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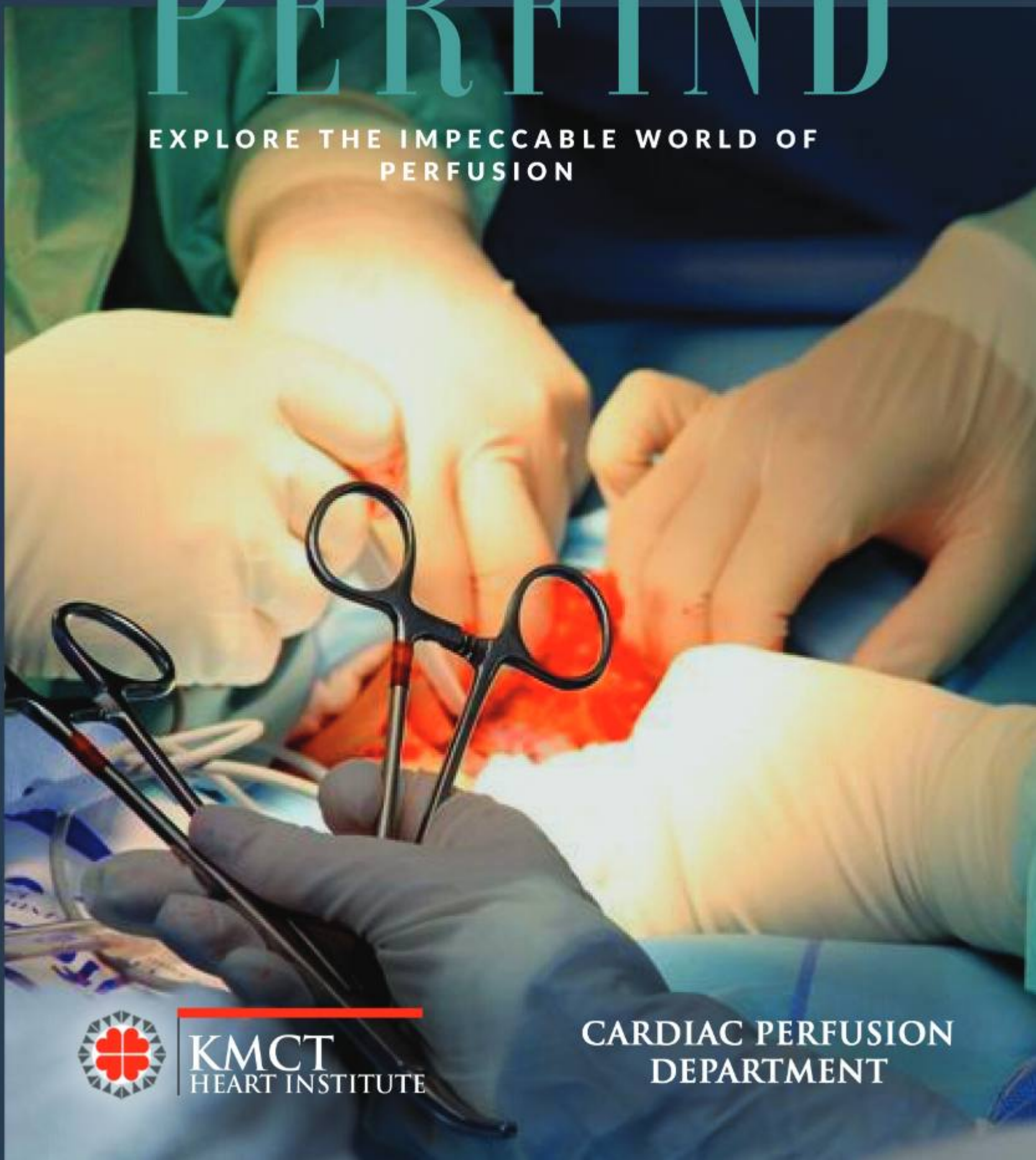

KMCT HEART INSTITUTE

CARDIAC PERFUSION DEPARTMENT

The Cardiac Perfusion Department
Kmct Heart Institute and Research Centre

PERFIND
2022

PERFIND 2022

● **Explore the impeccable world of perfusion** ●

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SPECIAL THANKS TO MR. MANU JACOB, MR. SANDEEP J JOSE, AND MRS. AISWARYA SETHUMADHAVAN.

MESSAGE

I am happy and very proud to present the journal "PERFIND 2K22" by the Cardiac Perfusion Department of Kmct Heart Institute in connection with the World Perfusion Appreciation Week.

At the same time, I wish the Cardiac Perfusion team all the best and congratulate them on their proactive effort in bringing out this journal, which would be an eye-opener to the public about extracorporeal perfusion technology and its crucial relevance in cardiovascular surgery and, at the same time, would be a reference journal for newcomers to the field of perfusion technology.

Warm regards,
Dr. K.M. Kuriakose MBBS, MS, MCH
PROFESSOR AND HEAD CARDIOVASCULAR AND THORACIC SURGERY
KMCT Medical College Hospital

MESSAGE

It is a matter of pride to pen down this message to encourage the perfusion department to release the magazine "perfind 2k22" on the occasion of World Perfusion Appreciation Week.

The magazine, I am sure, will be informative and resourceful and will provide excellent opportunities for the students as well as the perfusion profession to sharpen their academic and professional skills and focus their attention on further growth and development of the perfusion department.

My heart fills with immense pleasure as I perceive the valiant effort put forward by the students and faculties in their efforts to bring out the magazine.

Dr. Bijoy Jacob, MBBS, MS, MCH
ASSISTANT PROFESSOR CARDIOVASCULAR THORACIC SURGERY
KMCT Medical College Hospital

MESSAGE

It is with immense pride and pleasure that I wish to appreciate the efforts of our perfusion team, under the leadership of Mr. Akhil Jose, who have brought out an edition of PERFIND 2K22 on the occasion of the perfusion appreciation week.

The role of the perfectionist in cardiac surgery in improving the safety of patients is commendable. They form the backbone of a cardiac surgery unit and play a very crucial role in the successful conduct of cardiac surgery.

I once again take this opportunity to congratulate the editorial team and wish my perfusion colleagues a wonderful year ahead.

Dr. Vijish Venugopal MBBS, MD, PDCC, PGDEM(USA)
PROFESSOR AND HOD ANAESTHESIOLOGY
KMCT Medical College Hospital

MESSAGE

It is my pleasure to express my thoughts as Principal of KMCT College of Allied Health Sciences. Since 2015, we have been excelling in the academics of perfusion technology.

Every beat of the heart in its rhythm is an expectation of life. Professionally, that rhythm can be attained by sharing experience and knowledge in words as a collection.

I would like to convey my happiness to the students and faculties for releasing another edition of the magazine "PERFIND 2K22" on the occasion of World Perfusion Appreciation Week and appreciate the entire team. Keep striving for such excellence and keep progressing in your career and life.

Prof. Santheep.S
PRINCIPAL
KMCT College of Allied Health Sciences

THE EXTRA CORPOREAL CIRCULATORY SUPPORT

Dr. K.M. Kuriakose

PROFESSOR AND HEAD
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Until the concept of extracorporeal blood circulation support was introduced, surgical intervention in the heart was thought to be impossible. It took about 16 years for the pioneer of the ECC, Dr. John Gibbon, to use a device to support the circulation of a patient in the operation theatre to close an Atrial Septal Defect (ASD) in 1953. But as aptly quoted, "there is nothing psychological about ECC, and so it was associated with lots of complications. But the pioneering work of Dr. John Gibbon stimulated so many. The next step in the development of extracorporeal support was a testimony to the collaboration between biomedical engineers, physiologists, physicians, and surgeons to make the use of extracorporeal support devices safer for human beings. One revolutionary discovery was the synthesis of silicon rubber for use in artificial lungs.

The extracorporeal circulatory support to bypass the heart invariably and necessitates bypasses the lung also, as the lung, though a different organ, is serially connected between the right heart and left heart. The development of an artificial lung, which is nearly physiological, was the most challenging part of developing a safe EC support system. The tiresome efforts of many for years could make it possible for successful prolonged extracorporeal support (ECMO) critically in patients with respiratory cardiac failure. During the current pandemic situation of COVID-19, ECMO was instrumental in saving many lives.

Present techniques and devices make it possible to perform complex cardiac enlarged vessel surgeries safely.

With the evolution of ECC technology, a new profession, perfusion technology, has evolved. As the operation is on living beings, a thorough knowledge of the human anatomy, physiology, and pathophysiology of the organism, its side effects, and possible complications of ECC are essential components of the syllabus, in addition to the technology aspects. The perfusionist thus forms an integral component of the operating team in OT/ICU. Constant and contemptuous monitoring and vigilance on the part of the perfusionist, as well as constant communication between surgeons, anesthesiologists, and other staff, are critical components for the procedure's success.

TECHNIQUE ARTICLE

A Novel Technique for Intra-aortic Balloon Positioning in the Intensive Care Unit.

Dr. Vijish Venugopal

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ABSTRACT:

Proper positioning of the intra-aortic balloon catheter is very important as an improperly placed balloon can cause problems. A balloon placed too high can block off the arch vessels, whereas one placed too low can block the renal and splanchnic vessels. We propose a simple and reliable technique to properly position the intra-aortic balloon pump (IABP) catheter.

Postcardiotomy left ventricular failure is a well-known entity that leads to failure to wean off bypass. The insertion of an intra-aortic balloon pump (IABP) catheter is known to help in this situation.Insertion of the IABP into the femoral artery remains the most popular approach for those patients in need of mechanical support after a cardiac operation. In the catheterization laboratory or in the hybrid operating room, the IABP insertion and positioning are guided by fluoroscopy.

In the operating room, we have to rely on anatomical landmarks for the proper positioning of the IABP catheter, and this is later confirmed by doing a chest x-ray (CXR) or by transesophageal echocardiography (TEE).

TECHNIQUE:

An IABP catheter (RediGuard IABP; Arrow International, Everett, MA) was inserted into the descending aorta by the modified Seldinger approach through the common femoral artery in 27 cardiac surgical cases over a 12-month interval. The CXR in the Intensive Care Unit (ICU) showed that the IABP tip was positioned distal to the desired location, although we had inserted it after measuring the distance from the sternal angle to the umbilicus and from there to the femoral artery and confirmed by TEE in the operating room.

This could be the result of the fact that we tend to position the patient's legs in a flexed and abducted position using pillows, as shown in Figure I for harvesting the vein. The IABP is also inserted in this position, and it is fixed in the groin once the pillow is removed at the end of the case. The IABP tends to move distally from point A to point B, as shown in the schematic insert in Figure 1.

In the ICU, we perform the following procedure if we note that the IABP catheter has migrated from its desired position on the CXR:

We insert a guidewire into the central lumen of the IABP catheter and reduce the balloon volume by 10–20%. The balloon augmentation is then reduced to 1:2 for heart rates below 100 beats/minute and 1:4 for heart rates above 100 beats/minute.

The balloon movement along the guidewire is done only during the deflation phase of the IABP. We then monitor the balloon-mediated changes in left radial arterial (LRA) pressures on the patient monitor (Figure 2) to decide the optimal positioning. Once the balloon obliterates the LRA trace, we assume that the catheter tip is beyond the left subclavian orifice. Then the catheter is pulled back along the guidewire until the augmented LRA trace is obtained. Once the augmented trace is obtained, we pull back 1-2 cm to position the catheter optimally.

Balloon movement is advocated only along a guidewire to avoid the tip of the balloon causing an iatrogenic dissection.

Movement during inflation of the catheter can cause coiling of the distal portion of the IABP without any appreciable forward movement of the tip, so the balloon catheter is moved only during deflation. Balloon volume is reduced to avoid the balloon hugging the aortic wall and impeding movement. