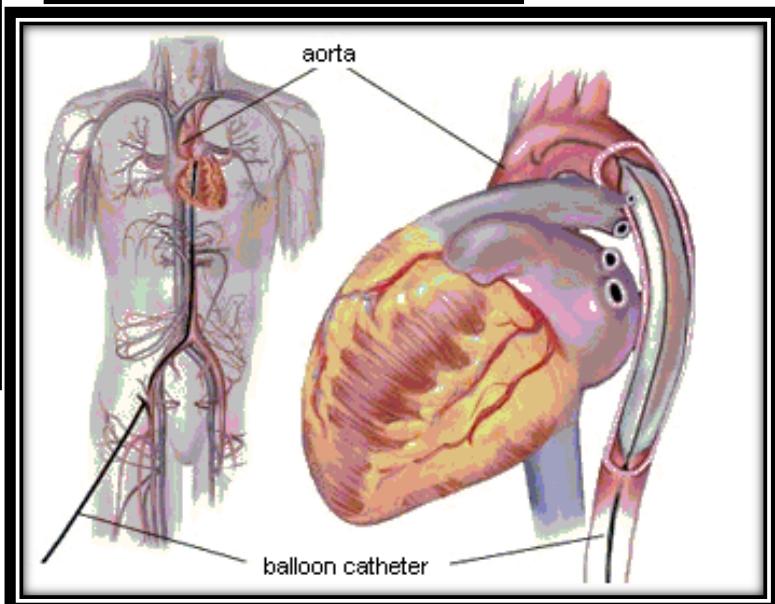
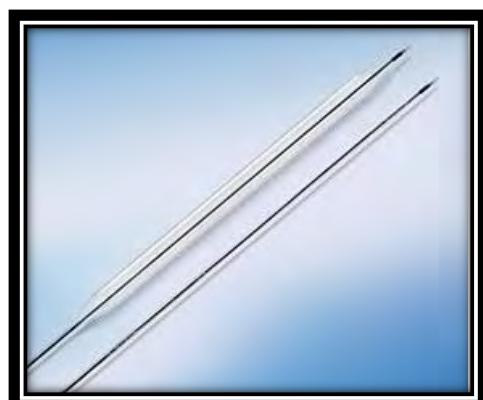


How does Intra Aortic Balloon Counterpulsation work?

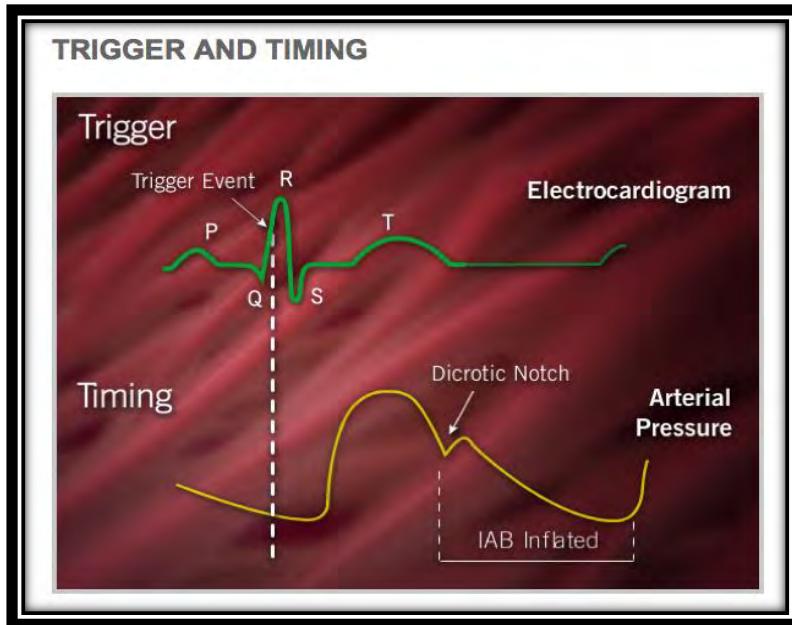
The catheter is inserted in most cases through a common femoral artery and advanced until the distal end is positioned in the proximal descending aorta, usually about one centimetre distal to the left subclavian artery.

The IABP is composed of two principal parts:

- A flexible catheter with one lumen that allows for distal aspiration/flushing or pressure monitoring and a second that permits the periodic delivery and removal of helium gas to a closed balloon.
- A mobile console that contains the system for helium transfer as well as computer control of the inflation and deflation cycle.



- IABP works using the principle of counter-pulsation. This refers to the alternating of inflation and deflation of the balloon, during diastole and systole.
- The mechanical pump uses the R wave on the ECG or the arterial systolic pressure to identify the cardiac cycle.
- Helium is used to fill the balloon and the balloon is rapidly inflated and deflated depending on the cardiac cycle



- IABP is required to be timed accurately to give maximum benefit.
- Inflation of the IABP should occur on the dicrotic notch of the arterial waveform.
- Deflation should occur prior to systole as indicated by the downward stroke.
- Inflation and deflation of the balloon has two major consequences:
 - Blood is displaced to the proximal aorta by inflation during diastole.
 - Aortic volume (and thus afterload) is reduced during systole through a vacuum effect created by rapid balloon deflation.

The IABP has the following primary effects:

- Increases coronary artery perfusion
- Increases myocardial oxygen supply
- Decreases myocardial oxygen demand
- Decreases myocardial work by reducing afterload
- Increases blood pressure

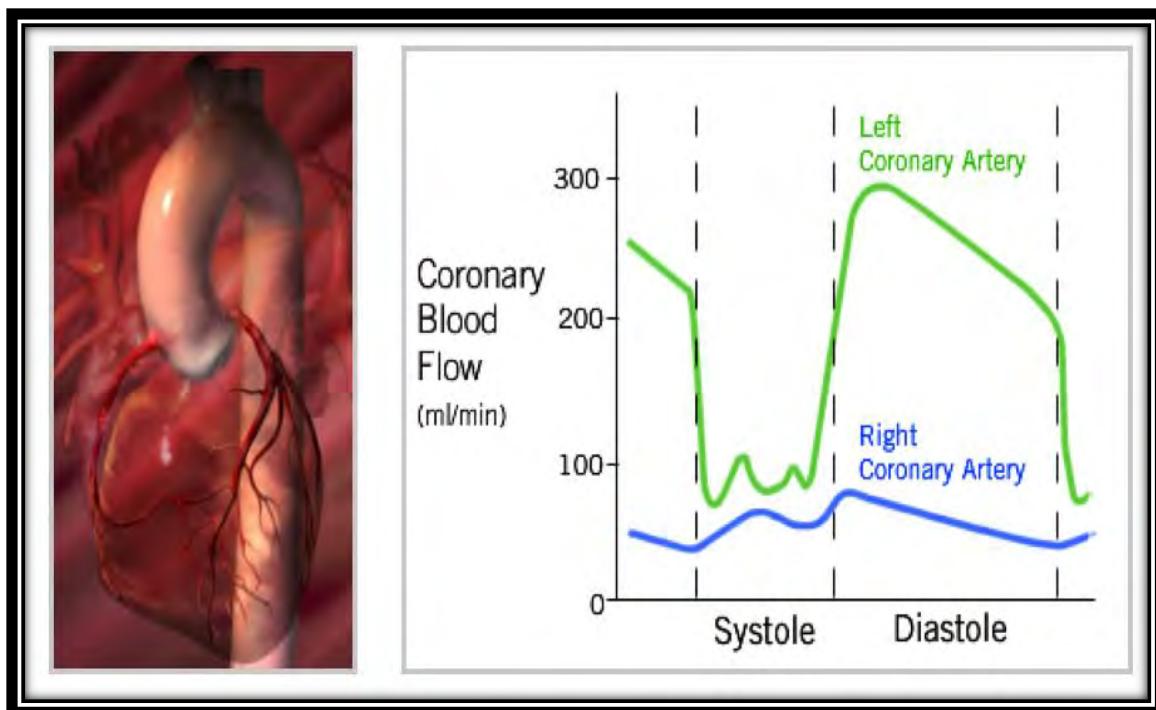
The IABP has the following secondary effects

- Decreases pulmonary artery pressure
- Decreases SVR
- Increases cardiac output and cardiac index

The IABP has the following systemic effects

- Increased cerebral perfusion
- Increased renal perfusion

These effects may be quite variable, and they depend upon the volume of the balloon, its position in the aorta, heart rate, rhythm, the compliance of the aorta, and systemic resistance³



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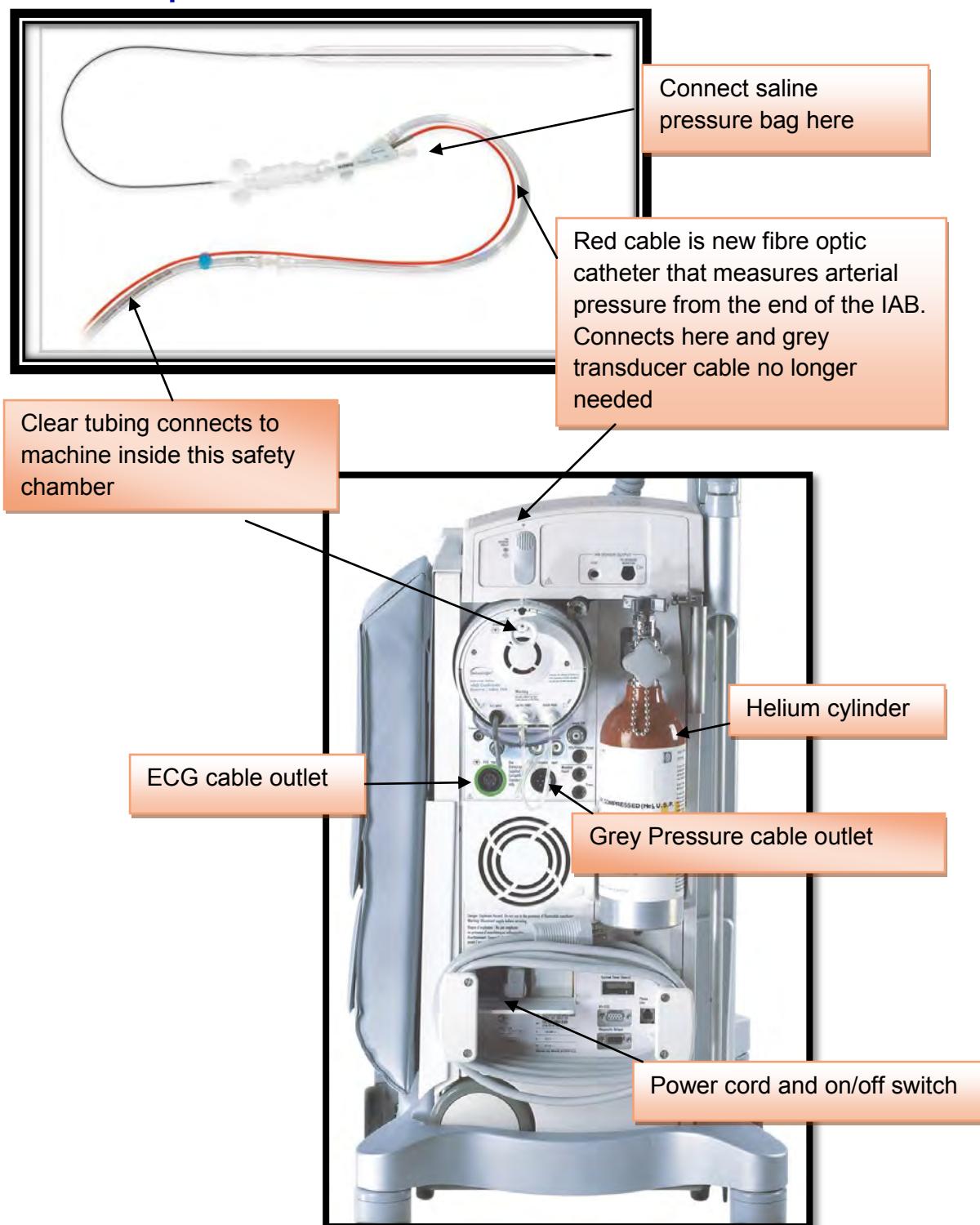
Indications

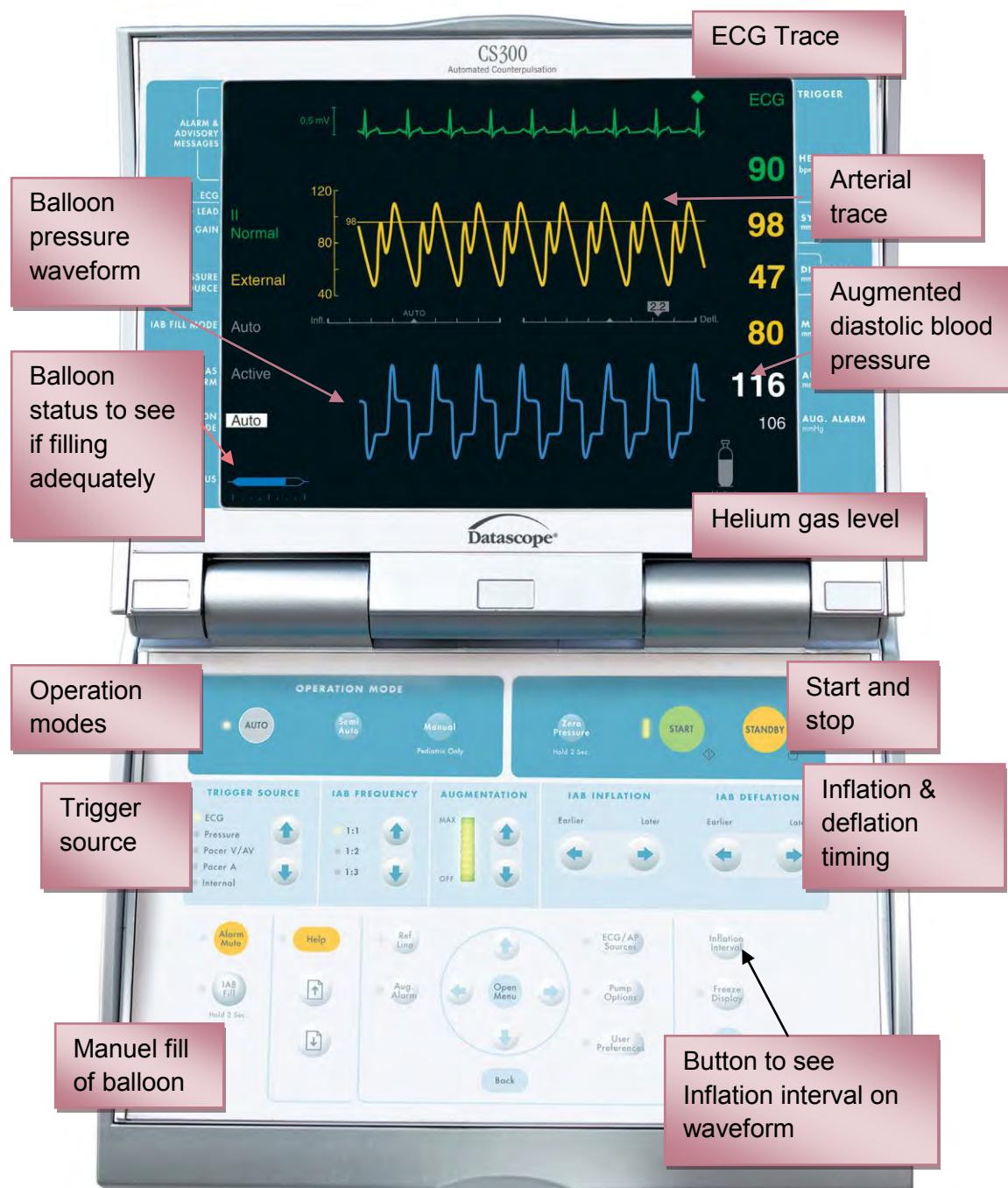
- Refractory Unstable Angina
- Impending Infarction
- Acute MI
- Refractory Ventricular Failure
- Complications of Acute MI [i.e. acute MR or VSD, or papillary muscle rupture]
- Cardiogenic Shock
- Support for diagnostic, percutaneous revascularization, and interventional procedures
- Ischemia related intractable ventricular arrhythmias
- Septic Shock
- Weaning from bypass
- Cardiac support for non-cardiac surgery
- Prophylactic support in preparation for cardiac surgery
- Post surgical myocardial dysfunction/low cardiac output syndrome
- Myocardial contusion
- Mechanical bridge to other assist devices
- Cardiac support following correction of anatomical defects

Contraindications

- Severe aortic regurgitation
- Abdominal, aortic or thoracic aneurysm.
- Severe calcified aorta-iliac disease or peripheral vascular disease.
- Sheathless insertion with severe obesity, scarring of the groin.

IABP -Components



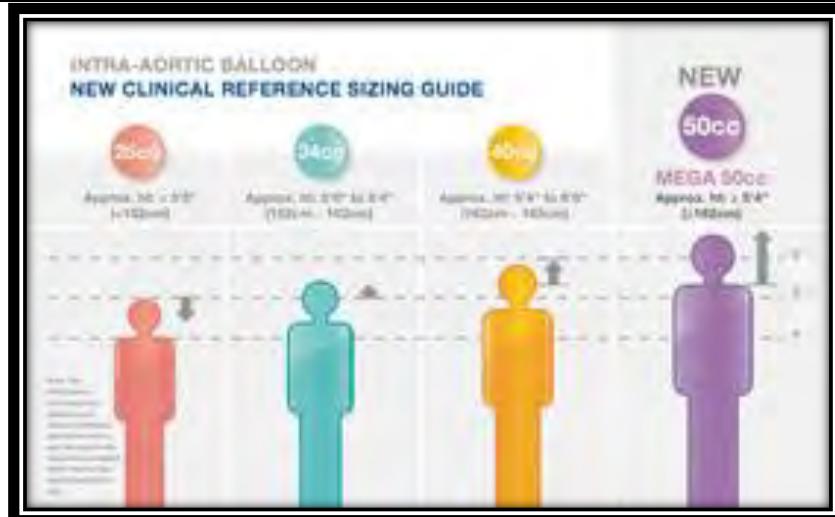


INSERTION OF IABP

Equipment:

- ❖ IABP catheter: size is determined by the patient's height.
- ❖ The sizes are displayed on the IAB catheter box

SIZE	HEIGHT
25cc	< 152cm (5f)
34cc	152–162cms (5f– 5f 4 inches)
40cc	162–183cms (5f 4inches – 6f)
50cc	> 162cms (> 5f 4 inches)

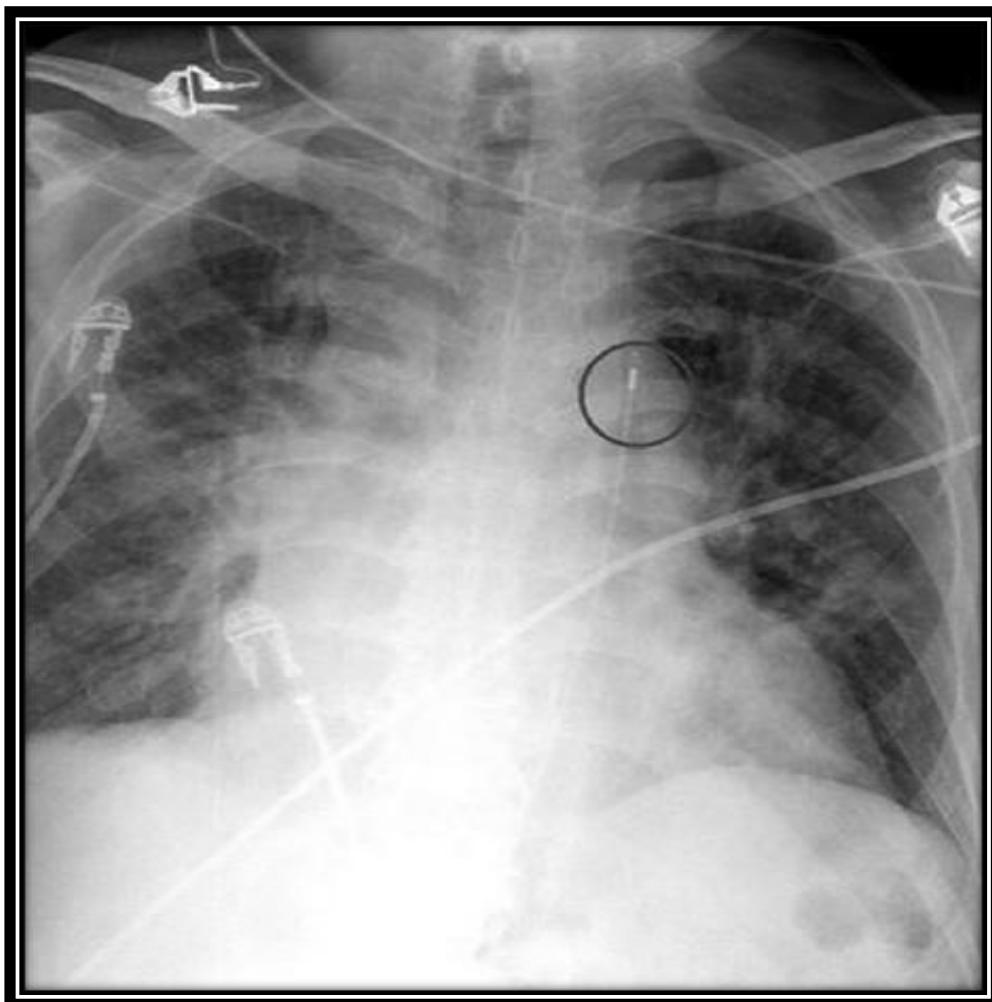


- IAB catheter insertion tray (call OT for tray and catheter and send a requisition form to replace OT catheter)
- IABP console (found in ICU 3, OT or Cardiac Cath Lab)
- Mask, sterile gloves gowns
- Sterile drapes
- Chlorhexidine 0.5% with alcohol 70%
- 2 large transparent occlusive dressings
- Scalpel
- Suture material
- Combines
- Large dressing pack
- Pressure bag with 500ml 0.9% sodium chloride
- Extension tubing for transducer
- Transducer cable for IABP
- ECG cable for IABP

Insertion of IAB catheter

- Explain procedure to patient emphasising the importance of keeping the leg that the IAB catheter is being inserted straight at all times
- Position patient flat
- The catheter is inserted into patient's femoral artery then into the descending thoracic aorta, such that the balloon is distal to the subclavian artery and proximal to the renal arteries.
- Reassure patient and monitor haemodynamics during insertion
- Before pumping, after insertion, gently aspirate & discard 3mls of blood & manually flush immediately with 3 – 5mls of 0.9% sodium chloride
- 12 lead ECG post insertion
- Check limb circulation observations and document
- Check CXR for proper positioning of catheter 2 cm below the origin of the left subclavian artery, or between the second and third ribs and above the renal arteries.

Position of IABP: Tip at left, 2nd intercostal space. Cardiac Anaesthesia 2011

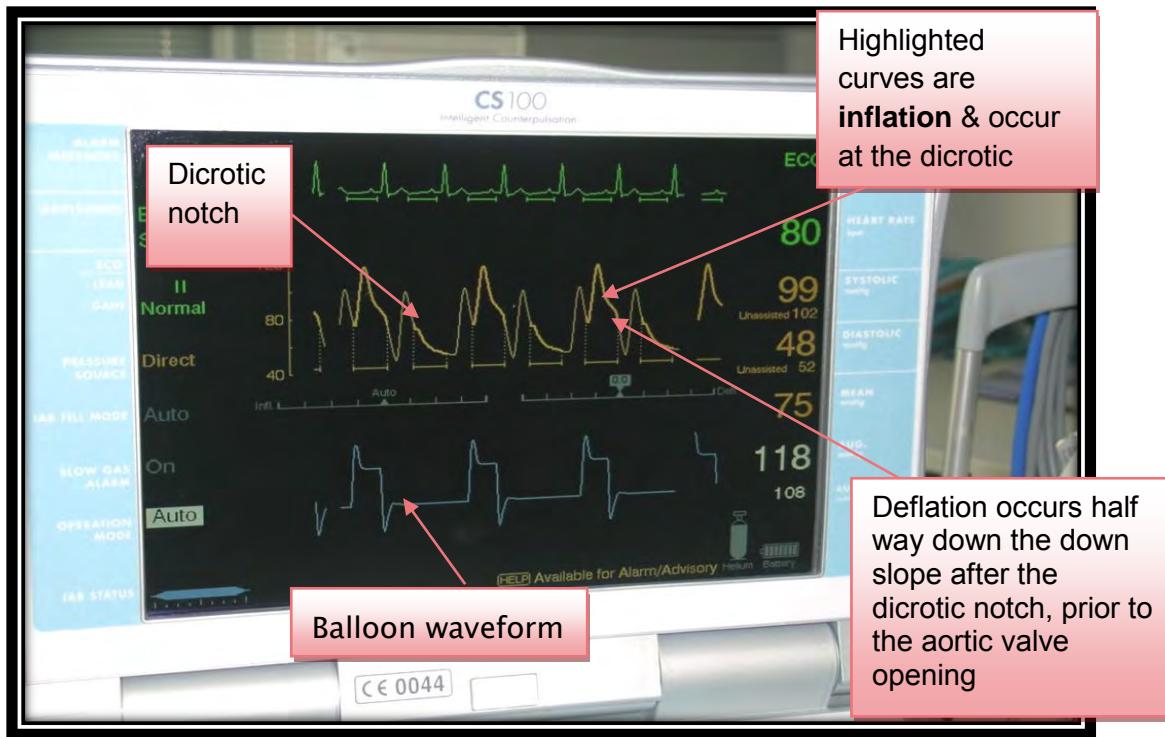


Set up of IABP console

- Ensure console is plugged in to power and power switch on front and rear of machine are “on”
- Confirm initial pump settings:
 - Mode: AUTO
 - ECG trigger
 - IAB frequency 1:1.
 - Augmentation: MAX
 - Ensure that the auxiliary controls are switched ON:
 - Slow gas loss alarm - On.
 - IAB fill - Auto.
 - Timing - Auto.
 - ECG gain – Normal
- Open helium tank and verify helium pressure (the range is within the green area on the helium pressure gauge).
- Connect ECG and pressure cables from console to patient.
- Prepare pressure bag with 0.9% sodium chloride and transducer tubing to keep arterial line patent and to monitor arterial pressure
- Once catheter is inserted connect and Zero femoral arterial IAB catheter, press ZERO PRESSURE on IABP console and hold for 2 seconds
- Connect IAB catheter coming from patient to clear plastic tubing which then connects to the front of the IABP machine where it says “Balloon” inside the safety chamber
- Turn machine to ‘Standby’, and you will hear five balloon inflations which uncoils the balloon once in place
- Check ECG and pressure tracings and decide on appropriate trigger
- Press ‘Start’ button to commence pumping
- Set Augmentation to MAX slowly as balloon expands
- Set Augmentation alarm limits
- Set operation mode (balloon inflation and deflation) to AUTO, unless timing is not accurate then put in semi auto mode and adjust timing appropriately
- Set IAB frequency to 1:1
- Document on ICU flow chart:
 - site of catheter insertion, whether there is oozing
 - catheter size
 - mode
 - trigger mode
 - Frequency of IAB ratio
 - Augmentation of balloon
 - Augmented blood pressure
- Put pump in 1: 2 to check proper timing

Timing

- Balloon must be timed accurately to give full benefit of augmentation to the patient
- Incorrect timing will cause the heart to work harder
- Balloon is timed by comparing the arterial pressure waveform while the balloon is augmented with the cardiac cycle
- A good arterial trace is essential for proper timing to occur
- Timing should be checked on a 1:2 or 1:3 ratio so you can see a normal beat and press the inflation interval key



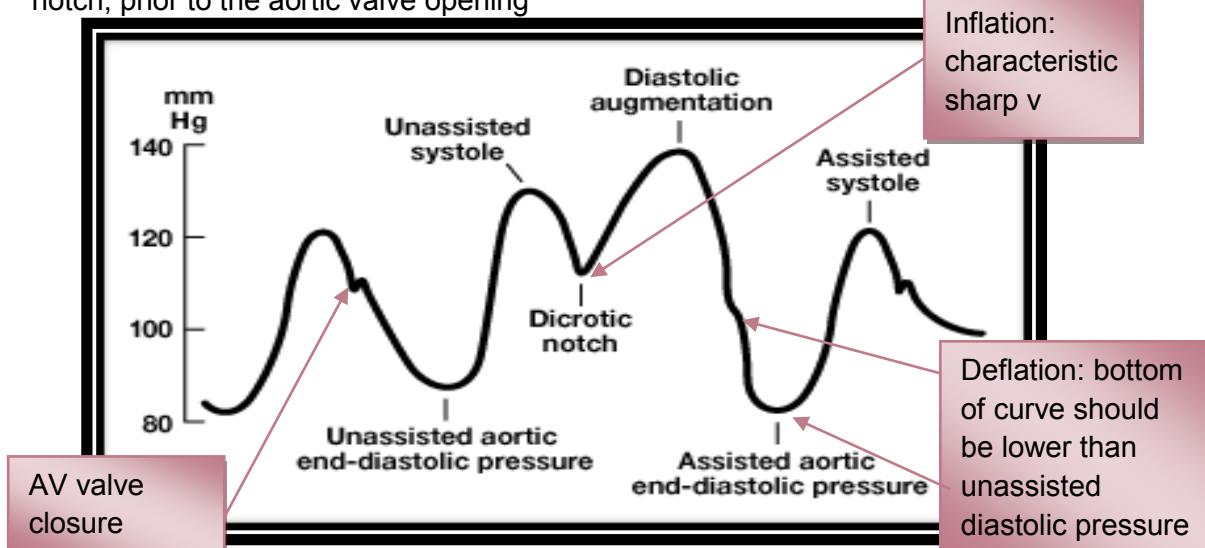
IABP 1:2 ratio

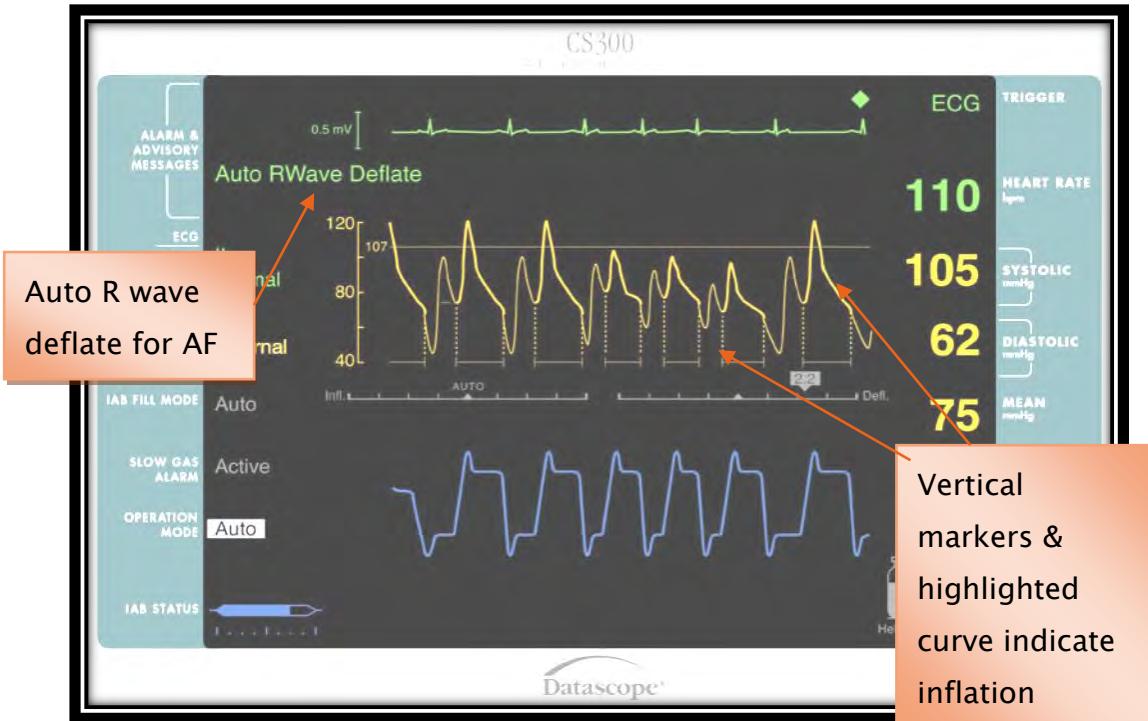
Inflation:

- Inflation occurs during diastole when the aortic valve closes and the left ventricle relaxes
- This period is when blood is not being pumped forward by the heart, therefore with the balloon inflated at this time the flow of blood will not be impeded
- Aortic valve closure is represented on the arterial trace by the dicrotic notch
- Inflation of the balloon is timed to occur at the dicrotic notch on the arterial pressure trace

Deflation:

- Deflation is timed to occur just before the next systole
- It is the depression of the balloon and the transfer back of helium into the console
- Can be seen on the IABP monitor as half way down the down slope after the dicrotic notch, prior to the aortic valve opening

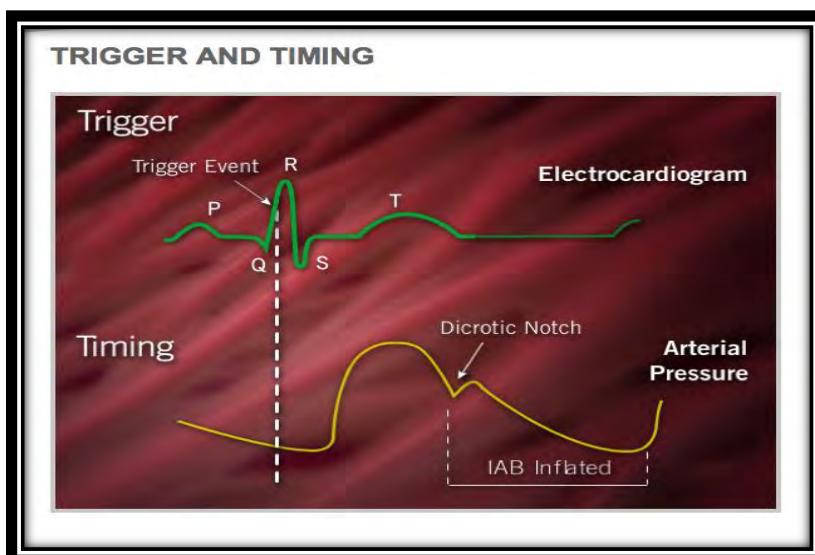




- A unique automatic timing algorithm allows effective balloon pumping even during atrial fibrillation.
- Press the Inflation Interval key to observe the period of inflation while pumping.
- Vertical markers located below the arterial waveform and the highlighted portion indicate the period of balloon inflation

Trigger

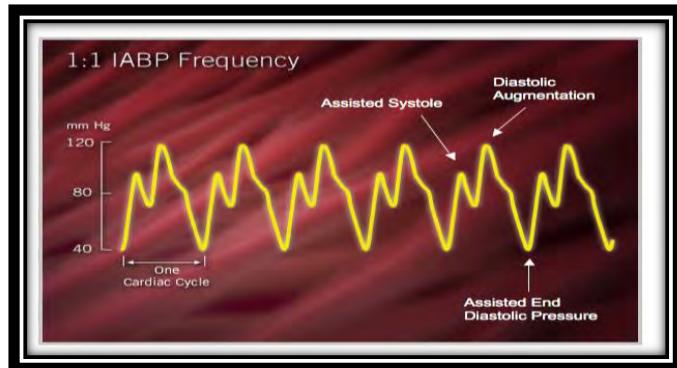
- The IABP must have a consistent signal in order to perform trigger and timing functions
- For effective IABP therapy, the pump needs the clearest signal possible from the patient
- Both the ECG and the arterial pressure (AP) waveforms should be monitored on the IABP
- If the ECG trace is lost (e.g. electrode falls off) the pump will automatically use the pressure signal for the trigger



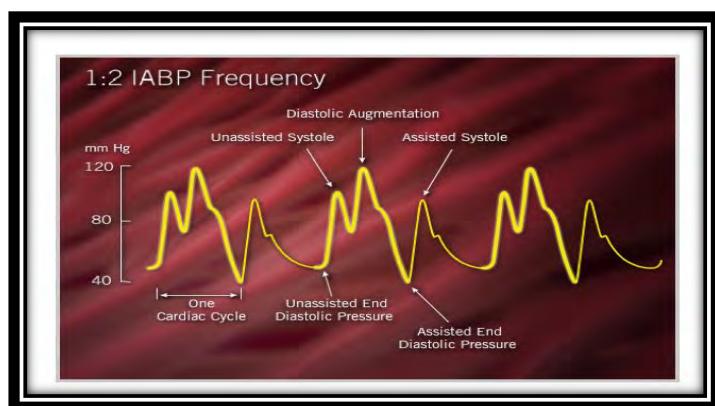
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- The arterial pressure waveform is from the arterial lumen of the catheter where a transducer is attached in the same way as for any arterial line.
- If the balloon arterial trace cannot be utilised due to a poor trace, then an alternative site (IE radial artery) can be used
- The most reliable trigger is the R wave of the ECG.
- This signal is what the pump uses to identify the onset of systole and therefore initiates the deflate/inflate cycle of the IAB

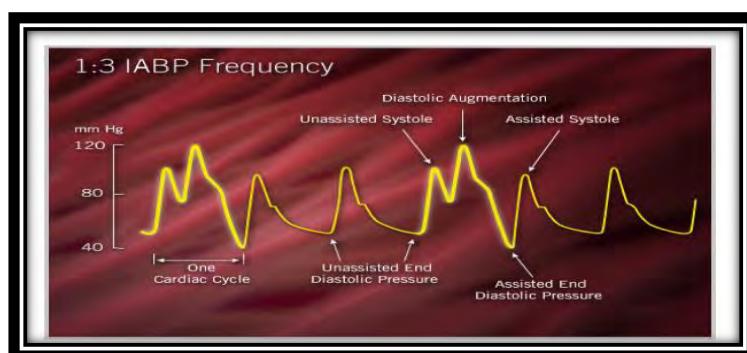
IABP Waveforms



- 1:1 frequency: balloon inflates every beat
- Provides maximum augmentation



- 1:2 frequency: balloon inflates/augments every 2nd beat
- Utilised for weaning and checking timing

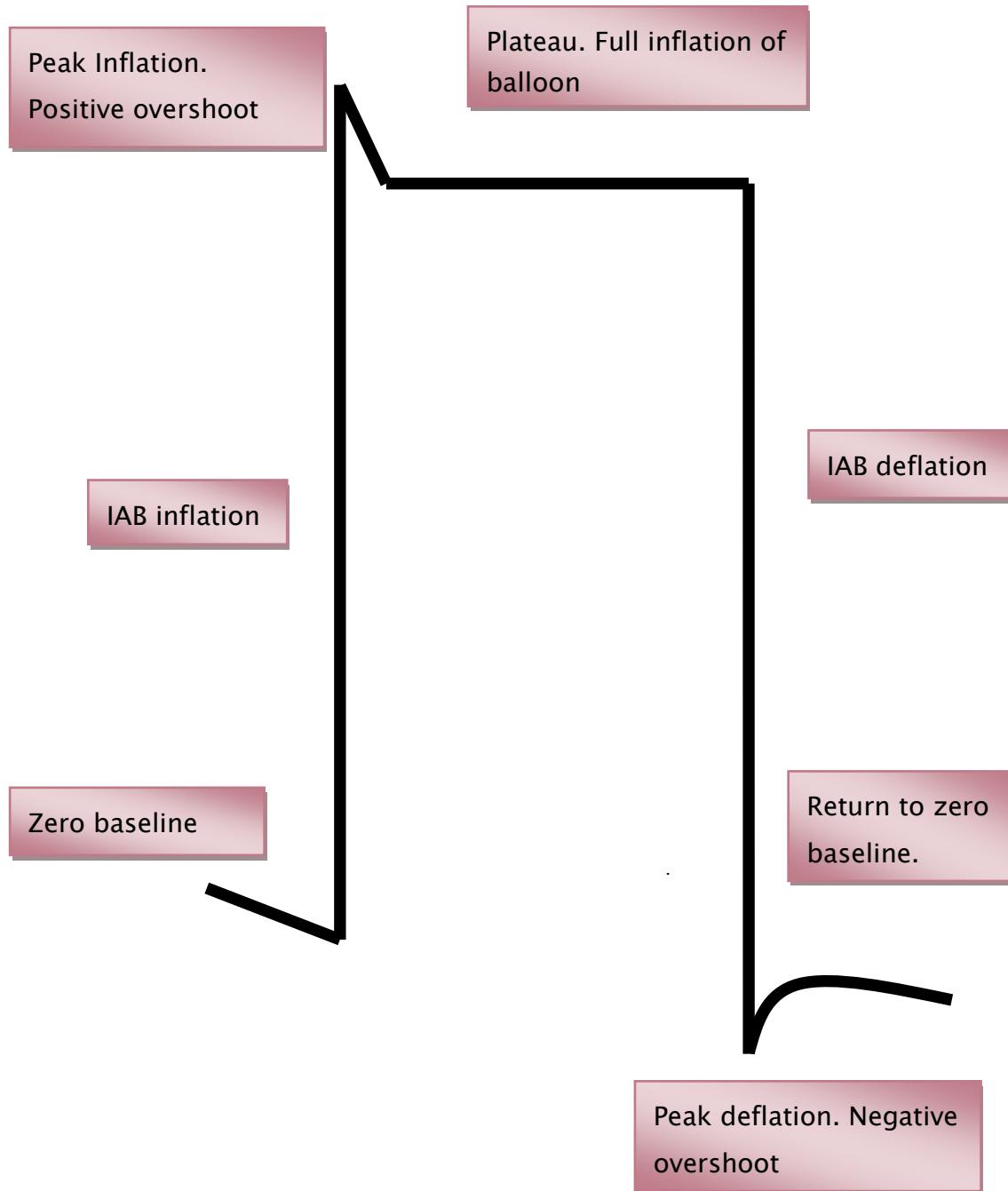


- 1:3 frequency: balloon inflates / augments every third beat
- Utilised for weaning

Balloon Pressure Waveform

- The balloon pressure waveform is the bottom waveform on the console.
- Two important points about the shape of the waveform are:
 - The width of the waveform corresponds to the duration of balloon inflation during the cardiac cycle
 - The plateau of the waveform reflects pressure within the aorta when the balloon is inflated. The balloon pump has to overcome the pressure within the aorta to fill the balloon with gas. Since the balloon material is very compliant, the pressure on either side will be approximately the same.
 - Therefore the plateau pressure on the BPW should be within ± 20 mmHg of the diastolic on the arterial pressure waveform

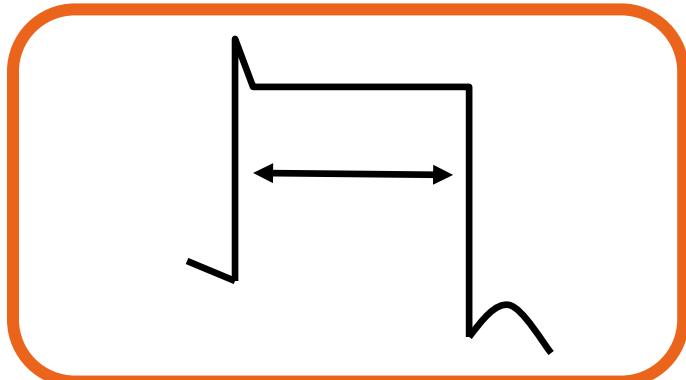
Balloon Pressure waveform (normal)



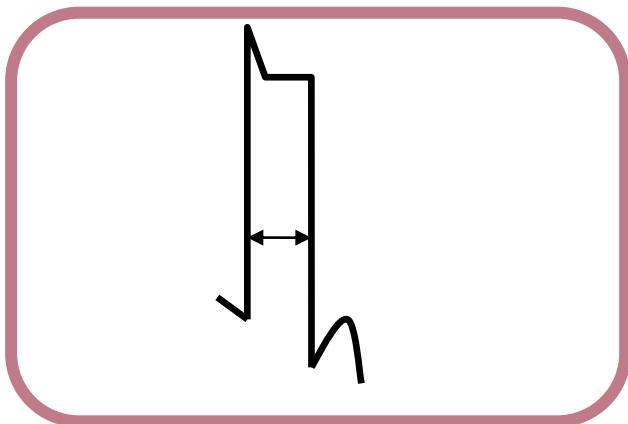
Variations in balloon pressure waveforms

Changes in balloon pressure waveforms maybe due to the following:

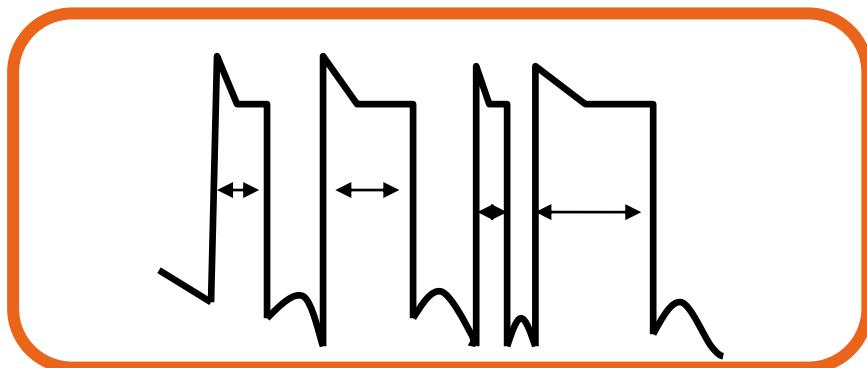
- Bradycardia: increased duration of plateau due to a longer diastolic phase



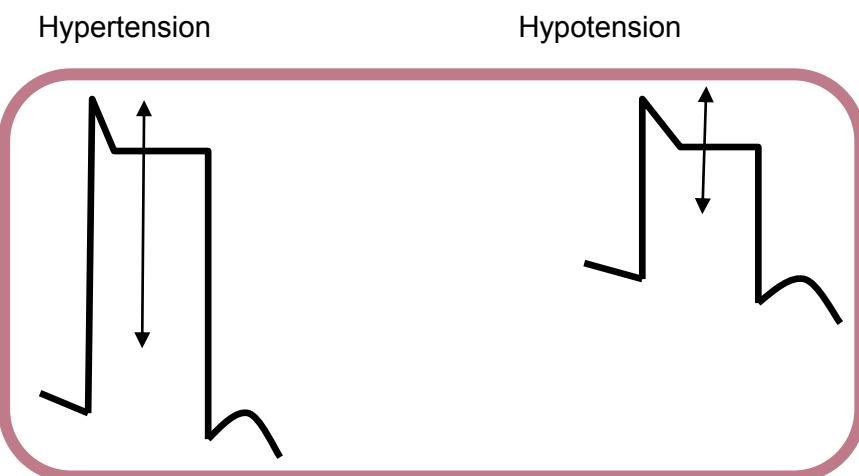
- Tachycardia: decreased duration of plateau due to shorter diastolic phase



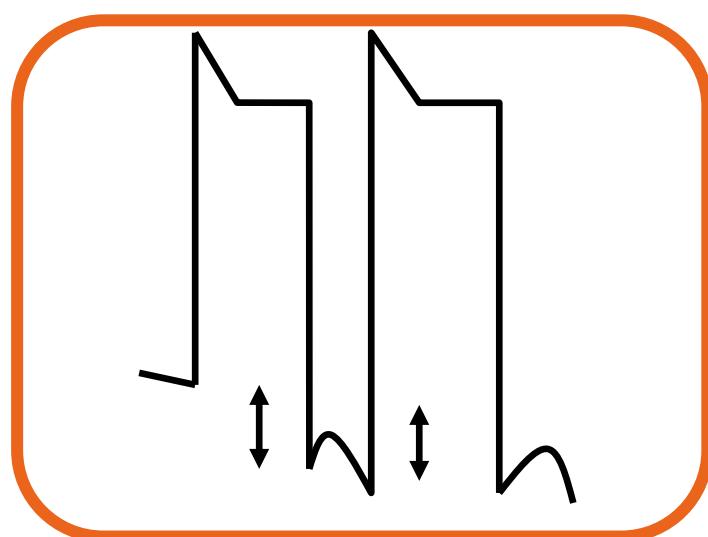
- Rhythm: changes in width due to erratic diastolic phase.
If the heart rate is erratic, as in atrial fibrillation or there are frequent premature complexes, the waveform will have varying widths



- Blood pressure: affects the amplitude of the waveform



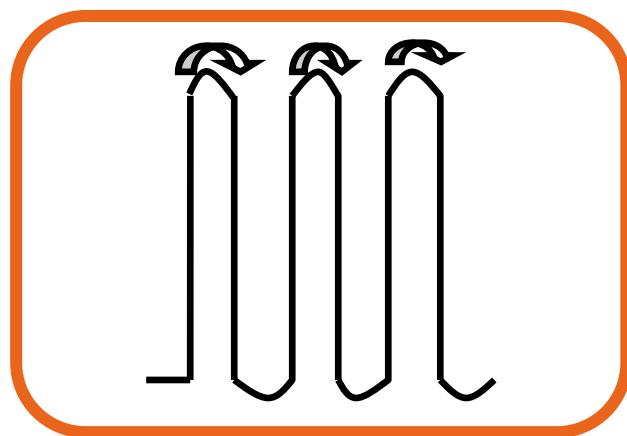
- Gas Loss: Leak in the closed system causing the balloon pressure waveform to fall *below* zero baseline. This may be due
 - to a loose connection
 - a leak in the IAB catheter
 - H₂O condensation in the external tubing
 - a patient who is tachycardiac and febrile which causes increased gas diffusion through the IAB membrane.



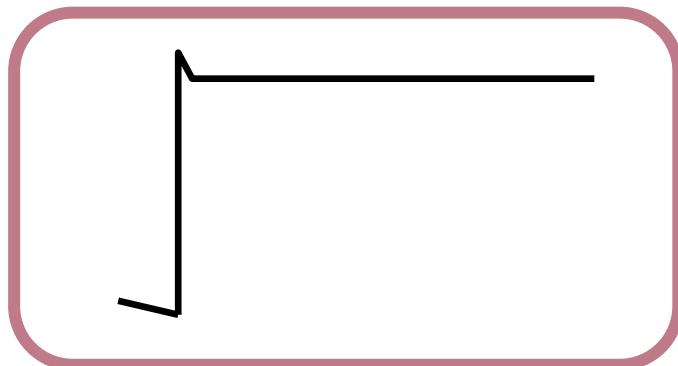
- Catheter Kink: Rounded balloon pressure waveform, loss of plateau

This may be due to

- kink or obstruction of shuttle gas
- kink in the catheter tubing
- improper IAB catheter position
- sheath not being pulled back to allow inflation of the IAB
- the IAB is too large for the aorta
- the IAB is not fully unwrapped or
- H₂O condensation in the external tubing



- Sustained inflation: Theoretical possibility if the IAB remains inflated longer than 2 seconds. System 90 Series intra-aortic balloon pump will activate the System Failure alarm and deflate the IAB.



Management

Patient management

- Perform full physical assessment
- Educate patient on not being able to bend leg with IAB
- Special attention to recording groin bleeding/ooze, peripheral perfusion, colour, bilateral pulses, temperature, capillary return, movement and sensation. **This should be attended on lower extremities and circulation observation chart every hour.**
- Pressure area care 2 – 4 hourly as patient immobile
- Hourly haemodynamic observations recorded
- Patient nursed supine 30-45 degrees head up. May be nursed on side as long as leg with IABP is kept straight
- Check IAB site regularly for signs of infection and change occlusive clear dressing PRN

Pathology, Tests:

- Daily CXR to ensure correct placement of IABP and ensure that it has not migrated.
- Daily pathology for electrolytes, coagulation, urea , creatinine
- Daily ECG and more frequently as indicated by patients clinical status
- Careful monitoring of renal function (The balloon sits above the bifurcation of the renal arteries - backward migration may compromise blood flow to the kidneys).

Documentation

- Document hourly on ICU chart
 - site of catheter insertion, whether there is oozing
 - catheter size
 - mode
 - trigger mode
 - Frequency of IAB ratio
 - Augmentation of balloon
 - Augmented blood pressure

IABP machine management:

- Obtain optimal diastolic augmentation and optimal afterload reduction. Notify Medical team of difficulty
- Prevent inflation of IABP during Ventricular Ejection
- Maintain optimal ECG and arterial trace
- Adjust augmentation alarm to patients augmented blood pressure
- Monitor extender tubing for blood. If blood present inform Senior registrar immediately and stop pump
- Watch for signs of balloon leak: frequent loss of augmentation
- Pump should not be put in standby for longer than 20 minutes due to increase risk of thrombus formation
- The helium cylinder should be replaced whenever pressure drops below the preset level as indicated by the LOW HELIUM message. There is no need to interrupt IABP therapy.
 - The cylinder should be replaced as soon as possible to avoid a potential AUTO FILL failure, which can delay pumping.
 - Replacement of the Helium Cylinder:
 - Close helium cylinder valve fully clockwise
 - Slowly loosen cylinder yoke
 - Remove cylinder
 - Check that the plastic washer is present and in good condition on cylinder yoke
 - Install fresh helium cylinder
 - Tighten cylinder yoke

- Slowly open helium cylinder valve
- Verify the helium gauge needle is on full
- Note IAB will auto fill every 2 hours
- Always aspirate 3cc initially if the central aortic pressure line becomes damped. Should resistance be met upon aspiration, consider the lumen to be occluded.
- Discontinue use of the central aortic pressure line, if occluded by placing a sterile male luer lock cap on the port.
- Arterial blood sampling should be performed cautiously with careful technique by expert staff
- Maintain optimal augmentation and afterload reduction by adjusting timing PRN
- Re-zero and level transducer (to phlebostatic axis) of arterial IAB catheter once per shift and PRN
- Ensure 0.9% sodium chloride in pressure bag is replaced every 24hrs and pumped up to 300mmHg
- Plug balloon console into power point
- Ensure tubing from IAB to console is not kinked
- Alarms: the HELP screen can be utilised by staff for step by step instructions on troubleshooting alarms. See troubleshooting section below.

Cardiac Arrest:

- If counter pulsation is to be continued and synchronised to the CPR effort, then arterial trigger should be selected.
- If CPR generates sufficient blood pressure, then in most cases, the IABP will pump and may improve perfusion to coronary and carotid arteries. In the event that the CPR cannot generate a consistent and reliable trigger, then additional steps should be taken as follows.
 - 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.
 - In most cases the clinician may decrease the assist interval or decrease the volume of the IAB.
 - This trigger will maintain movement of the catheter and therefore reduce the risk of thrombus formation.
 - WARNING: The use of INTERNAL TRIGGER will produce asynchronies counter pulsation & 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 re-established, the trigger mode must be changed from INTERNAL to an acceptable patient trigger.
- If the IABP is not used in one of the above methods & the IABP is turned off, the IAB should be manually inflated.
 - Aspirate with a large Luer lock syringe to check for blood.
 - Inject 10cc of air greater than the total balloon volume (i.e. 50 ml for a 40 ml IAB) into the balloon connector and aspirate it immediately.
 - Manual inflation should be done 4 to 5 times every 30 minutes that counter pulsation is discontinued.

Defibrillation:

- If patient needs to be defibrillated the IABP has protection and is isolated from the patient and the defibrillators electrodes
- Staff still need to stand clear of patient and the IABP

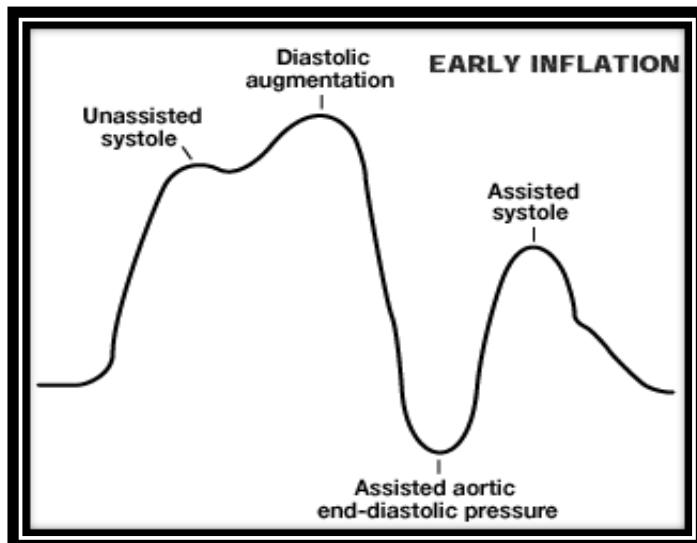


TROUBLESHOOTING

Timing errors:

- Can occur due to improper inflation and deflation of IAB
- They include – early inflation, late inflation, early deflation, late deflation

A. Early Inflation:

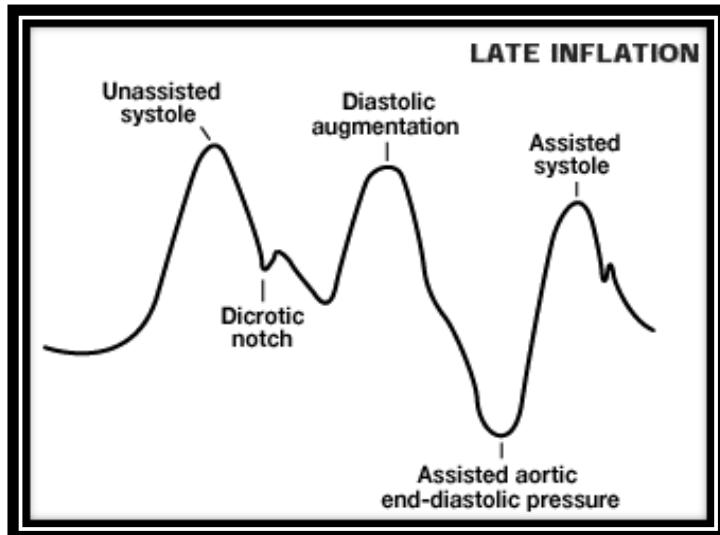


Inflation of the IABP before aortic valve closure

- Waveform Characteristics:
 - Inflation of IABP prior to dicrotic notch.
 - Diastolic augmentation encroached onto systole (may be unable to distinguish).
- Physiologic Effects:
 - Potential premature closure of aortic valve.

- Potential increase in left ventricular end diastolic volume (LVEDV) and left ventricular end diastolic pressure (LVEDP) or PCWP.
- Increased left ventricular wall stress or afterload.
- Aortic Regurgitation.
- Increased myocardial oxygen delivery (MVO₂) demand

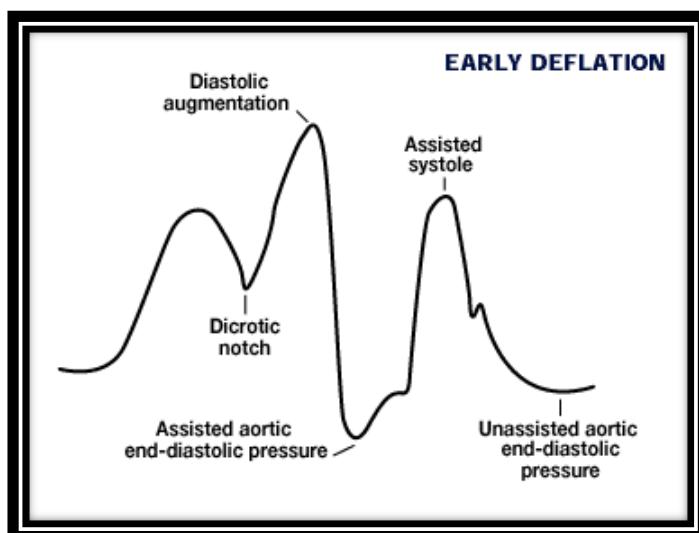
B. Late Inflation:



Late Inflation of IABP: after closure of aortic valve

- Waveform Characteristics:
 - Inflation of the IABP after the dicrotic notch.
 - Absence of sharp V.
 - Sub-optimal diastolic augmentation.
- Physiologic Effects:
 - Sub-optimal coronary artery perfusion

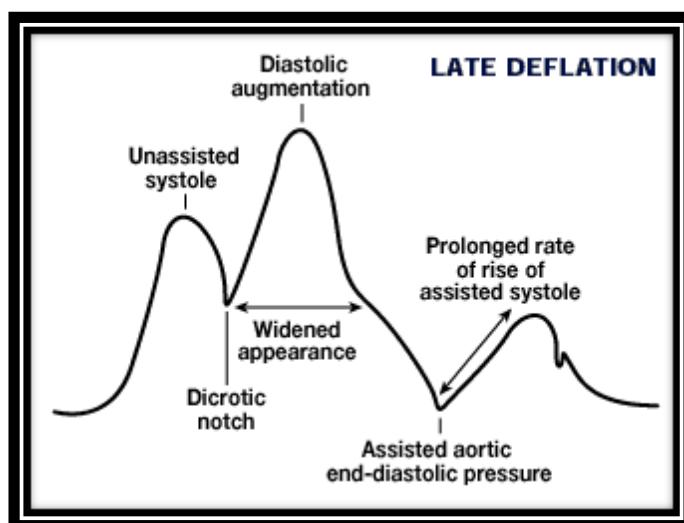
C. Early Deflation:



Early Deflation of IABP Premature deflation of the IAB during the diastolic phase.

- **Waveform Characteristics:**
 - Deflation of IAB is seen as a sharp drop following diastolic augmentation.
 - Sub-optimal diastolic augmentation.
 - Assisted aortic end diastolic pressure may be equal to or less than the unassisted aortic end diastolic pressure.
 - Assisted systolic pressure may rise.
- **Physiologic Effects:**
 - Sub-optimal coronary perfusion.
 - Potential for retrograde coronary and carotid blood flow.
 - Angina may occur as a result of retrograde coronary blood flow.
 - Sub-optimal afterload reduction.
 - Increased MVO₂ demand.

Late Deflation:



Late deflation of IABP

- **Waveform Characteristics:**
 - Assisted aortic end-diastolic pressure may be equal to the unassisted aortic end diastolic pressure.
 - Rate of rise of assisted systole is prolonged.
 - Diastolic augmentation may appear widened.
- **Physiologic Effects:**
 - Afterload reduction is essentially absent.
 - Increased MVO₂ consumption due to the left ventricle ejecting against a greater resistance and a prolonged isovolumetric contraction phase.
 - IAB may impede left ventricular ejection and increase the afterload.

Loss of trigger:

Check

- ECG trace
- Replace ECG electrodes
- ECG cable
- Choose an alternate ECG lead
- Check pressure trace

Loss of pressure trace

Check

- Pressure bag inflated to 300mmhg
- Patency of arterial line by withdrawing blood then flushing
- Transducer is level to phlebostatic axis

Alarms

- Leak in IAB circuit / Rapid Gas Loss / IAB disconnected
- Ensure catheter tubing is not leaking
- Check connections along catheter and at IABP console safety disk, auto fill tubing and drain port
- Check catheter is not kinked

Blood detected

- Blood detected in IAB catheter
- Check for blood in tubing if seen stop the pump and notify Senior Registrar

Auto fill failure / No helium

- Check helium tank is not empty, relace if necessary
- Fill the IAB by pressing the IAB fill button for 2 seconds
- Resume pumping by pressing START

Weaning of IABP therapy:

When the haemodynamic and clinical state of the patient who has undergone IABP therapy has improved to the point where assistance is no longer required, the IABP must be weaned and removed.

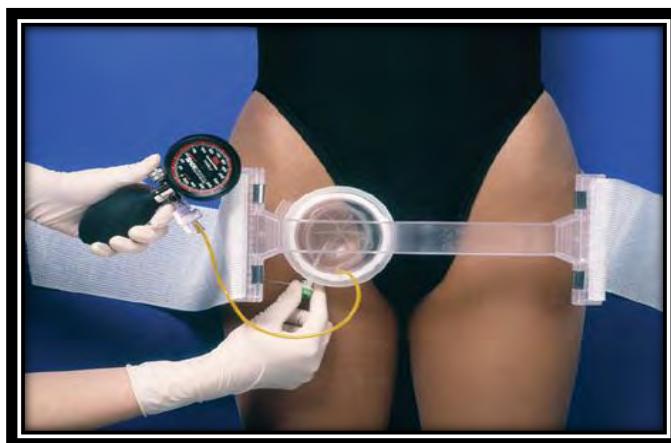
Assess if:

- CI > 2.2 -2.5
- MAP >65mmhg
- Stable heart rate and haemodynamics
- Weaning is commenced by decreasing the IABP frequency from 1:1 then 1:2 then 1:3. The augmentation of the balloon should never be decreased for weaning due to the increased risk of thrombus
- When the ratio of the balloon is decreased each time the patients haemodynamics should be assessed before the next stage of weaning is commenced

Removal of IAB:

- Ensure patient is haemodynamically stable
- Check INR and APPT are within normal range
- Explain the sheath removal procedure to the patient: include the function of the manual compression device (Femstop), the approximate time that it will be in place and activity restrictions during, and following the procedure.
- Equipment :
 - Dressing pack
 - Stitch cutter
 - Chlorhexidine 0.5% & alcohol 70%
 - Femstop dome and arch clamp
 - Gauze and combines
 - Gloves gown and protective eyewear
 - Transparent occlusive dressing

- Wash hands and apply PPE
- Patient to lie supine
- Put IABP on STANDBY then turn off as this will allow for balloon to deflate passively
- Position Femstop arch clamp (See Femstop guideline)
- Disconnect tubing from IAB to pump as this will also help deflate the balloon passively
- Remove the IAB, let site bleed for 2 seconds to help remove any thrombus
- Apply digital pressure till femstop device is pumped up and in proper position
- Apply sufficient pressure to achieve haemostasis while maintaining adequate distal limb circulation.
- Inflate dome to 20mmHg above SBP after removing sheath.
- Maintain initial pressure for 2-3mins when artery is occluded and pedal pulses absent. Do not exceed 3 minutes
- Reduce pressure to attain strong pedal pulse.
- Maintain that pressure for 30mns.
- Lower pressure by 15mmHg every 15minutes until pressure of 40mmHg.
- Ensure skin does not become trapped as the dome folds and pressure is being released.
- Maintain 40mmHg pressure for 30mns, and then completely deflate the dome.
- Ask patient to cough observing for bleeding.
- If not bleeding, remove the femstop pressure device
- Monitor HR, BP, RR, and SpO₂, neurovascular limb observations (colour, warmth, sensation, movement, pulses, and capillary return), puncture site (bleeding, haematoma). Every 15mns for 1 hour. Every 30 minutes for 2 hours. Hourly until removal of femstop pressure device.
- Head of bed elevated 30° for 1 hour, 45° for 1 hour, 60° for 1 hour then, as patient desires.
- Patient may commence ambulation 6 hours after the IAB catheter removal.
- Instruct the patient to inform the nurse immediately of any obvious bleeding, or sensation of wetness, burning, tearing, tingling and numbness, either at the puncture site or the affected limb



Femstop device. Cath lab Digest

- Complications post removal
 - Limb ischaemia.
 - Excessive bleeding from insertion site.
 - Immobility of balloon catheter.
 - Balloon leak.
 - Infection.
 - Compartment syndrome may develop after IABP removed.

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