بنام خدا

Intraaortic BalloonPump Counterpulsation

(IABP)

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Cardiogenic shock:

- defined as the inability of the heart to deliver sufficient blood flow to meet the metabolic requirements of the body, despite the presence of adequate intravascular volume.

- Generally, cardiogenic shock entails :

  - sustained hypotension (SBP <90 mm Hg or 30 mm Hg below baseline)
  - low cardiac output(cardiac index <2.2 L/min/m_2)
  - high central filling pressures (PCWP >12 mm Hg)
  - signs of diminished tissue perfusion.

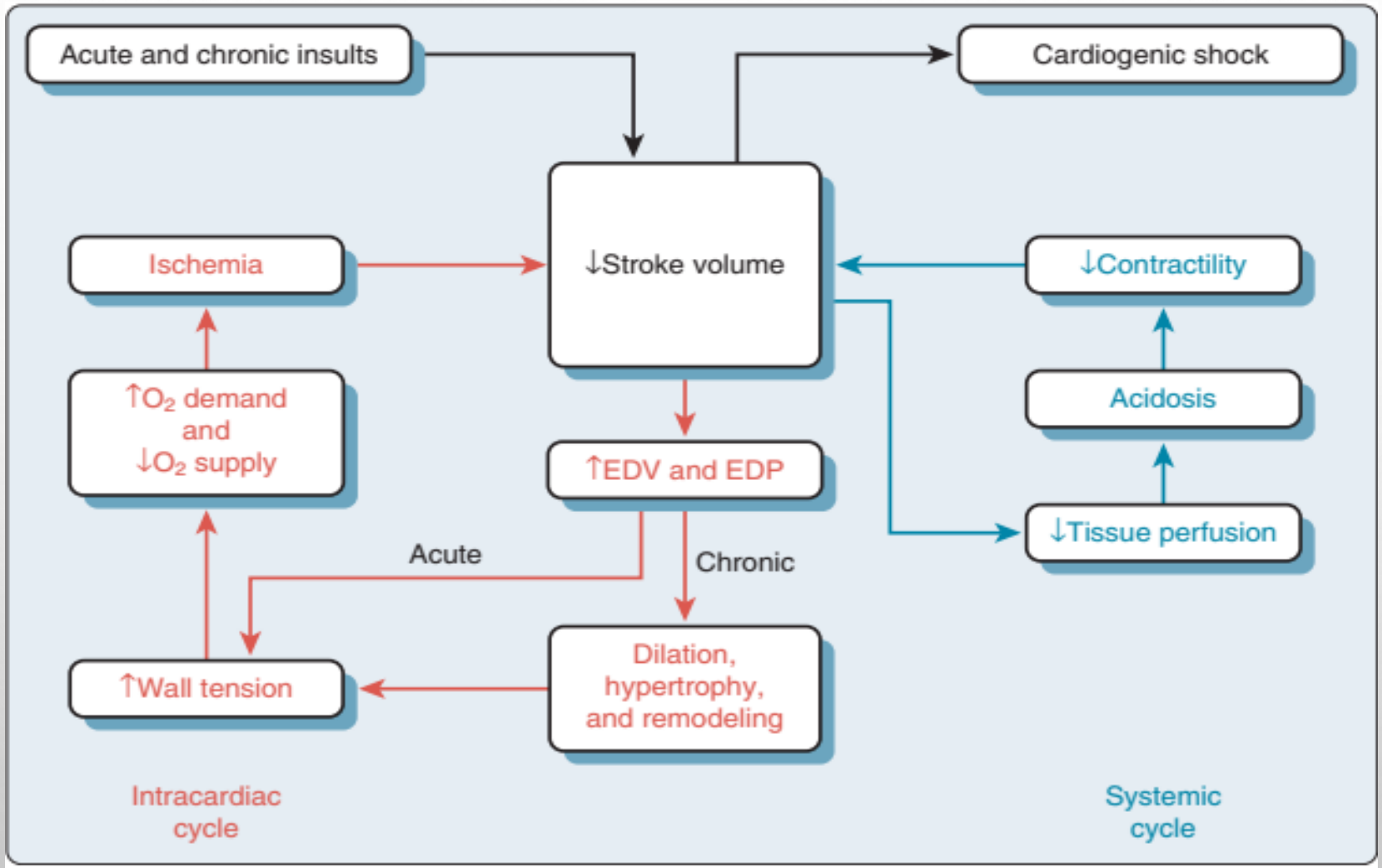


Fig. 28.1 Vicious cycles leading to cardiogenic shock. *EDP*, End-diastolic pressure; *EDV*, end-diastolic volume.

first-line treatment for acute heart failure:

- Manipulations and optimization of preload, afterload, heartrate, and contractility .

- Adequate myocardial oxygen supply, lowest feasible myocardial oxygen demand.

pharmacologic management with inotropes and vasopressors :

- increased myocardial oxygen demand and decreased perfusion to the peripheral and splanchnic circulations

- For the myocardium, β-adrenergic stimulation may improve contractility , but increase myocardial oxygen demand.

Vasoconstriction:

- improve coronary and systemic perfusion pressures.

- increase both systemic and pulmonary vascular resistances making it harder for failing ventricles

  to eject. especially problematic when there is right ventricular (RV) failure.

- intentional vasoconstriction often leaves the peripheral and splanchnic beds under perfused

Afterload reduction with vasodilators:

- Assist the failing heart and its overall function as a pump can be improved.

- Results in hypotension and poor tissue perfusion that predisposes to multisystem organ failure.

The Role of the Intraaortic Balloon Pump:

- IABP was introduced in 1968 and still remains a very commonly used VAD
- increases myocardial oxygen supply and decreases oxygen demand
- is often an effective treatment for left ventricular failure.

Intraaortic BalloonPump Counterpulsation:

- IABP increasing coronary blood flow during diastole and unloading the left ventricle during systole .

- Displacement of a volume of blood (usually 30–50 mL) by alternately inflating and deflating a balloon positioned in the proximal segment of the descending aorta.

Effects:

- **Improvements** CO, LVEF, coronary blood flow, and MAP

- **decreases** in aortic and ventricular systolic pressures, LVEDP, pulmonary capillary wedge pressure, LAP, HR, frequency of premature ventricular contractions, and suppression of atrial arrhythmias.

IABP:

- inserted percutaneously into the femoral artery retrograde up the aorta to its correct position that is just distal to the left subclavian artery.

- Balloon inflation during diastole occludes aorta and displaces arterial blood, abruptly increasing the aortic root pressure. This increases coronary perfusion pressure, which increases myocardial oxygen supply

- Abrupt deflation, just before the next systolic ejection decreases the pressure in the aorta in a sudden fashion,
  facilitating forward ejection from the heart by decreasing impedance to opening of the aortic valve.

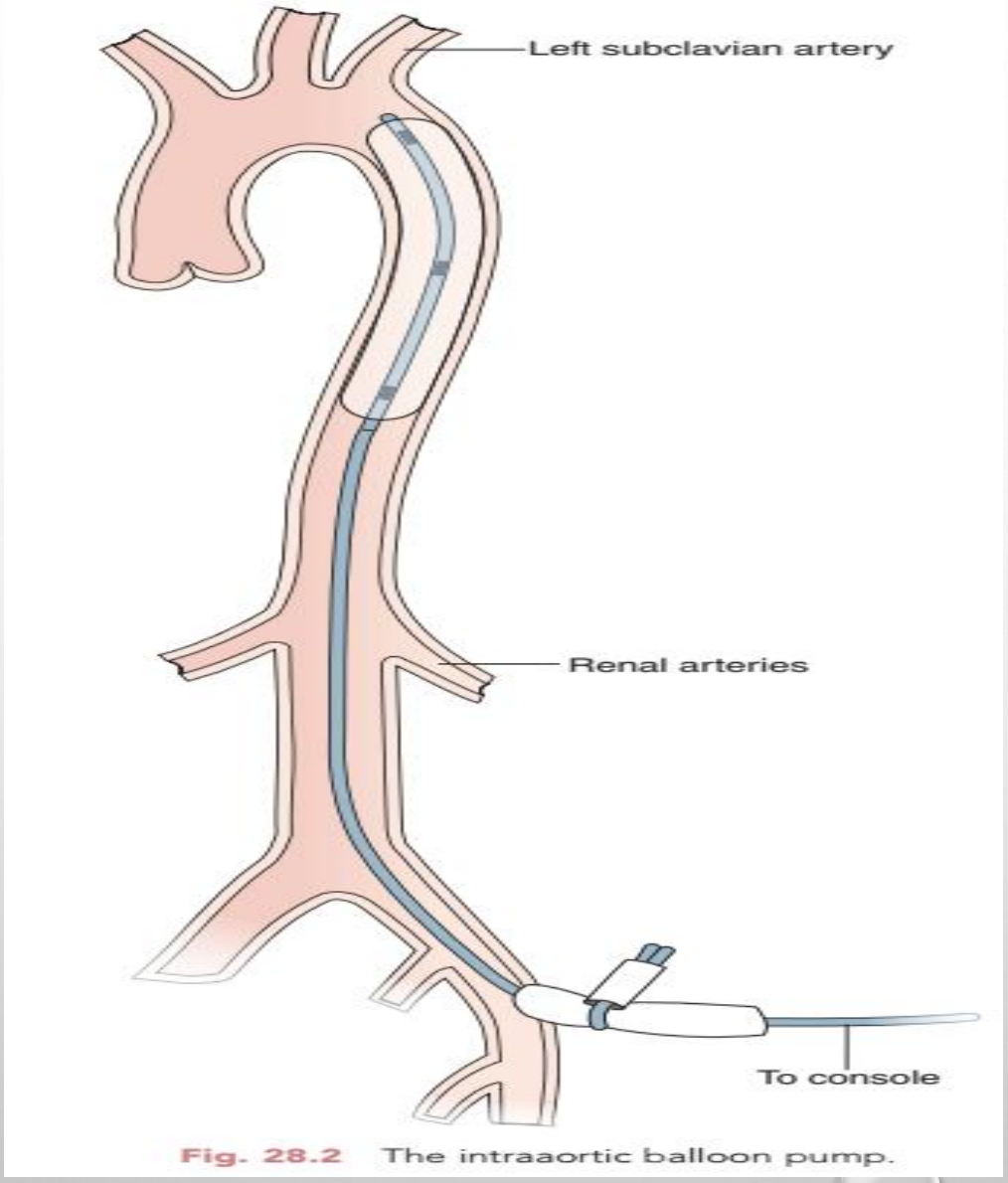
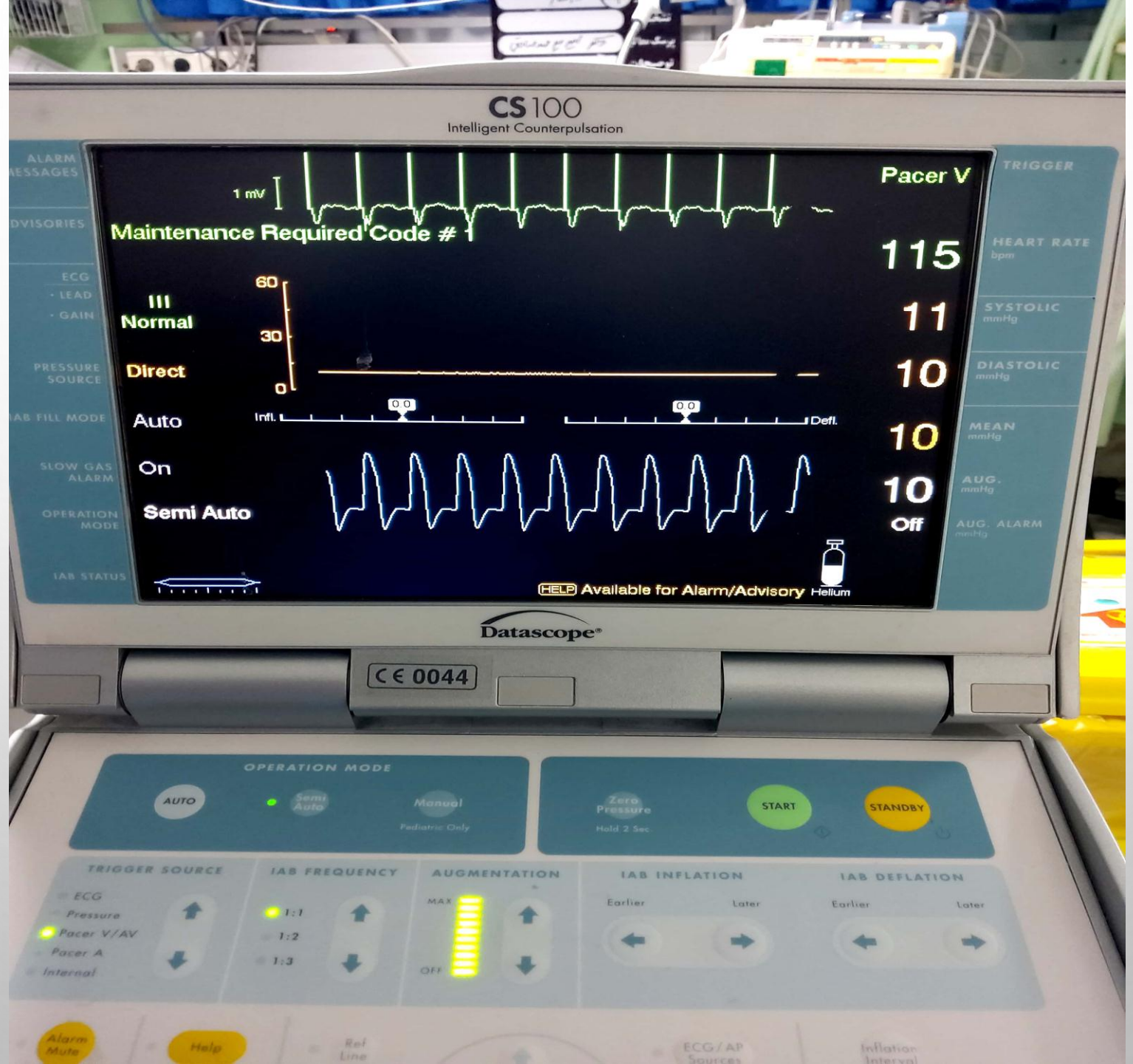


Fig. 28.2 The intraaortic balloon pump.


CS 100
Intelligent Counterpulsation
1 mV
Pacer V
Maintenance Required Code # 1
115
III
Normal
60
30
0
11
Direct
10
Auto
Infl.
Defl.
10
On
10
Semi Auto
Off
HELP Available for Alarm/Advisory
Helium
TRIGGER
HEART RATE
bpm
SYSTOLIC
mmHg
DIASTOLIC
mmHg
MEAN
mmHg
AUG.
mmHg
AUG. ALARM
mmHg
ALARM MESSAGES
ADVISORIES
ECG
· LEAD
· GAIN
PRESSURE SOURCE
IAB FILL MODE
SLOW GAS ALARM
OPERATION MODE
IAB STATUS
Datascope
CE 0044
OPERATION MODE
AUTO
Semi Auto
Manual
Pediatric Only
Zero Pressure
Hold 2 Sec
START
STANDBY
TRIGGER SOURCE
ECG
Pressure
Pacer V/AV
Pacer A
Internal
IAB FREQUENCY
1:1
1:2
1:3
AUGMENTATION
MAX
OFF
IAB INFLATION
Earlier
Later
IAB DEFLATION
Earlier
Later
Alarm Mute
Help
Ref Line
ECG/AP Sources
Inflation Interval

Results:

- increased stroke volume and decreased myocardial work and *therefore less oxygen demand* of left ventricle.

- optimally functioning balloon pump can increase cardiac output by20% -30% and decrease afterload by as much as 15%.

benefits :

- In acute deterioration of a chronically failing ventricle, IABP stabilize hemodynamics as a bridge

  to intervention.

- reduction in systemic acidosis and improvements in cerebral and renal microcirculatory perfusion.

Notice:

- augments forward cardiac output by only 25% to 30% at maximum and it will not augment anything if there is a complete absence of left ventricular output.

- As a sole intervention, the IABP cannot be expected to rescue a patient from catastrophic myocardial failure.

- **Appropriate timing of balloon inflation and deflation** is key to realizing the hemodynamic benefits of the device.

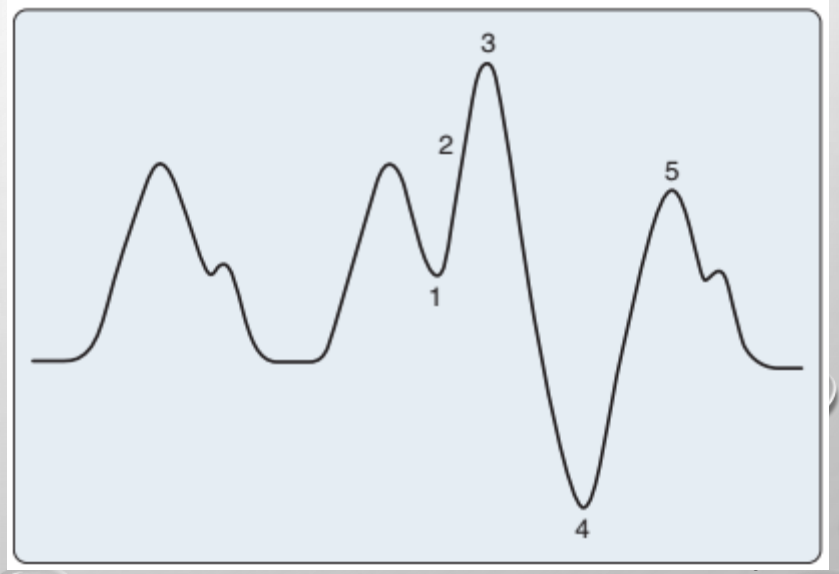
- The usual trigger for balloon inflation is the R wave of the patient's ECG; however, an arterial pressure tracing and pacing spikes can also be used.

Timing:

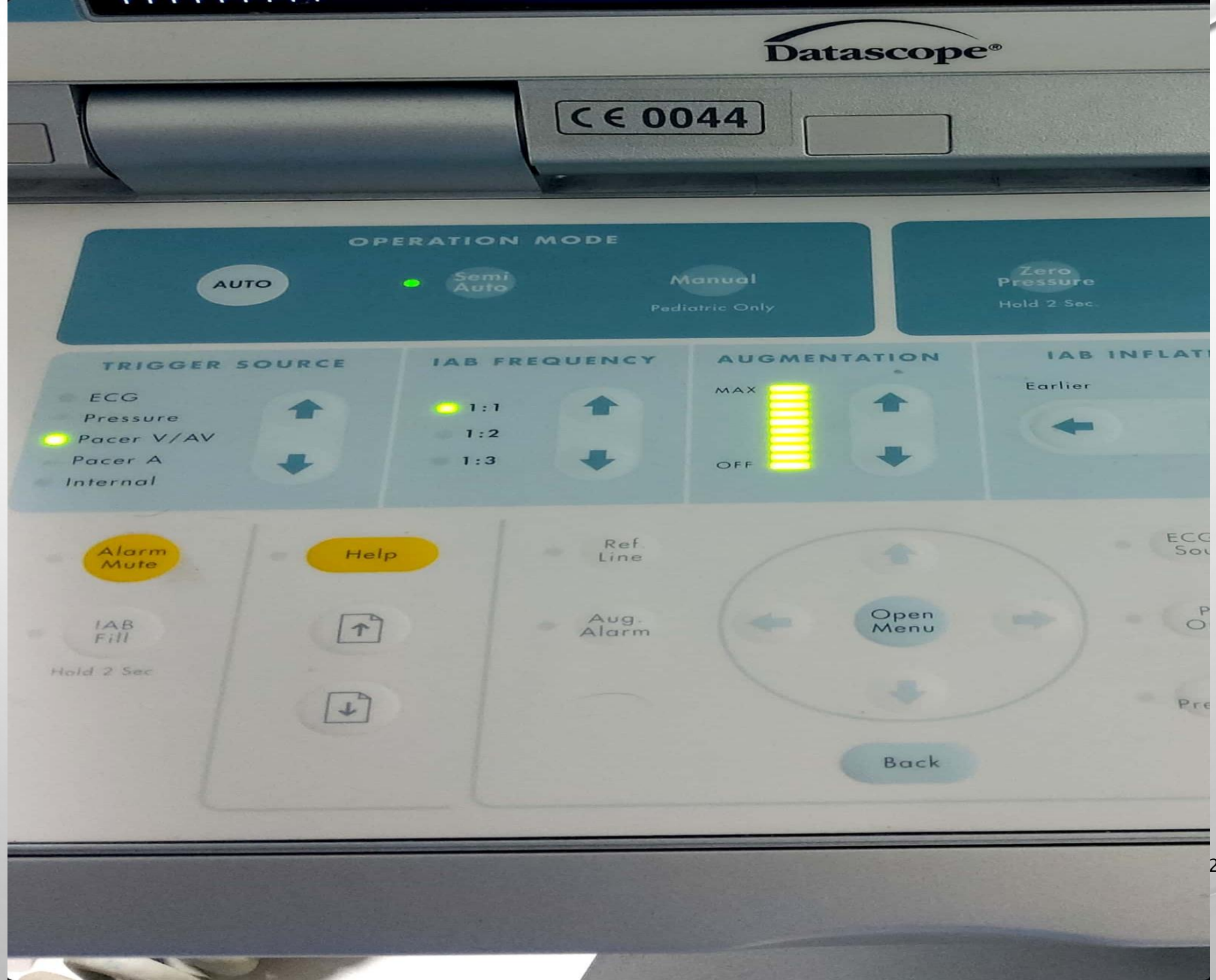
- Inflation should always coincide with the dicrotic notch of the arterial tracing and should
  continue throughout diastole.

- Deflation should always occur just at end-diastole, *immediately before* the next systolic ejection.

Fig. 28.3 A well-timed intraaortic balloon pump (IABP) inflation. The figure demonstrates an arterial pressure tracing taken from a patient with an IABP. The first pulse seen on the left is the familiar waveform of an arterial pulse. An IABP is triggered to inflate during the second pulse, generating a typical sinusoidal balloon inflation-deflation waveform. The third pulse represents an assisted ejection due to the action of the IABP. Characteristics of the typical balloon waveform include the following: *1,* The balloon inflation point coinciding with the location of the patient's dicrotic notch (representing aortic valve closure at the end of systole). *2,* A steep slope of increasing pressure indicating rapid balloon inflation. This creates a rapid rise in aortic root pressure to reach. *3,* The assisted diastolic peak pressure perfusing the coronary arteries while the IABP is inflated. This increased in coronary perfusion pressure creates the increased myocardial oxygen supply associated with IABP action. *4,* A steep slope of pressure decline indicates a rapid balloon deflation, resulting in a decrease in end-diastolic aortic root pressure. This localized decreased afterload decreases impedance to opening of the aortic valve at the beginning of systole, and creates the decreased myocardial oxygen demand associated with IABP action. *5,* The assisted systolic peak pressure of the next beat perfusing the body. The systolic pressure attained by this ejection was accomplished with less myocardial work thanks to the IABP. Depending on the level of assistance required, the balloon can be triggered with each cardiac cycle (so-called 1 : 1 assistance), every other cycle (1 : 2), every third cycle (1 : 3), and so forth.



- Depending on the level of assistance required, the balloon can be triggered with:
  - each cardiac cycle (so-called 1 :1 assistance)
  - every other cycle (1 :2)
  - every third cycle (1 : 3), and so forth
- Ratios of 1 :2 or 1 :3 are ideal for optimizing the timing of inflation and deflation.


Datascope
CE 0044
OPERATION MODE
AUTO
Semi Auto
Manual
Pediatric Only
Zero Pressure
Hold 2 Sec
TRIGGER SOURCE
ECG
Pressure
Pacer V/AV
Pacer A
Internal
IAB FREQUENCY
1:1
1:2
1:3
AUGMENTATION
MAX
OFF
Earlier
Alarm Mute
Help
Ref Line
IAB Fill
Hold 2 Sec
Aug. Alarm
Open Menu
Back

Insertion Techniques:

- In the initial , insertion was by surgical access to the femoral vessels.

- Now, percutaneous IABP insertion, is performed rapidly with commercially available kits.

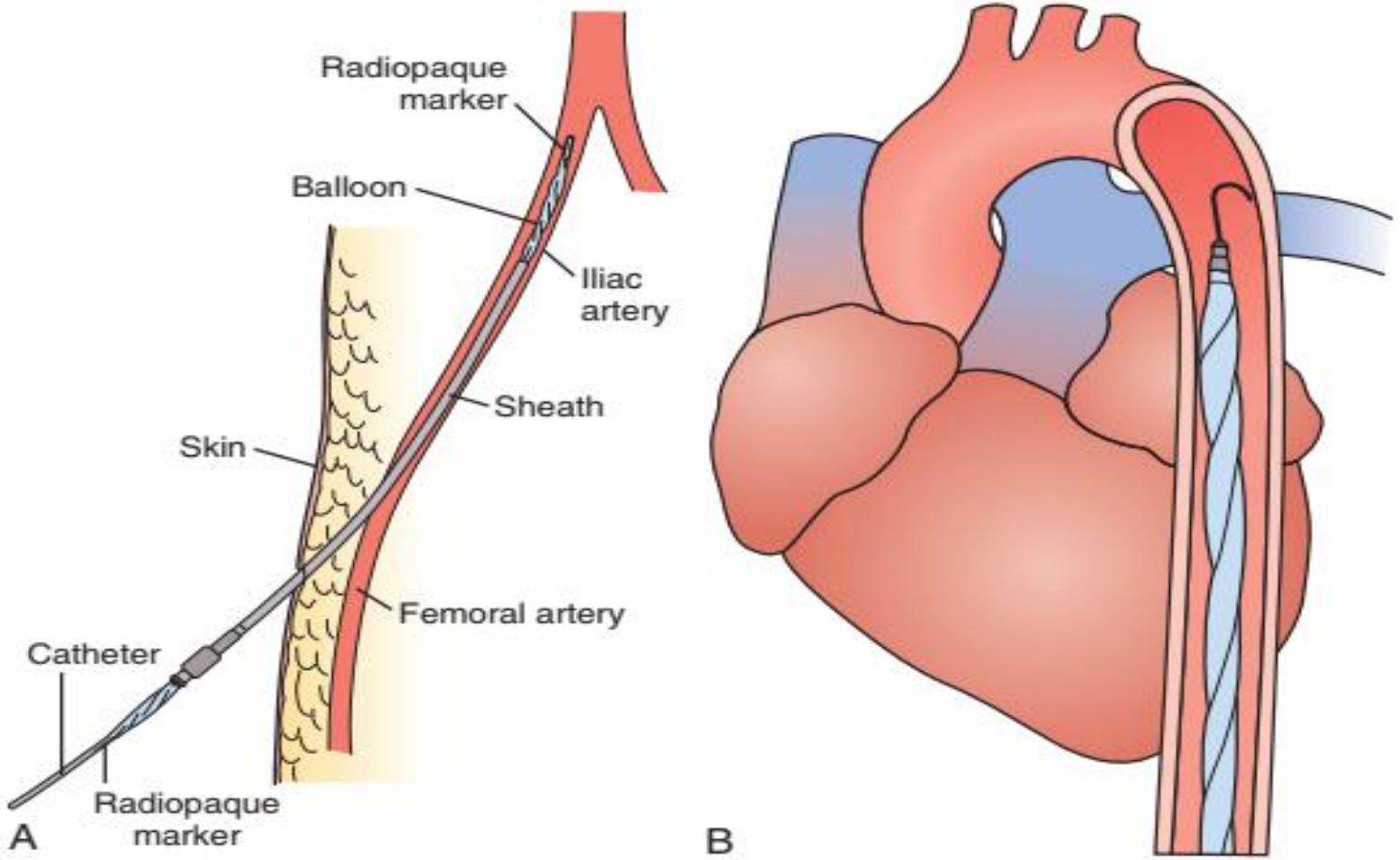


Fig. 36.3 Intraaortic balloon pump insertion. (A) Cannulation and insertion of the balloon through the femoral artery. Notice the tightly wrapped balloon as it traverses the sheath. A guidewire is not visible in this drawing. (B) Correct positioning of balloon in proximal descending aorta. The J-tipped guidewire is seen exiting from the balloon's central lumen. *(A, Courtesy Datascope Corporation, Fairfield, NJ; B, Courtesy Kontron, Inc., Augsburg, Germany.)*

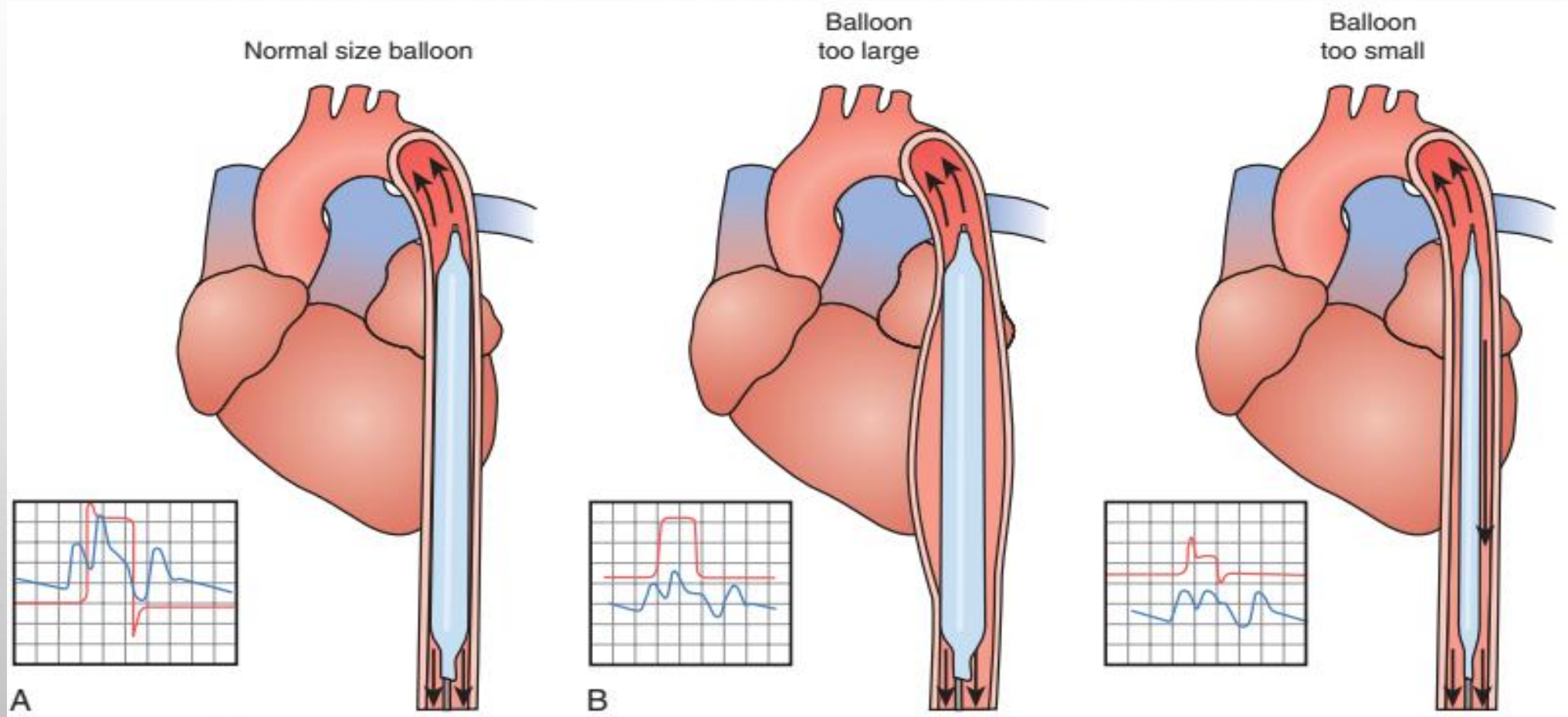


Fig. 36.5 Variations in waveform caused by incorrect balloon size. (A) The balloon is correctly positioned and appropriately sized for the aorta. Notice the arterial waveform diagram in the *lower left corner*. (B) Examples of too large *(left)* or too small *(right)* balloon sizes with their correspondingly altered arterial waveforms. A similar effect can result from overinflation and underinflation of the balloon. Compare the waveforms in B with the ideal waveform in A.

TO correct placement :

- ❑ fluoroscopy during the procedure
- ❑ radiography or TEE after insertion.
- ❑ alteration of the arterial pulse waveform

In patients with:

- extreme peripheral vascular disease or in pediatric , the ascending aorta or aortic arch may be entered for balloon insertion by sternotomy

- Other routes of access include the abdominal aorta ,subclavian, axillary, and iliac arteries.

- The iliac approach may be especially useful for pediatric cases.

TABLE 36.10 Intraaortic Balloon Pump Counterpulsation Complications

Vascular	*Miscellaneous*	*Balloon*
Arterial injury (perforation, dissection)	Hemolysis	Perforation (preinsertion)
Aortic perforation	Thrombocytopenia	Tear (during insertion)
Aortic dissection	Infection	Incorrect positioning
Femoral artery thrombosis	Claudication (postremoval)	Gas embolization
Peripheral embolization	Hemorrhage	Inadvertent removal
Femoral vein cannulation	Paraplegia	—
Pseudoaneurysm of femoral vessels	Entrapment	—
Lower extremity ischemia	Spinal cord necrosis	—
Compartment syndrome	Left internal mammary artery occlusion	—
Visceral ischemia	Aggravation of dynamic outflow tract obstruction	—

Indications:

1. Cardiogenic shock

a. Myocardial infarction

b. Myocarditis

c. Cardiomyopathy

2. Failure to separate from CPB

3. Stabilization of preoperative patient

a. Ventricular septal defect

b. Mitral regurgitation

4. Stabilization of noncardiac surgical patient

5. Procedural support during coronary angiography

6. Bridge to transplantation

INDICATION:

- preoperatively in patients with unstable angina unresponsive to medical treatment
- Intraoperatively in high risk patients (redo sternotomy with poor LV function)
- patients who fail to wean from CPB, or in patients on maximal inotropic support after CPB
- patients who do not successfully wean from CPB

Contraindications:

1. Aortic valvular insufficiency
2. Aortic disease

a. Aortic dissection

b. Aortic aneurysm

3. Severe peripheral vascular disease
4. Severe noncardiac systemic disease
5. Massive trauma
6. Patients with “do not resuscitate” instructions
7. Mitral SAM with dynamic outflow tract obstruction

Contraindications to the use of the IABP include clinically significant aortic insufficiency, aortic aneurysms, and significant friable atherosclerotic plaques in the aorta.

performance of the IABP:

- positioning of the balloon within the aorta, balloon volume and cardiac rhythm.
- inflation should be coincide with aortic valve closure, or aortic insufficiency and LV strain will result.
- late inflation results in a diminished perfusion pressure to the coronary arteries.
- Early deflation causes inappropriate loss of afterload reduction.
- late deflation increases LV work by causing increase afterload.

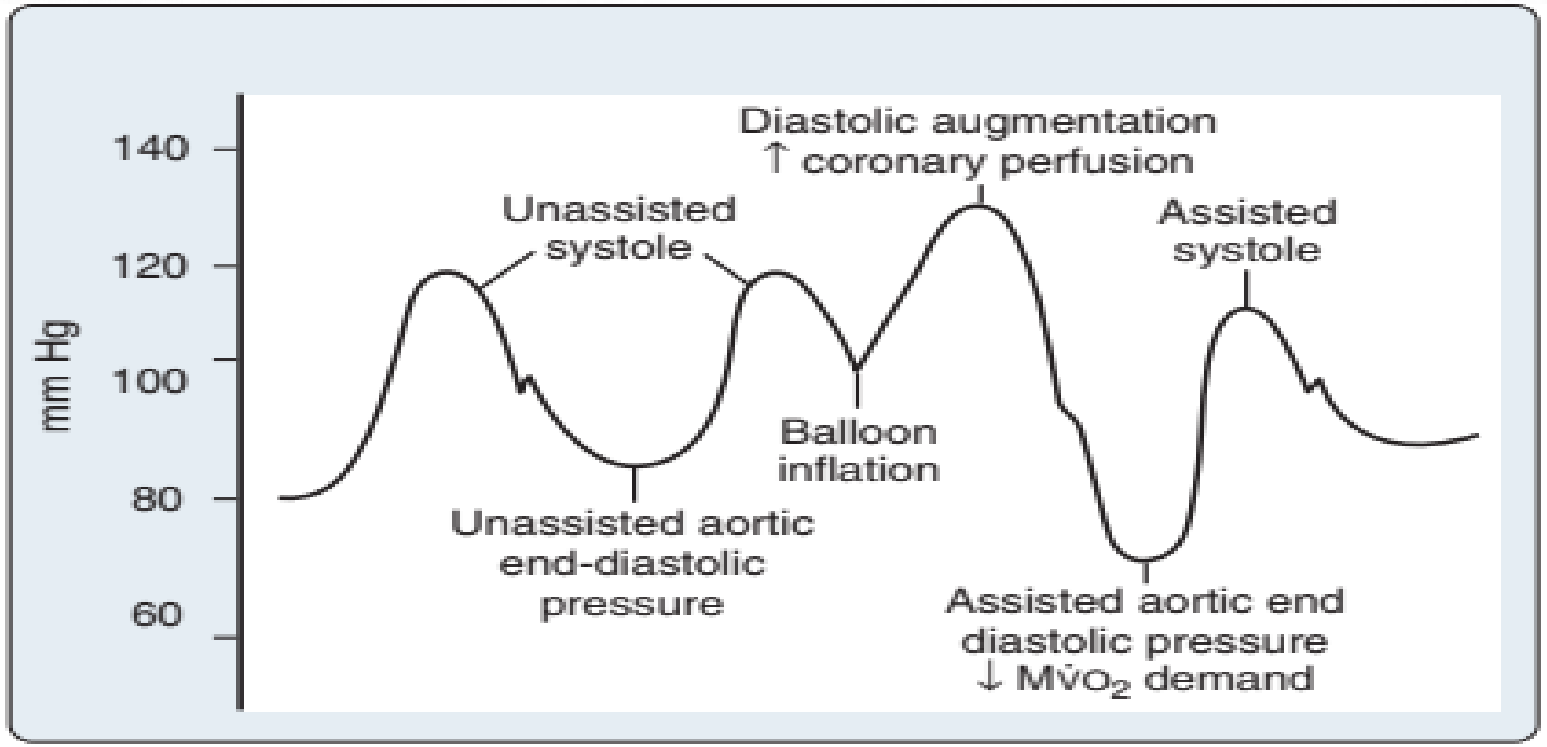


Fig. 36.4 Arterial waveforms seen during intraaortic balloon pump assist. The first two waveforms are unassisted, and the last is assisted. Notice the decreased end-systolic and end-diastolic pressures and augmented diastolic pressures caused by balloon pump augmentation and the (correct) point at which balloon inflation occurs. These are waveforms generated by a correctly positioned and timed balloon. $M\dot{V}O_2$, Myocardial oxygen consumption. *(Courtesy Datascope Corporation, Fairfield, NJ.)*

Inflation of the IAB before aortic valve closure

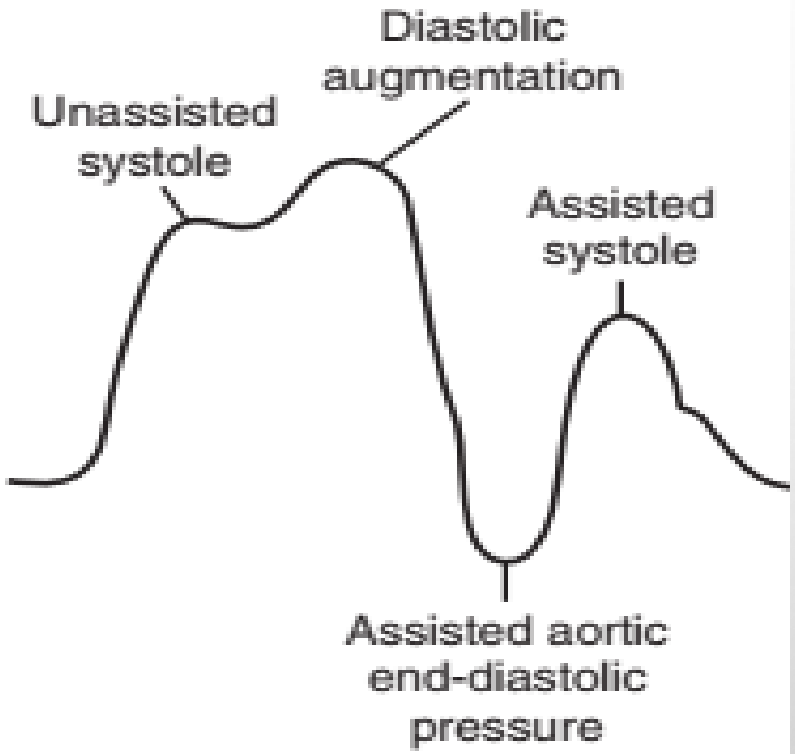
Waveform characteristics:

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

Physiologic effects:

- Potential premature closure of aortic valve
- Potential increased in LVEDV and LVEDP or PCWP
- Increased left ventricular wall stress or afterload
- Aortic regurgitation
- Increased $M\dot{V}O_2$ demand

C



Inflation of the IAB markedly after closure of the aortic valve

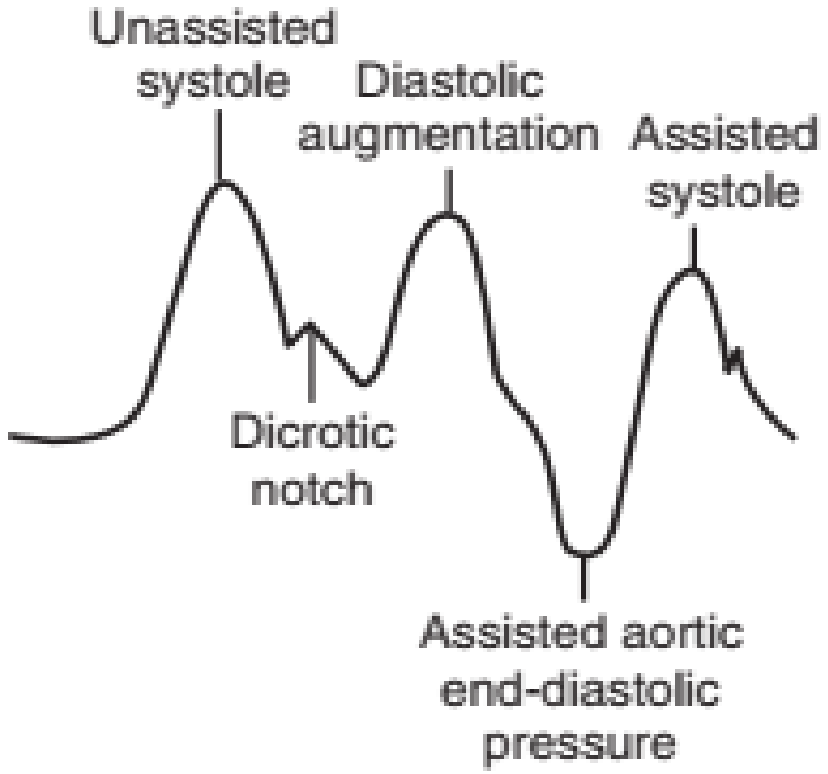
Waveform characteristics:

- Inflation of the IAB after the dicrotic notch
- Absense of sharp V
- Suboptimal diastolic augmentation

Physiologic effects:

- Suboptimal coronary artery perfusion

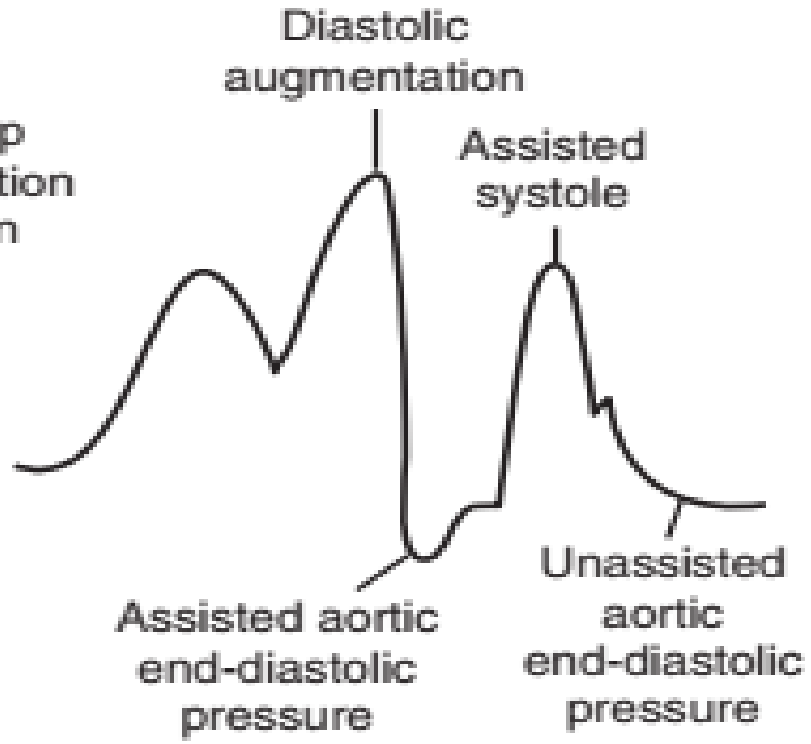
D



Premature deflation of the IAB during the diastolic phase

Waveform characteristics:

- Deflation of IAB is seen as a sharp drop following diastolic augmentation
- Suboptimal diastolic augmentation
- Assisted aortic end-diastolic pressure may be equal to or greater than the unassisted aortic end-diastolic pressure
- Assisted systolic pressure may rise



Physiologic effects:

- Suboptimal coronary perfusion
- Potential for retrograde coronary and carotid blood flow
- Angina may occur as a result of retrograde coronary blood flow
- Suboptimal afterload reduction
- Increased $M\dot{V}O_2$ demand

A

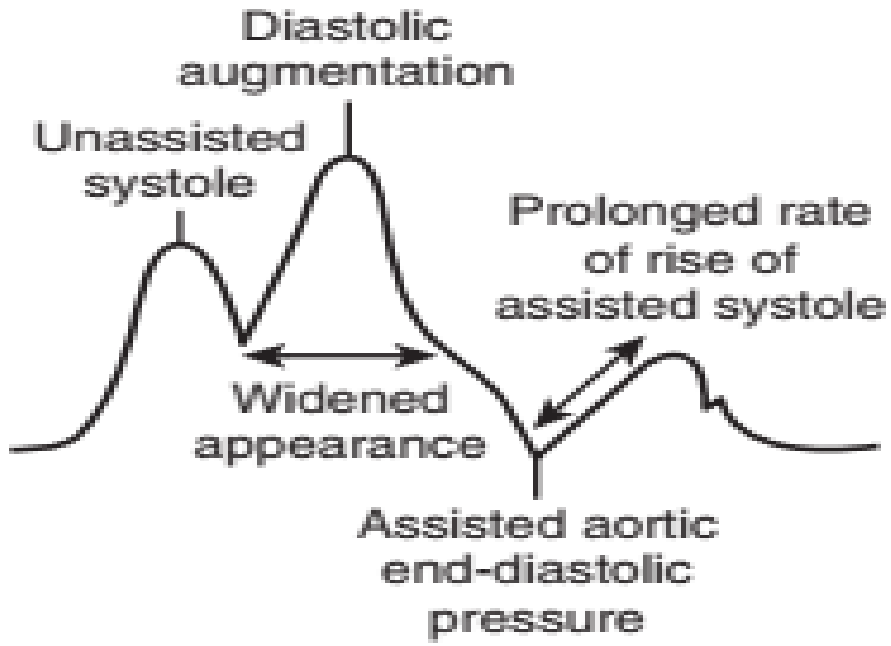
Deflation of the IAB late in diastolic phase as aortic valve is beginning to open

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 $M\dot{V}O_2$ 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



B

IABP discontinue and remove:

- As cardiac performance improves, the IABP support must be removed in stages rather than abruptly.
- vasodilator and inotropic medications can assist this procedure.
- balloon augmentation reduce in steps from1 :1 to 1 :2 and then to 1 :4
- appropriate intervals must be at each stage to assess hemodynamic and neurologic stability
- at 1 :4 or 1 :8 counterpulsation, balloon assistance can be safely discontinued and removed.

Removal of a percutaneously inserted IABP:

- may be by the open(surgical removal) or closed technique.

- In closed technique the artery should be allowed to bleed for several seconds to prevent distal embolization of clot.

- If surgical removal is chosen, embolectomy catheters may be passed in antegrade and retrograde fashion before suture closure of the artery