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ROLE OF IABP IN CLINICAL PRACTICE: A REVIEW

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ABSTRACT
Last few decades IABP is widely used for mechanical circulatory support which increases oxygen supply and reducing oxygen demand, works on the principles of diastolic inflation and systolic deflation of balloon. IABP is a type of internal counterpulsation, placed in descending thoracic aorta through the femoral artery, favored by Cardiologists and Cardiac surgeons due to easy insertion as well fast insertion and sometimes serious complications (bleeding, stroke, infections) occurs. Clinically, IABP is used in high risk patients of Myocardial infarction mainly complicated by cardiogenic shock, instable patients of elective percutaneous coronary intervention (PCI) and during cardiac artery bypass graft surgery (CABG).Converging data proved that IABP has great role in heart failure patients awaiting for heart transplantation as long term supports. Still, IABP is preferred, though many counterpulsation devices have been developed and tested.

KEYWORDS: Counterpulsation; IABP (intra-aortic balloon pump); PCI (percutaneous coronary intervention); CABG (cardiac artery bypass graft surgery).

INTRODUCTION
Failure of heart requires various supports like counterpulsation (either internal or external), Bypass pumps (cardiopulmonary) and Auxiliary heart pumps (different modes). Nearly, 1/3 procedures for coronary revascularization occurs due to impaired LV function which are closely associated with morbidity as well as mortality.[1],[2],[3] In recent years, discussion have been going on for proper use of intra-aortic balloon pump(IABP) in clinical practice.[4],[5].[6],[7] Intra-aortic balloon pump is a type of internal counterpulsation which augmentates the diastolic pressure during inflation which ultimately contributes to circulation (coronary, cerebral and systemic). The pivotal role of IABP is to increase the myocardial O_2 demand ratio which ultimately improves O_2 supply and LV subendocardial blood flow, better recognized by endocardial viability ratio. Presystolic deflation decreases the myocardial work and O_2 demand stated by Freedman et al.[8]

HISTORY
Kontrowitz[9] developed an idea about counterpulsation in 1952 by increasing coronary artery flow by delaying arterial pulse. This study was done in animal models. In 1958 Clauss et al[10] used femoral artery cannula for augmentation of diastolic to prevent failing left ventricle. This is a type of extracorporeal counterpulsation. Use of this method was limited due to various reasons like massive hemolysis and demand of arteriotomies. Moulopoulas et al[11] developed an intra-aortic balloon pump with the use of carbon monoxide (co) in which inflation and deflation were coordinated with cardiac cycle but Kantrowitz[12] was the first who used IABP in two patients (refractory cardiogenic shock). The important point was that, one of the patient with refractory cardiogenic shock was survived and discharged from the hospital. In early' 80s two surgical procedures were required one for insertion and second for removal of intra-aortic balloon pump. These procedures were associated with higher complication rates. Bregman et al done an effective insertion of IABP in twenty five patients through seldinger technique (femoral artery) and there was no complication occurred during the whole process.[13] This was considered as a milestone in counterpulsation history.

SEARCH STRATEGY
We searched PUBMED, MEDLINE, GOOGLE SCHOLAR and other sources under the headings of ''Intra-aortic balloon pump'' ''IABP'' and ''Counterpulsation'' for articles published till end of June 2017. We also searched the references list of review articles of IABP extensively and also considered the older publications. There was no language restriction while searching articles.

PHYSIOLOGICAL PRINCIPLES
IABP is placed in thoracic aorta (Descending) through the femoral artery and works (inflates/deflates) simultaneously to cardiac cycle. Inflation occurs in

diastolic phase of cardiac cycle which causes aortic augmentation, results in high coronary perfusion (improves coronary flows and myocardial supply).[14],[15] The balloon deflates in early systole. This deflation decreases afterload of the left ventricle (reduce oxygen demand).

In simple words
Systole……..Balloon deflates……QRS-T (R wave trigger balloon deflation).
Diastole…….Balloon inflates……T-P interval.

Coronary autoregulation is defined as reactive vasoconstriction of coronary and myocardial bed due to mechanical effect of counterpulsation. De Silva et al[16] done a study in IABP patients (active/inactive regulation) by using adenosine infusion. In his study he measured intracoronary flow and pressure. Results clearly shows that effects of IABP on coronary flow is directly depends upon autoregulation (cornonary).

Active Autoregulation
Increase coronary pressure.
Increase microvascular resistance.
Coronary blood flow (unchanged).

Inactive Autoregulation
Increase coronary pressure (distal).
Increase coronary blood flow.
Microvascular resistance (unaffected).

CHARACTERSTICS OF BALLOON PUMP DEVICE
Cabinet contains various parts which are described as:
Gas source cyclinder.
Valve unit delivers gas.
Monitor for ECG and Arterial Blood Pressure.

Control Unit---Controls timing of inflation and deflation

CO_2 and Helium both used as driving gases but, Helium is preferred due to its low viscosity than carbon dioxide and also supported by Hendrickx.

Regarding balloon catheters and position
The size of aorta of patient is depends upon its age, weight and size. There are some important points regarding ideal balloon like length should be from left subclavian artery to celiac artery, inflated diameter should be 90%-95% of descending aorta and equal volume needed to volume of blood in aorta. This statement was also supported by Kantrowitz and its co-workers. There are different sizes of catheter available.

Balloon volume [25cc (smallest) 50cc (largest)].
Balloon membrane length [180mm (min) 270mm (max)].
Inflated diameter [13mm (mim) 18mm (max)].

In clinical practice, mostly 40cc intra-aortic balloon are used. Smallest size catheter can reduce benefit whereas large IAB increases morbidity. In tall patients 50cc size of IAB is preferred. One important point is that when SV is equal to balloon volume then diastolic augmentation is maximum. Low or high stroke volume can affect the efficacy of augmentation. The position is very important for proper augmentation. More close the tip to aortic valve more diastolic augmentation. It is advised to place tip distal to left subclavian artery take off and proximal balloon end should be above the renal vessels. Inappropriate position can cause plaque distortion, embolization and even complete occlusion of the lumen (artery).

MEDICATIONS DURING IABP
Heparin (unfractionized) used as a standard medication during IABP. It can prolong the PTT (partial thromboplastin time) 50 to 70 seconds. As we clearly, knows about the fact that it prevents thrombotic events related to catheter. A study done in 150 patients (approx.) which showed no difference between limb ischemia (Heparin used or not).[17] In experimental studies (without heparin) deflated balloon leads to thrombosis within twenty minutes.[18] So, it is advised to remove balloon immediately (Non functioning), as it can cause thrombosis. Even manufacturers recommends removal of IABP (Non functioning) within 30 minutes.[19] In case of rupture of balloon (uncommon) which can cause thrombosis, so to avoid the adverse event the heparin should be discontinued and device should be removed urgently. For elective removal of IABP, heparin must be discontinued for ≥ 2hours and balloon should be inflated intermittently. This is to be done for prevention of hemostasis and thrombosis.

Proper sedation and pain killers (analgesia) are required before IABP insertion. Patient must be immobile during IABP because there is risk of dislocation of device and even can cause aortic injury. If extubation is planned then first remove IABP. It is recommended after the removal of IABP patient should be on immobile posture for ≥ 6 hours, so it is better to stop the sedation after this period and extubate the patient.

INDICATIONS
IABP improves coronary circulation, decrease in LV stress as well cardiac work load.

Risk factors that leads to IABP usage
1) Myocardial infarction (MI).
2) Female gender.
3) Diabetes.
4) Peripheral vascular disease.
5) STEM disease (left).

IABP are indicated for: 1) Left ventricular support (temporary) either due to MI, cardiogenic shock or during surgery (cardiac injury). 2) To secure myocardial viability by improving oxygen supply.

Triple vessel disease with moderate preservation of LV function and mechanical lesions (mitral insufficiency/ventricle septal defect) are conditions which shows more beneficial results with IABC, as suggested by Singh et al.[20]

Role of IABP in unstable angina

There is a window period during ischemic attacks in which proper hemodynamic support prevents the myocardium for adequate function and followed by CABG[21,22] supported by cardiologists, in this situation IABP plays important role. Gold and its colleagues proved in there study that IABP recovers pain, improve elevation (ST) and prevents arrhythmias. Moreover, they also showed that without IABP usage before CABG is far inferior than IABP followed by CABG.[23],[24] The use of IABP in unstable patients(LV dysfunction) prepares the patients for diagnostic tests and surgical procedures safely. Less operative mortality, decrease incidence of infarction(pre-operative) are supported by Zhang et al.[25] A study of 75 patients done by Langou and its colleagues[26] which adopted the same course of treatment and found 5.3% mortality (operative) and 6.6% infarction rate (perioperative).

Role of IABP in ventricular arrhythmias: IABP is used for ventricular arrhythmias after the failure of first and second line drugs for the control of ventricular tachyarrythmias (after MI).[27] Cardiac catheterization and CABG should be done after the IABP insertion. Most of the ventricular arrhythmias are controlled by medications but in few patients in which arrhythmias are refractory to medications are the ideal candidates for IABP before revascularization procedure.

Role of IABP in PCI: International Benchmark reported in his report about the usage of IABP in high risk PCI (one patient out of five high risk PCI). Many govern bodies around world agree about the use of IABP during high risk percutaneous coronary interventions (PCIs).[28],[29] IABP has a pivotal role in first few minutes of complicated PCI.

COMPLICATIONS

There are some serious complications reported like stroke, bleeding (Major episodes), local/systemic infections and even vascular complications. To overcome mechanical complications (limb ischemia/distal embolization), new method has been adopted in which 6 Fr catheter (sheathless) is used but the benefit is questionable.[30],[31] High incidence of stroke has been reported in IABP patients due to peripheral embolization which leads to cerebral ischemia.[32]

In a cohort study done by Schiariti et al observed, no significant relation of thrombocytopenia with ischemic attacks (1year follow up) which underwent percutaneous coronary intervention unless IABP was assigned. However, it was noticed patient of IABP who developed thrombocytopenia had worse outcomes. It was noticed that high rates of cardiogenic shock, more use of thrombolytic agents and PCI are associated with IABP patients. Critically ill patients are more prone to have worse outcomes due to thrombocytopenia as compared to stable patients (Hemodynamically) which had less worse events related to thrombocytopenia in IABP used patients.

As we know, bleeding (Major) can affect the outcomes and even transfusion indirectly increase the mortality in acute coronary syndrome.[33]

Therefore, it is very important to take decision about heparinize the patients. Consider risk and benefit ratio for bleeding then heparinize the patient instead of blindly. So selective heparinize is better than universal heparinize theory.[34],[35] There are two main reasons for local and systemic infections that are immobilization and long lasting vascular access. These minor infections affect clinical outcomes. Especially, critically ill patients with cardiogenic shock infections can lead to SIRS (systemic inflammatory response syndrome) which is associated with high mortality.

FUTURE DIRECTIONS

Right sided heart failure (RHF): We have little data about the role of IABP in RHF. Benefit of IABP in right ventricular failure as explained in experiment model by Darrah et al.[36] There are three important points regarding IABP circulatory support; 1) Increase in MAP (mean arterial pressure), 2) Cardiac index, 3) Right ventricular ejection fraction. Arafa et al[37] done a study in 5 patients who underwent cardiac transplantation due to right heart failure were supported by IABP, he observed there was increase in MAP, Cardiac index as well as drop in Right atrial pressure. The extent of alterations (hemodynamic) were enhanced after 12 hours of IABP support. All 5 patients discharged from hospital. There is great role of IABP in reversing right ventricular dysfunction. More studies will be needed in future about role of IABP in right sided heart failure.

Bridge to cardiac transplantation: End stage heart failure patients requires heart transplantation. The number has been increased in past few years and still in increasing order. So patients awaiting for heart transplantation, required circulatory support (IABP). Various clinical studies had been done in this direction.

Kantrowitz et al done study in 27 patients and given circulatory support (IABP) for mean of 33 days [range from 20-71 days]. The result was positive, 63% discharged from hospital (17 patients who required long term support) and 30% survived for more than 2 years (9 patients expired within 6 months of discharge). A cohort study done by Cochrane et al[38] from year 2000 to 2001 year (16 months) enrolled 4 patients, supported by IABP for mean of 37 days [range from 12-70 days] awaiting for transplantation. Balloon exchange done in two patients due to IABP related issues and all patients bridged to transplantation. IABP procedure is less expensive compared to ventricular device.

NEW COUNTERPULSATION DEVICES

In past two decades, new devices had been developed and tested in order to prove better counterpulsation than IABP. These are Para-aortic counterpulsation device (PACD), CPD and C-Pulse.

INVENTOR	DEVICE	SITE OF IMPLANTATION	STROKE VOLUME (ML)
Nanas et.al[39],[40]	PACD	IN ASCENDING AORTA	65
Koenig et.al[41]	CPD	IN AXILLARY ARTERY	32
Mitnovetski et.al[42]	C-Pulse	ASCENDING AORTA (Round it)	Between 20-30

CONCLUSION

IABP is commonly used for counterpulsation in cardiogenic shock, high risk PCIs and during CABG. This internal counterpulsation technique is well accepted by cardiologists and cardiac surgeons which increases oxygen supply and decreases oxygen demand by diastolic inflation and systolic deflation of balloon. Bleeding, stoke and infections can occurs with IABP usage. Great research is going on for new devices of counterpulsation with the hope that it will shows better results in future practice.

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COMPETING INTEREST

No conflicts of interest for this article.

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