SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore - 35

Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIO PULMONARY PERFUSION CARE TECHNOLOGY

COURSE NAME : PRINCIPLES OF PERFUSION TECHNOLOGY I

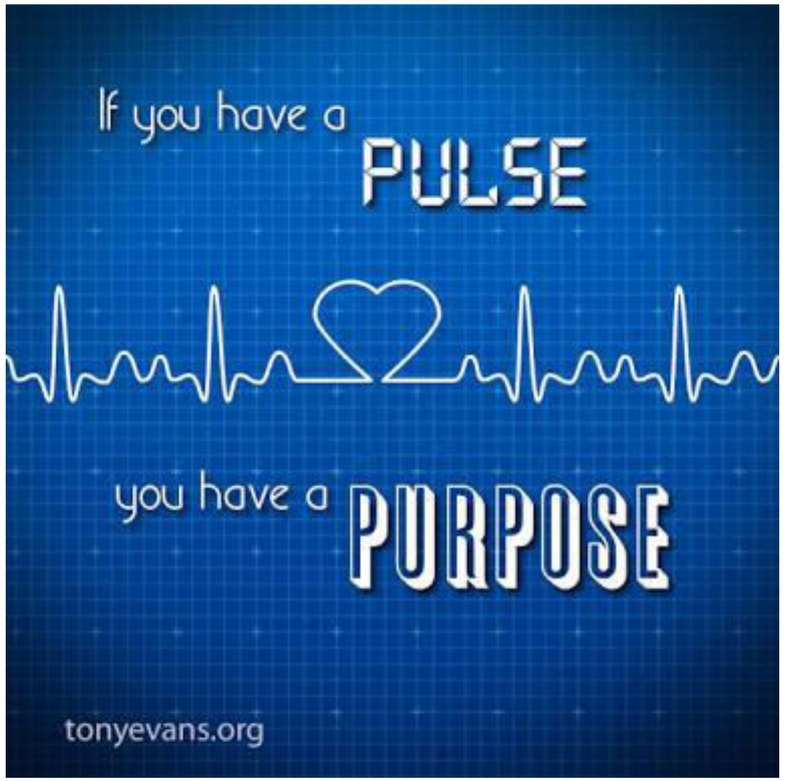
II nd YEAR

TOPIC : PULSATILE PERFUSION

Outline

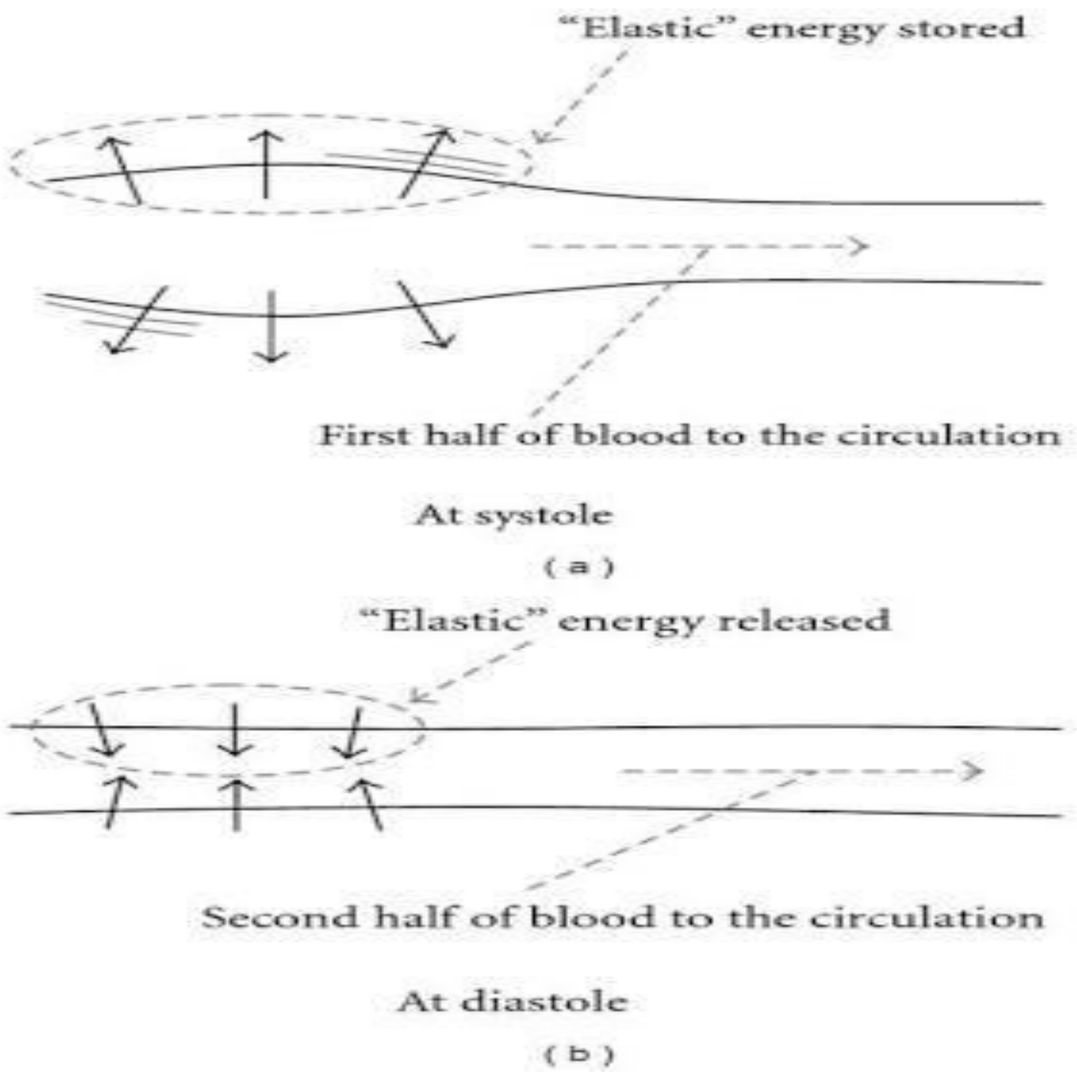
- Why Pulsatile perfusion
- Theories behind pulsatile perfusion
- Effects of pulsatile perfusion
- Benefits
- Systems delivering pulsatile perfusion
- Setting pulsatile mode in HLM
- Conclusion

WHY PULSATILE FLOW??



– MORE PHYSIOLOGIC….. WHEN COMPARED WITH CONTINUOUS FLOW.

Windkessel Principle



Video

THEORIES OF PULSATILE FLOW

- Energy Equivalent Pressure
- Capillary Critical Closing Pressure
- Neuro Endocrine Reflex Mechanism

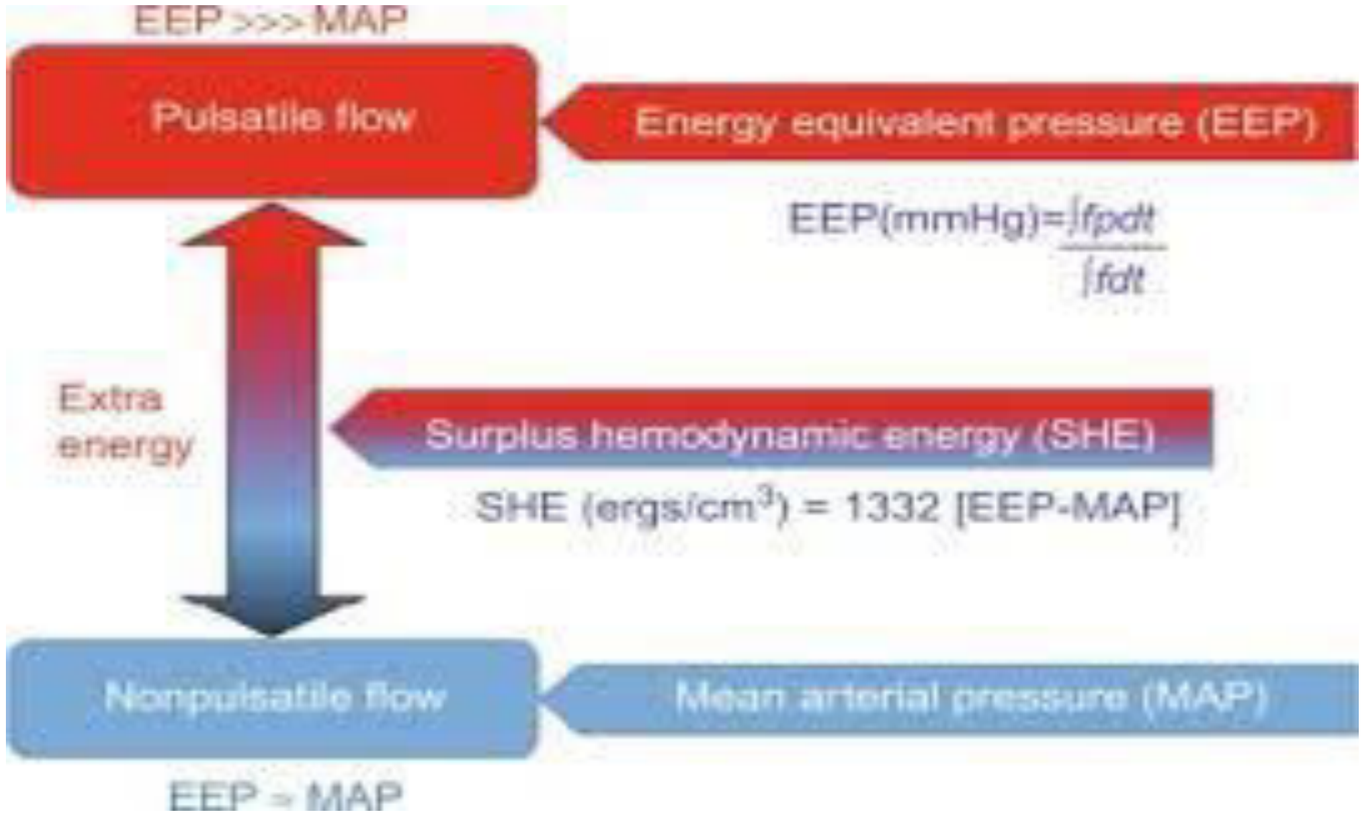
Energy Equivalent Pressure

- Introduced by Shepard to quantify the pulsatile energy and waveform.
- definition: the energy per unit of volume pumped.

$$\text{EEP (mm Hg)} = \left(\int fpdt\right)/\left(\int fdt\right)$$

- Using this formula it was determined that the energy needed to deliver pulsatile flow was up to 3.4 x that required to produce non-pulsatile flow for the same levels of mean pressure and flow.

Surplus Hemodynamic Energy



Thought to be available to the tissues by capillary patency, increased lymph flow, oscillatory movements at the cell level.

Plasma vasopressin level & catecholamines

Renin secretion

Angiotensin levels

vasoconstriction

Release of barorecept ors in aorta and carotid

Critical Closing Pressure

Visceral perfusion

Neuroendro crine reflex mechanism

Afterload (at the end of bypass)

Effect on Hemodynamics

- Pulsatile perfusion is associated with significantly lower levels of vascular resistance in all regional vascular beds.
  - –Benefits:
    - Improved tissue perfusion
    - Lower afterload for ventricle at the end of the perfusion period

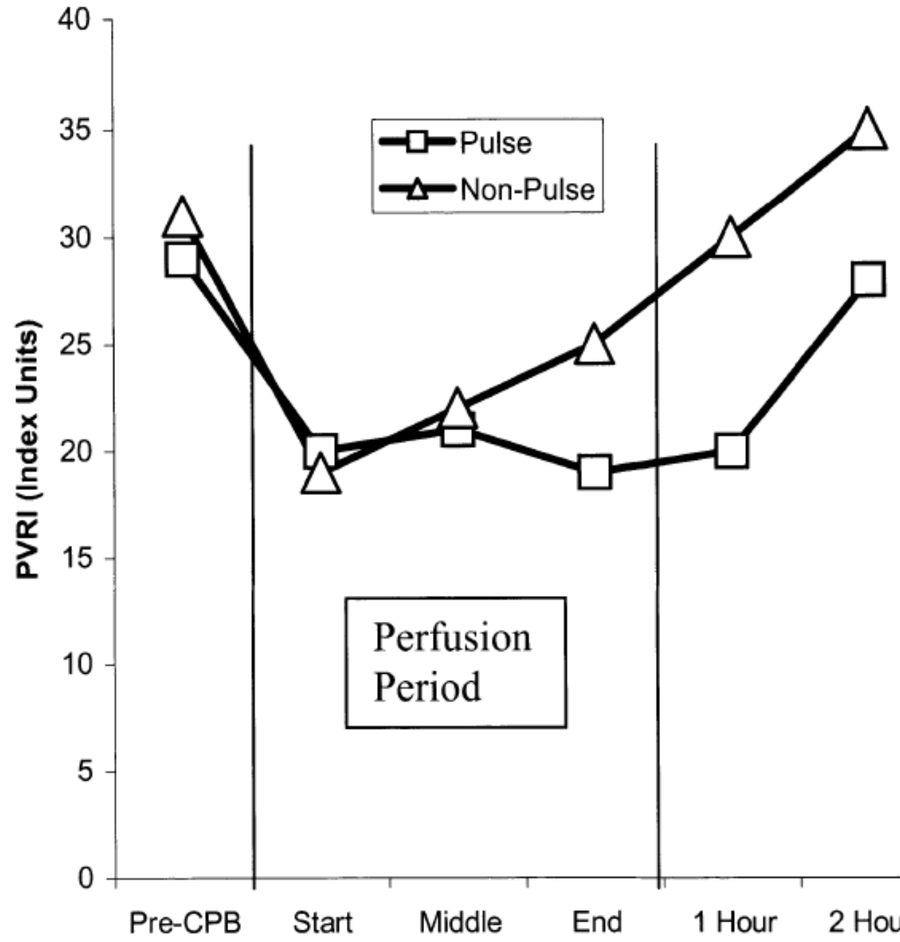


Fig. 2. Peripheral vascular resistance (Index Units) associated with pulsatile and

Effect on Microcirculation , lymph flow and Metabolism

Pulsatile Versus Nonpulsatile Flow During Cardiopulmonary Bypass: Microcirculatory and Systemic Effects

Michael P. O'Neil, MS, CCP, Jennifer C. Fleming, PhD, Amit Badhwar, PhD, and Linrui Ray Guo, MD

Departments of Surgery and Clinical Perfusion Services, Division of Cardiac Surgery, London Health Sciences Centre; Department of Medical Biophysics, Schulich School of Medicine and Dentistry, University of Western Ontario; and Centre for Critical Illness Research, Lawson Health Research Institute, Victoria Research Laboratories, London, Ontario, Canada

- Improves microcirculation and tissue metabolism
- Inhibits edema formation by increasing lymph flow
- Lactate production is reduced as a result of aerobic metabolism.

(Ann Thorac Surg 2012;94:2046–53)

Effect on Renal System

- Improved kidney function is the result of better gas exchange at the capillary level together with the maintenance of normal lymph flow.

Original Paper

Perfusion

2016, Vol. 31(6) 477–481

DOI: 10.1177/0267659116634829
prf.sagepub.com
SAGE

The effect of pulsatile cardiopulmonary bypass on the need for haemofiltration in patients with renal dysfunction undergoing cardiac surgery

Shakil Farid,[1] Hannah Povey,[1] Simon Anderson,[2] Samer A M Nashef[1] and Yasir Abu-Omar[1]

- CrCl is higher in pulsatile group

Effect on Brain

Better preservation of regional cerebral blood flow causing reduction in cerebral acidosis

- Pulsatile flow reduces cerebral vascular resistance by as much as 25%. The improvement in regional blood flow distribution causes reduced cerebral lactate production .
- Anaerobic metabolism is suppressed with pulsatile blood flow, particularly during the critical cooling and rewarming phases.

Original Paper

Perfusion

Perfusion
2016, Vol. 31(1) 72–77

DOI: 10.1177/0267659115586280
prf.sagepub.com
SAGE

Cerebral oxygen saturation during pulsatile and non-pulsatile cardiopulmonary bypass in patients with carotid stenosis

T Tovedal,[1] S Thelin[2] and F Lennmyr[1]

- No difference in cerebral oxygen saturation.

Effect on Pancreas & Liver

- Preserves pancreatic function better than nonpulsatile CPB.
- Reduced incidence of elevated amylase levels in patients undergoing CPB with pulsatile flow.
- Hepatic function is also preserved as reflected in postoperative SGOT level. Hepatic blood flow shows a vasoconstrictive response to nonpulsatile CPB with decrease in hepatic oxygen consumption.

Pulsatile blood flow and the gut

- Postoperative gastrointestinal morbidity occurs in undergoing CPB. The cause is mesenteric hypoperfusion leading to ischemia CPB associated with endotoxemia which in turn cause increase in gut permeability.
- Pulsatile blood flow results in improved blood flow to the gut ,reducing mucosal ischemia by increasing oxygen delivery.

European Journal of Cardio-Thoracic Surgery 57 (2020) 210–251
doi:10.1093/ejcts/ezz267 Advance Access publication 2 October 2019

2019 EACTS/EACTA/EBCP guidelines on cardiopulmonary bypass in adult cardiac surgery

Recommendation for the type of cardiopulmonary bypass pump flow

Recommendation	Class[a]	Level[b]	Ref[c]
Pulsatile perfusion may reduce postoperative pulmonary and renal complications and should be considered in patients at high risk for adverse lung and renal outcomes.	IIa	B	[214, 218]

[a]Class of recommendation.
[b]Level of evidence.
[c]References.

SYSTEMS FOR DELIVERING PULSATILE FLOW

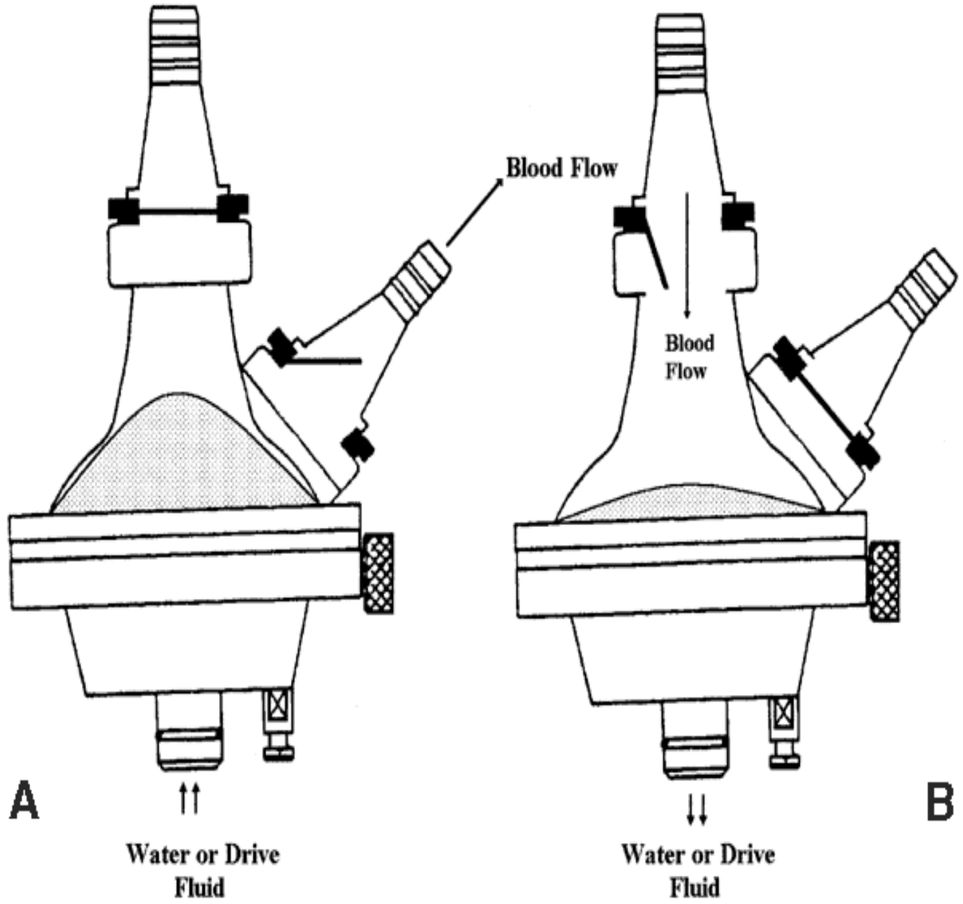
- ROLLER PUMP
- SIMPLE RELIABLE

MAQUET HL 20

STOCKERT S5

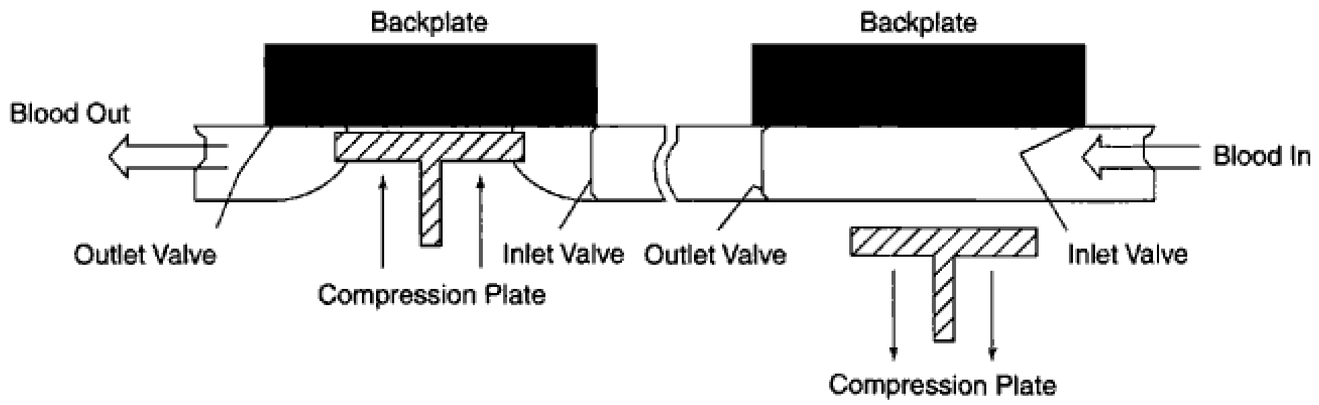
VENTRICULAR PUMPS

- → Physiologic method for generating pulsatile blood flow
- → Operate in a similar manner to the ventricle of the heart.
- → Consist of compressible sac and two one-way valves permitting blood to flow into and out of the ventricle in only one direction.



