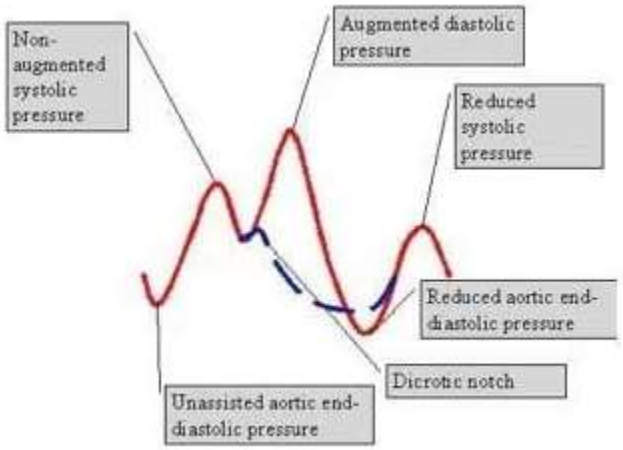
Management of the Intra-Aortic Balloon Pump

Temporary support for the LV by mechanically displacing blood within the aort
Concepts – Systolic unloading and Diastolic augmentation



Indications
Used as a supportive treatment tool that will improve (bridging therapy) due to recovery or treatment

- Cardiogenic Shock
- Post bypass
- Post MI
- Cardiomyopathy
- Severe Ischemic Heart Disease awaiting intervention or surgery
- Severe Mitral Valve Regurgitation awaiting surgery
- Prophylactically in high risk patients pre-stenting and/or cardiac surgery

Contraindications

- Aortic regurgitation
- Aortic dissection
- Severe Aorto-iliac or peripheral vascular disease
- Aneurysm or other anatomical diseases of the aorta
- Prosthetic aortic tree grafts
- Local sepsis
- Severe coagulopathy

Effects of IABP Therapy
Primary

- Increased coronary perfusion
- Increased myocardial oxygen supply
- Decreased myocardial oxygen demand
- Decrease myocardial workload
- Increased BP

Secondary

- Decreased pulmonary artery pressure
- Decreased SVR

- Increased cardiac output and index

Systemic
- Increased cerebral perfusion
- Increased renal perfusion

**All of these effects may be quite variable and they depend upon: the volume of the balloon, it's postion in the aorta, heart rate, rhythm, compliance of the aorta, and systemic resistance

Counterpulsation
- IABP is composed of 2 principal parts
    - Flexible catheter 2 lumens
        - First for distal aspiration/flushing or pressure monitoring
        - Permits periodic delivery and removal of helium gas to a closed balloon
    - IABP works using the principle of counter-pulsation; Refers to the alternating of inflation and deflation of the balloon, during diastole and systole
- 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
    - The IABP should ideally occlude 85-90% of the aortic lumen during inflation. You can have a not so great ECG waveform as long as your R wave is recognized; ECG will continue to trigger
- Mechanical pump uses the R wave on the ECG or the arterial systolic pressure to identify the cardiac cycle
    - Low deity gas that will rapidly inflate and deflate the balloon
    - Helium is easily absorbed into the bloodstream in the event of a rupture

Triggering and Timing
- The balloon is timed to inflate and deflate in time with the cardiac cycle
- Trigger options include:
    - ECG (using the R wave to identify the onset of systole); if sinus rhythm (SR) then deflation can be for a set time period, in atrial fibrillation (AF) the balloon deflates when R waves are sensed
    - If paced then pacing spikes can be used to detect cardiac cycle events
    - Arterial waveform (using the arterial upslope to designate systole)
    - An internal trigger mode is available for asystolic arrested patients
- Deflation should occur just prior to systole as indicated by the downward stroke
- Inflation and deflation of the IABP has 2 major consequences:
    - Blood is displaced to the proximal aorta by inflation during diastole
    - Aortic volume/afterload is reduced during systole through vacuum effect created by rapid balloon deflation
- Incorrect timing will cause the heart to work harder
    - Timing should be checked on 1:2 ratio
    - Compare balloon timing by comparing the arterial pressure waveform while balloon is augmented with cardiac cycle

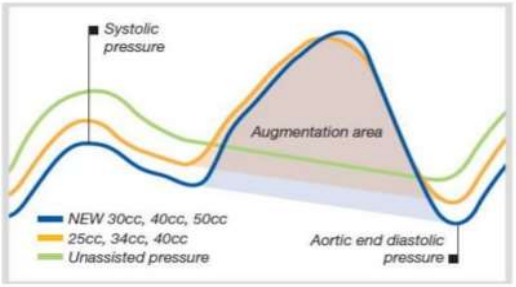
Balloon sizing

- Sizing based on patients height
- Four common balloon sizes
- Balloon length and diameter increases with each larger size
- 40 cm^3 balloon is most commonly used
- Paediatric balloons also available : sizes 2.5, 5.0, 12.0 and 20 cm^3

Balloon size	Height
50 cm^3	> 6 feet
40 cm^3	5 feet 4 inch to 6 feet
34 cm^3	5 feet to 5 feet 4 inch
25 cm^3	< 5 feet

Benefits of larger volume IABs

- More blood volume displacement
- More diastolic augmentation
- More systolic unloading



Factors Affecting Augmentation

Patient:

- Heart rate
- MAP
- SV
- SVR

IABP Catheter

- In sheath
- Not unfolded
- Kink in catheter
- Leak
- Low helium concentration

Pump

- Timing
- Positon of augmented control

Tachy or brady: treat the patient first

A fib: fix the A fib (AFib auto R deflate engages when rhythm is irregular)

Optimizing Performance

- Correct position (balloon just distal to left subclavian artery, 2 cm above left main bronchus)
- Optimal balloon volume
- Balloon timing
  - inflation at onset of diastole and deflation prior to the beginning of systole (check this in 1:2 augmentation ratio)
- Regular rhythm
- Timing: 1:1 – inflation takes place at the dicrotic notch
- Slope of augmented diastolic wave form is straight and parallel to the systolic upstroke

- Augmented diastolic pressure should exceed non-augmented systolic pressure
- End-diastolic pressure at balloon deflation is lower than preceding unassisted end-diastolic pressure by 15 mmHg
- Systolic pressure following a cycle of balloon inflation should be lower than the previous unassisted systolic pressure by about 5 mmHg

Efficiency

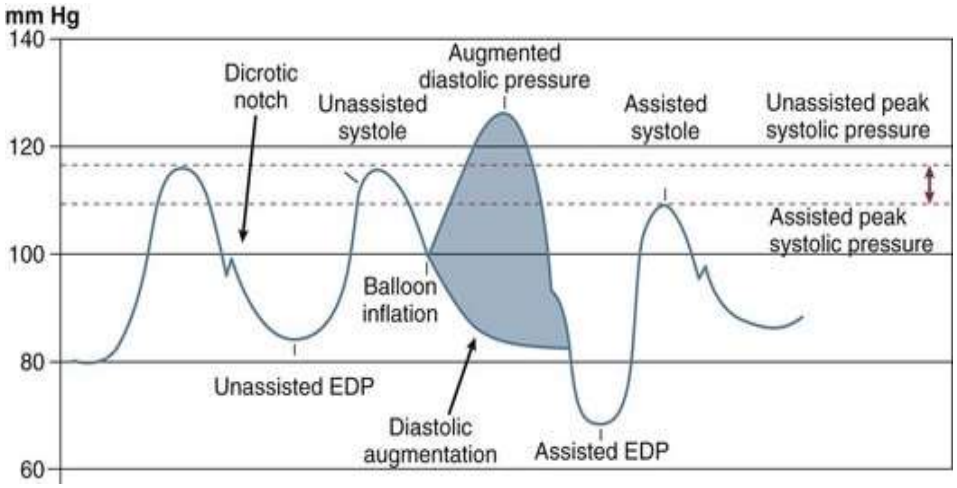
Efficiency is affected by:

- Timing of inflation and deflation
- Assist ratio
- Heart rate (Tachycardia > 130bpm reduces the benefit of IABP)
- Gas loss from the balloon
- Cardiac Index of 1.2-1.4 required for IABP to be effective

Setup and Insertion

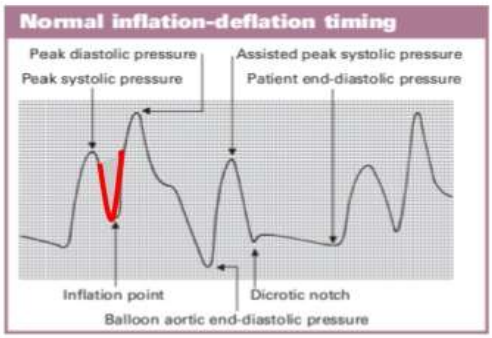
- Explain to the patient and/or family the procedure for insertion and the importance of keeping the affected extremity immobilized while the balloon is in place
- Insert a Foley catheter
- Ensure the consent has been signed unless it is an emergent procedure
- Assess and document baseline vital signs
- Assess bilateral brachial and pedal pulses. Mark the sites for future assessment
- Call the Cardiac Cath Lab to obtain the IABP console
- Discuss with provider which size catheter is to be used. Kits of 40cc and 34cc may be obtained from supply
- Flush the disposable monitoring tubing with Normal Saline and connect to the IABP monitor
- Level the proximal stopcock to the phlebostatic axis and zero the system. This will be connected to the central pressure line of the IABP after insertion
- Power on the IABP console
- Open the helium tank
- Connect the EKG cable from the IABP console to the patient
- Check initial IABP setts:
    - Mode –Auto
    - Trigger – EKG (preferred) or Pressure
    - Fill Timing – Auto
    - Gas Loss Alarm – ON
- Keep pump on standby mode
- Assist physicians to connect the catheter to the IABP console. Ensure that 3mL is aspirated from the arterial lumen and that the lumen is then flushed with 5mL of normal saline from the flush bag
- Connect the helium line
- Fill the IABP catheter by pressing and holding the FILL button. Look for the auto filling message on the console
- Once the auto fill message clears, press the start button to begin therapy

Interpreting Waveforms



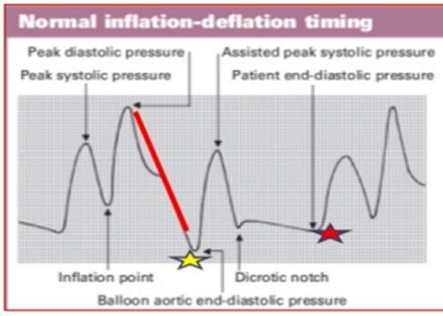
How to check waveform is acceptable ?

- First change from 1:1 to 1:2 augmentation
- Check the dicrotic notch
- See if augmentation starts at that point
  This should produce a sharp "V" at inflation.



How to check waveform is acceptable ?

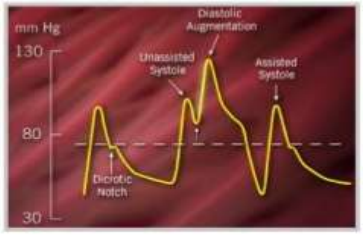
- First change from 1:1 to 1:2 augmentation
- Check the dicrotic notch
- See if augmentation starts at that point
  This should produce a sharp "V" at inflation.
- Check if diastolic augmented wave is › systolic wave
- Confirm if end diastolic wave following the augmented wave is less than an non augmented wave.
- Is Deflation slope ok

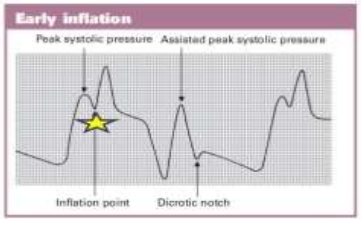


Timing Errors – Waveform

TIMING ERRORS – EARLY INFLATION

Inflation of the IAB prior to aortic valve closure





Waveform Characteristics:

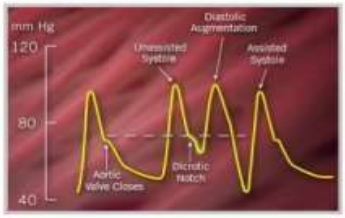
- Inflation of IAB prior to dicrotic notch
- Diastolic augmentation encroaches onto systole (may be unable to distinguish)

Physiologic Effects:

- Potential premature closure of aortic valve
- Potential increase in LVEDV/LVEDP/PCWP
- Increased left ventricular wall stress or afterload
- Aortic regurgitation
- Increased MVO_2 demand

Late Inflation

- Inflation of the IAB markedly after closure of the aortic valve.
- Waveform Characteristics:
  - Inflation of IAB after the dicrotic notch.
  - Absence of sharp V.
  - Sub optimal diastolic augmentation

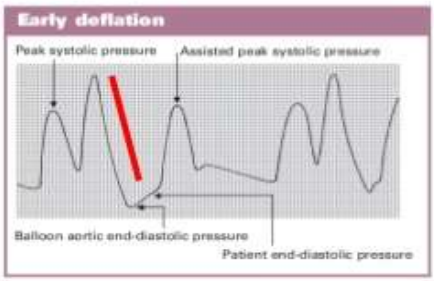


Physiologic Effects:

- Sub-optimal coronary artery perfusion

Early Deflation

- 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 unassisted aortic end-diastolic pressure
- Assisted systolic pressure may rise

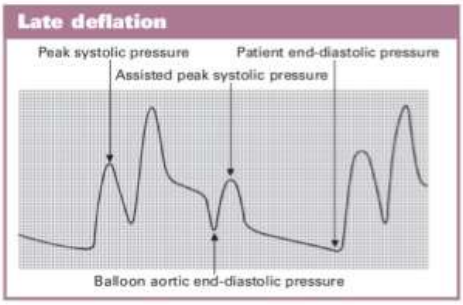
Physiologic Effects:

- Sub-optimal coronary perfusion
- Potential for retrograde coronary & carotid blood flow
- Angina may occur as a result of retrograde coronary blood flow
- Sub-optimal afterload reduction
- Increased MVO_2 demand

Late Deflation

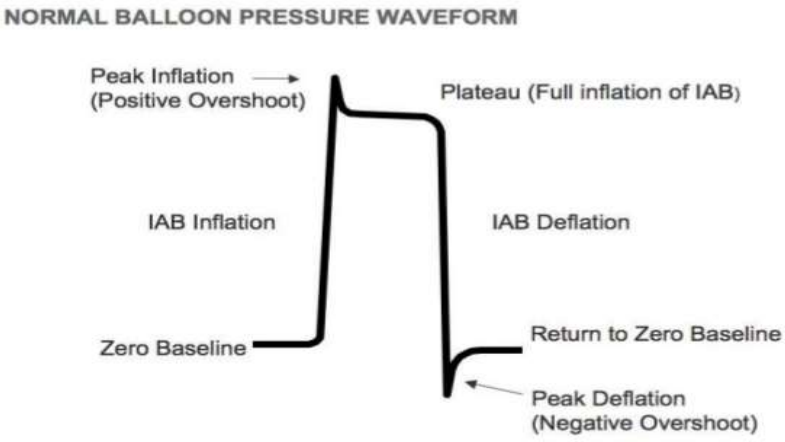
- Late deflation of the IAB during the diastolic phase.

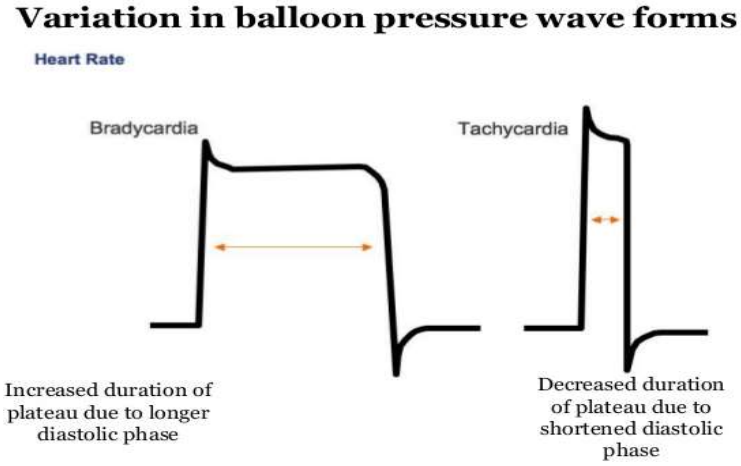
- Waveform Characteristics:
  - Assisted aortic end diastolic pressure may be equal to the unassisted aortic end diastolic pressure.
  - Rate of rise of assisted systole is prolonged.
  - Diastolic augmentation may appear widened

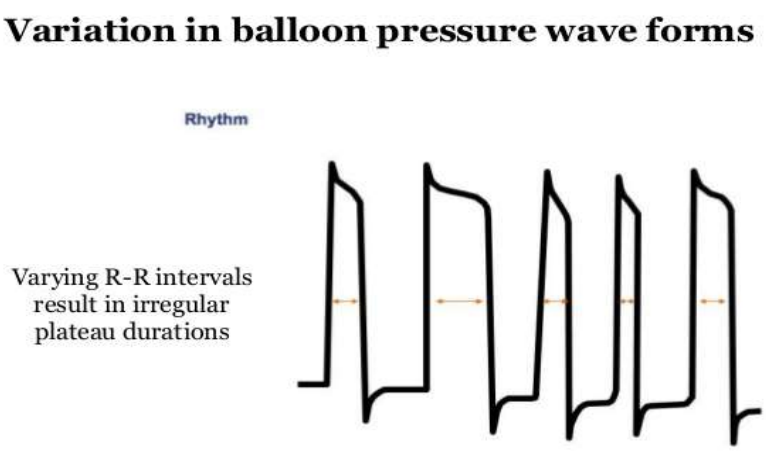


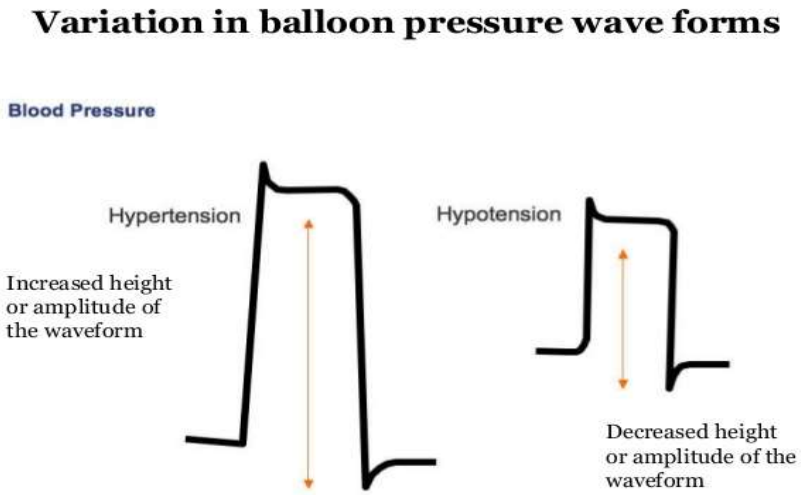
Physiologic Effects:

- Afterload reduction is essentially absent
- Increased MVO_2 consumption due to the left ventricle ejecting against a greater resistance & a prolonged isovolumetric contraction phase
- IAB may impede left ventricular ejection & increase afterload





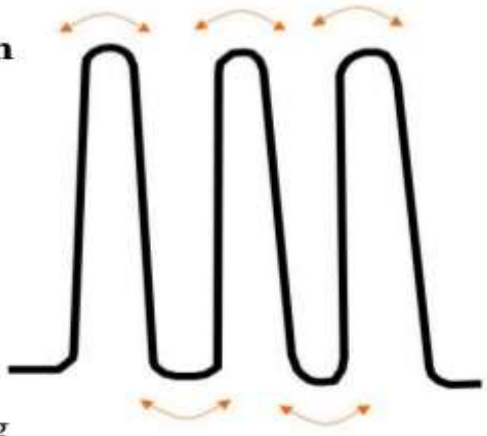




Catheter Kink

Rounded balloon pressure waveform
- Loss of plateau resulting from a 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
- IAB is too large for the aorta
- IAB is not fully unwrapped
- H_2O condensation in the external tubing



Waveforms

Early Inflation

Characteristics:

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Effects:

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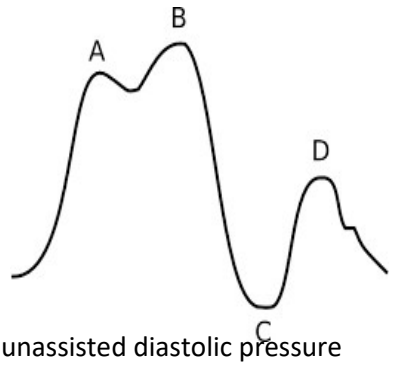
- Increase afterload
- Aortic regurgitation
- Increased O2 demand



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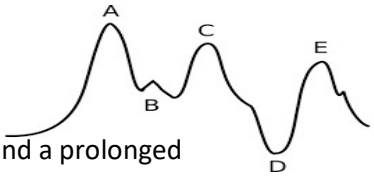


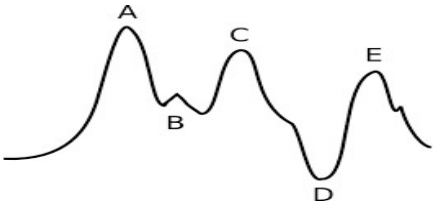
Late Inflation

Characteristics:

- Inflation of balloon after dicrotic notch
- Absence of sharp V
- Sub-optimal augmentation

Effects:

- Sub-optimal coronary perfusion



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- Sub-optimal afterload reduction
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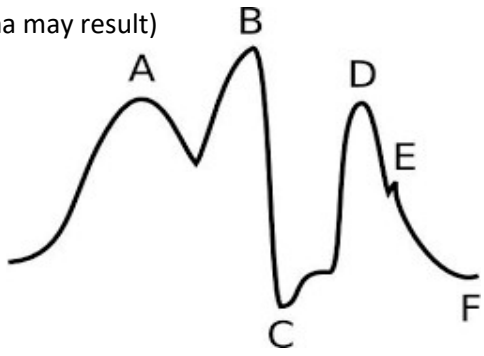

Nursing Care - Generalized

- 12 lead ECG upon arrival and daily
- Chest X-Ray upon arrival and daily
- BMP, CBC, INR, and APTT upon arrival and every 8 hours
- Maintain HOB less than 30 degrees
- Logroll patient when repositioning
- Change catheter dressing using sterile technique daily and as needed
- Assessments
    - CV:
        - Monitor temp, pulse, systolic, diastolic, MAP hourly
        - Observe and record IABP waveform
        - Ensure ECG leads are secure
        - Monitor and treat arrhythmias
        - Maintain therapeutic anticoagulation
        - Monitor radial and pedal pulses hourly
    - Respiratory
        - Monitor respiratory rate and pulse oximetry hourly
        - Provide supplemental oxygen as required
        - Encourage deep breathing exercises
    - Renal
        - Catheterize and monitor urine output hourly, watch for trends
        - Monitor renal function daily
    - GI
        - Assist and monitor patient's dietary and food intake
        - Use of nutritional supplements if required
        - Refer to dietician as needed
        - Monitor bowels and give laxatives as required
    - Skin
        - Educate patient about the need to elevate no more than 30 degrees and to keep affected leg straight
        - Observe pressure areas
        - Turn every 2 hours
        - Ensure insertion site is visible whilst maintaining patient dignity
        - Check IABP entry site hourly and observe for bleeding and/or hematoma formation
        - Monitor limb perfusion hourly

Nursing Care – IABP Specific

- Immobilize cannulated lower extremity with knee immobilizer
- Watch for signs of a dissecting aortic aneurysm (sudden or recurrent chest pain, back pain, discrepancy of upper extremity blood pressure)
- Auscultate the heart and breath sounds while the IABP is on standby
- Do not change augmentation or ratio without an MD order
- Keep augmentation at 100% unless contraindicated per MD order
- Monitor for signs and symptoms of balloon migration: loss of pulses, sudden decrease in urine output, or mental status changes. Notify MD immediately
- IABP should not be on standby for more than 30 minutes

Nursing Documentation

- Document systolic, diastolic, MAP, and augmented pressures from IABP console hourly
- Assess helium tubing every hour
- Confirm settings on IABP and document Trigger Mode, Assist Ratio, and Catheter Insertion site every hour
- Hourly I's and O's; If the balloon migrates down, renal arteries could be impaired – Notify provider if urine output is less than 0.5mL/kg/hr or about 30 mL/hr
- Document timing strips on 1:2 ratio every 4 hours and with timing changes
- Assess and document affected extremity pulse checks, including pulse intensity, color, and skin temperature every hour; You're monitoring for signs of limb ischemia
- Assess and document left radial pulse checks, including pulse intensity, color, and skin temperature every hour; If the balloon moves up or down, it could occlude perfusion to limbs

IABP Console Care

- Set the augmentation alarm 10mmHg below the augmented diastolic pressure. The alarm should be on continuously and on maximum volume
- If the patient is in A Fib, ECG trigger is the desired trigger but pressure trigger may be used
- If the patient has a pacer, the ECG trigger should still work as long as there is an R Wave. If moving the lead closer to the heart doesn't make the R wave more pronounced (and inflation is not occurring approximately after R wave consistently), consider Semi-Auto mode and Pacer V/AV trigger. The balloon will then trigger off the V spike (must be 100% spaced).
- Inspect the pressure bag for volume and proper inflation. Always use 0.9% NS, never Heparin. If patient arrives from OR or OSH with heparin, switch to NS. Change the flush bag Q 96 hours.
- While changing the helium tank, leave the console on and running

Weaning and Removal – Nursing

- Weaning of IABP by provider order only
- Wean ratio from 1:1 all the way to 1:3 per provider order and instructions
- Pump will then be turned off per instructions; disconnect/vent the helium shuttle line of the IABP catheter to allow for passive deflation
- After provider removes IABP and holds initial pressure, RN will take over and hold pressure to site for a minimum of 30 minutes and then until hemostasis is achieved.
- Position patient with HOB less than 30 degrees for 6 hours after IABP removed
- Assess peripheral circulation and site for hematoma formation every 5 minutes during removal process, then 15 minutes for 1 hour, every 30 minutes for 1 hour, and then every 1 hour until provider's order/instructions say otherwise
- Assess vital signs every 5 minutes during removal process, then 15 minutes for 1 hour, every 30 minutes for 1 hour, then every 1 hour until provider's order/instructions say otherwise

Complications

Limb Ischemia

- Femoral artery obstruction
    - Thrombus formation
    - Balloon migration up the aortic arch, reducing blood supply to the left arm
- Document pedal and radial pulses hourly, limb temperature, limb color
    - Notify provider if there's a change to limb perfusion

Bleeding from Insertion Site
- Secondary to coagulopathy
- Secondary to vessel damage during insertion
- Secondary to patient movement
- Retro-peritoneal bleeding
- Hourly CV checks, keep site exposed while maintaining patient dignity, observe insertion site anteriorly, observe bleeding posteriorly, observe posteriorly for bruising on flanks (Grey Turner's sign), prevent catheter movement
    - Inform provider if there is significant uncontrolled bleeding

Thromboembolism
- Caused by presence of balloon
    - Higher risk if there is a lower inflation ratio or if pump stops
- Anticoagulation as per policy, check clotting studies

Thrombocytopenia
- Mechanical damage to platelets
- Anticoagulation therapy
- Observe patient for bruising, oozing and/or bleeding; monitor platelet count, replace where indicated, monitor urine for blood

Balloon catheter rupture and gas loss
- Contact with sharp object
- Balloon membrane fatigue
- Contact with a calcified plaque
- You will see backflow of blood into the tubing
    - Immediate response required if console alarms "gas leak," "low augmentation," or "blood detect"
        - Inform medical provider immediately

Aortic dissection
- Increased risk in patients with a friable aorta (i.e. those with connective tissue disorders to include Marfan's)
- Observe patient for: back pain, abdominal pain, cardiovascular instability
    - Notify medical provider immediately

Compartment Syndrome
- Temporary or partial limb ischemia
- Observe limb for: swelling, loss of sensation and/or function, and pain; measure and record calf girth
    - Notify medical provider immediately

Infection
- During a insertion procedure: secondary to a failure to maintain aseptic technique, following insertion secondary to failure to maintain aseptic technique, secondary to site contamination from incontinence

- Hourly observations, check sepsis markers daily, aseptic technique for all line interventions, check and record VIP score daily, use semi-occlusive transparent dressings and change when soiled, consider bowel management system if the patient has diarrhea

Renal Failure

- Decrease urine output after the insertion of an IABP can occur if the balloon moves distally occluding the renal arteries and reducing renal perfusion
- Catheterize, hourly urine output, check renal function
    - Notify provider immediately for decreased urine output

Emergency Instructions

- If the patient cardiac arrests, switch the pump to a pressure trigger mode and decrease augmentation to 50%. Do not turn off the pump! The balloon will inflate and deflate in sync with compressions
- Monitor signs of balloon leak: frequent loss of augmentation
- Monitor helium tubing for blood: if present, STOP PUMP AND NOTIFY MD IMMEDIATELY
- Prevent inflation of IABP during ventricular ejection

Troubleshooting

- Never turn off IABP until provider is read to remove it.
- If IABP console fails, use a 60mL syringe and a stopcock to inflate and deflate the IABP Q5 minutes using 40mL of Helium until a new console is available
- Report to a provider if blood is observed (rust colored flecks) in the IABP catheter helium line of if a recurrent gas loss alarm occurs
- Turn off pump immediately if rupture is confirmed and follow procedure for removal with provider. If the patient still requires therapy, prepare for emergent travel to Cardiac Cath Lab
- If the IABP pressure waveform dampens, check all connections and ensure tubing is free of kinks and air bubbles. The IABP may be flushed using pigtail on the transducer or power flushed only when the pump is on standby

No Trigger

- IABP has lost the ECG trigger
    - Reconnect ECG leads

IABP Disconnected

- Extension tubing has become disconnected
- Reconnect the extension tubing, press IABP fill for 3 seconds then press assist/standby to start pumping

Rapid Gas Loss

- Leak, kink, or hole in the tubing
- Check the patient's leg isn't bent up, check all connections, and check tubing; If you see flecks of blood appear in the tubing the IABP may have ruptured
    - Stop pumping and inform provider immediately

Check IABP Catheter

- Catheter is kinked
- Examine catheter for signs of kinks and ensure patient's leg is straight

Low Helium
- Helium level low
- Change out the helium tank

Low battery
- Not plugged into the main power supply
- Plug the pump into the wall socket

IABP Failure
- IABP console fails to function as a result of technical malfunction or presence of blood in the condenser
- Contact cardiology immediately; use large syringe (adequate for balloon size) to inflate/deflate every 30 seconds until the pump is changed over

Leak in IABP Circuit
- Loose connection, high rate of helium diffusion from the balloon or ruptured balloon
- Check connections; If blood is evident in the line, stop the pump and contact provider immediately

Augmentation Set Below Limit
- Augmentation outside of set parameters
- Check patient's vital signs, review alarm parameters, check the transducer in the line with the patient

Prolonged Time in Standby
- Taking too long to troubleshoot alarms; error in recommencing therapy
- Do not recommence IABP pumping if the balloon has been stopped for 20 minutes

In the event of cardiac arrest
- IABP can be left in ECG trigger mode or pressure as it will synchronize to the rate and rhythm of chest compressions
- IF put into standby mode, it can be left in this mode for no more than 30 minutes
- The IABP is completely isolated from the patient and is safe for defibrillation
- May place in internal trigger mode if no ECG or arterial pressure source
    - If CPR can't generate a reliable trigger (interruptions), use internal
    - Remove ECG cable from console so the pump will automatically go to an arterial pressure trigger source
    - Internal inflation and deflation happen at a present rate regardless of pt's cardiac activity

Provider Notification
- Blood in tubing
- Any vascular changes (diminished pulses, lost signals)
- Augmentation pressure less than 5mmHg above systolic BP
- Bleeding or hematoma at insertion site or signs of retroperitoneal bleed

- Drop in hematocrit unexplained by other bleeding sites
- Abrupt stop in urinary output
- Any signs of dissecting aorta (sudden or recurrent chest pain, back pain, discrepancy of upper extremity blood pressure)

For troubleshooting or transport assistance, call perfusion services