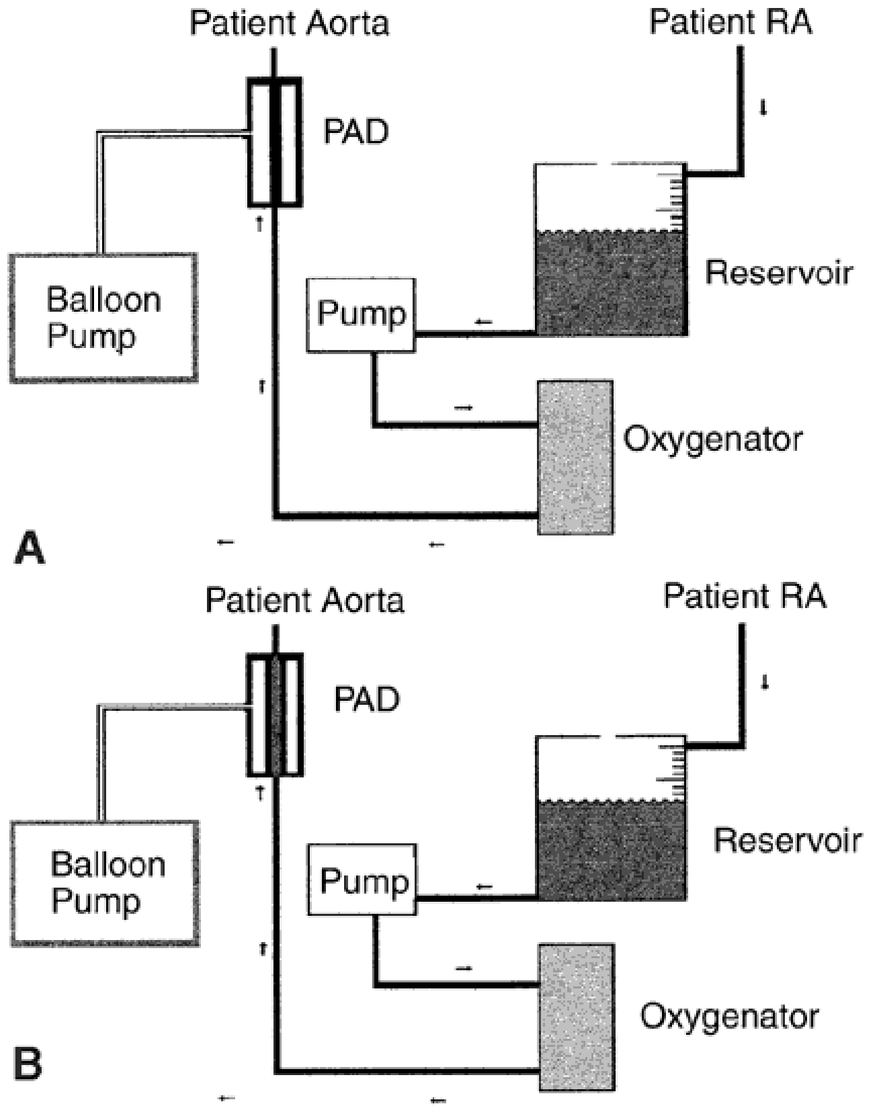
Compression plate pumps

A length of tubing of known diameter is placed on a rigid back plate and compressed by a moving plate that descends for a preselected stroke length, thereby ejecting a volume of perfusate from the tube .The direction of blood flow is ensured by valves positioned at the inlet and outlet of the ventricle or sac.



Pulsatile Assist Device

- Is an intermittent occlusive device that employs an intraaortic balloon pump apparatus to produce pulsatile blood flow in the arterial line of the CPB circuit.
- The pulse is generated by occluding the arterial line of the circuit under flowing conditions, thereby creating a large pressure and volume delay within the arterial side of the circuit. On deflation of the balloon in the arterial line, the pressure and volume are released in the aorta to the patient as a pulse.


Patient Aorta
Patient RA
PAD
Balloon Pump
Pump
Reservoir
Oxygenator
A
Patient Aorta
Patient RA
PAD
Balloon Pump
Pump
Reservoir
Oxygenator
B

Centrifugal Pump

Artificial Organs
35(2):E18–E26, Wiley Periodicals, Inc.

Clinical Effectiveness of Centrifugal Pump to Produce Pulsatile Flow During Cardiopulmonary Bypass in Patients Undergoing Cardiac Surgery

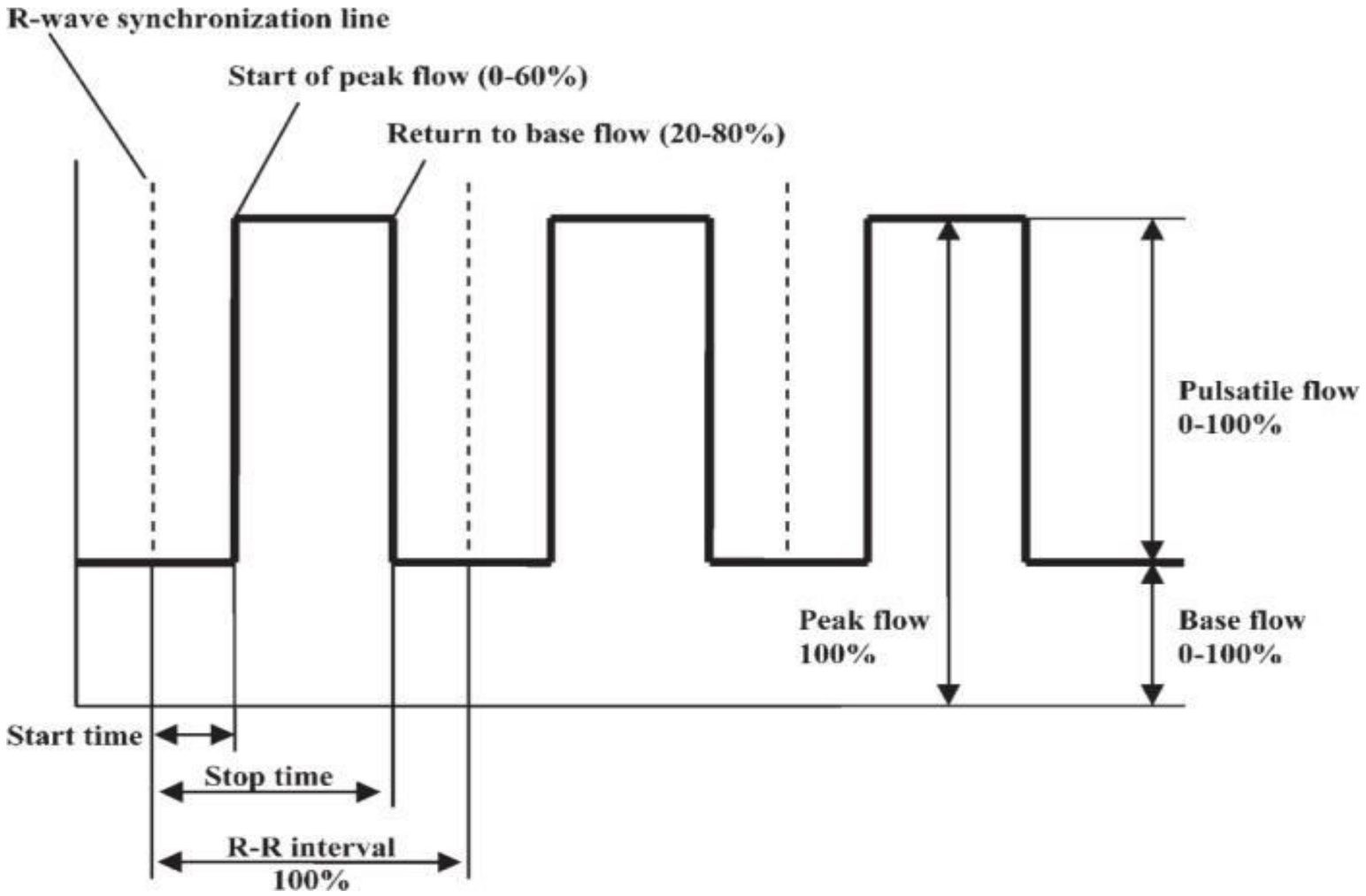
*‡Y. John Gu, *Willem van Oeveren, †Hubert E. Mungroop, †Anne H. Epema, ‡Inez J. den Hamer, ‡Jorrit J. Keizer, ‡Ron P. Leuvenink, ‡Massimo A. Mariani, and *Gerhard Rakhorst

–EEP and SHE is very minimum.

–Heat generation is more

–Afterload dependance makes them unreliable for this purpose.

PULSATILE PUMPING CURVE

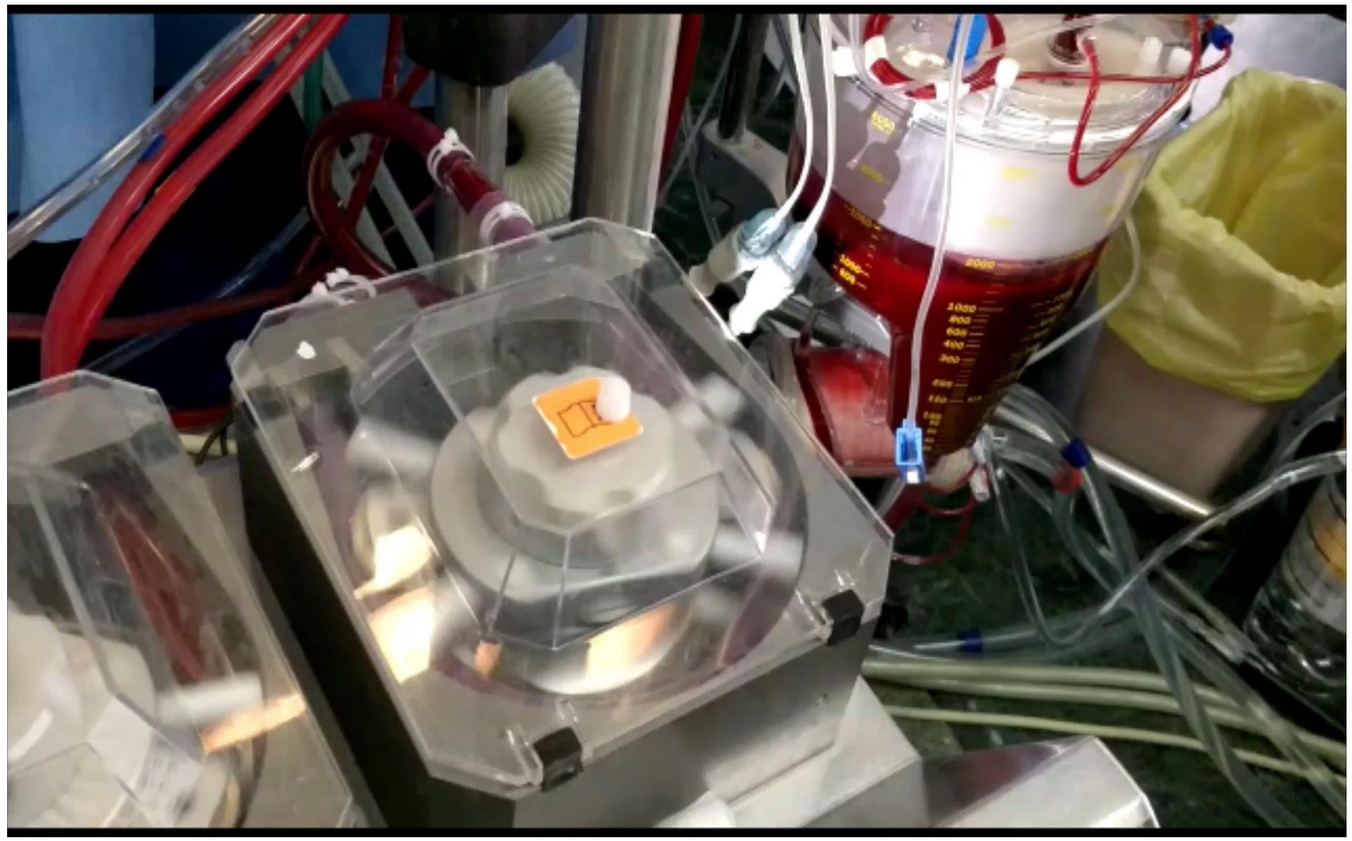


- BASE FLOW– CONTINUOUS FLOW WITHOUT THE PULSATILE COMPONENT
- START TIME--- TIME WHEN THE PUMP FLOW STARTS FROM THE BASE FLOW
- STOP TIME --- THE TIME WHEN THE FLOW RETURNS TO BASE FLOW.
- START AND STOP TIME POINTS REFLECT THE TIME BETWEEN THE TWO R WAVES OF ECG, MUST BE ATLEAST 20% OF CYCLE.
- INTERNAL FREQUENCY- 70 TO 80

SETTINGS OF HLM

- BASE FLOW
- FREQUENCY
- WIDTH

For cardiac surgery during pregnancy – increases placental blood flow and preserves the feotus.



Benefits

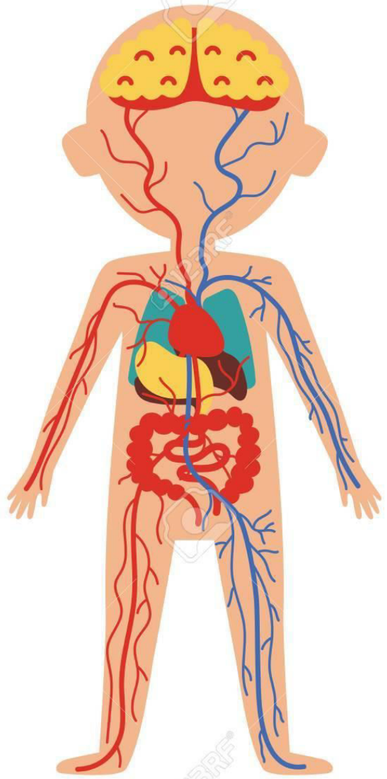
Attenuation of hormonal responses : Catacolamines, Renin Angiotensin Aldosterone, Antidiuretic hormone, Cortisol, Thromboxane, Prostacyclin.

Increase in Lymphatic function

Reduced markers of endothelial damage

Increases renal, cerebral, pancreatic flow

Increase capillary perfusion
Increase RBC transit



Decrease release of baroreceptor reflex hormones, limiting vasoconstriction

Increase blood flow in microcirculation

Changes in blood flow distribution facilitate aerobic metabolism due to increase microcirculation.

Attenuation of the systemic inflammatory response during CPB.

Improved gastric mucosal oxygenation

Decreased need for inotropic support, shortened hospital stay, and superior organ preservation

DEMERITS

Fear of shear stress/ hemolysis/intimal damage

Release of GME

Comfort level with non pulsatile flow

Diminished pulsatility

Difficult to understand the pressure curves and energy generated

Conclusion

- Beneficial in elderly patients,high risk group and patients with pre existing renal disease.
- Cardiac surgery in pregnancy

THANK YOU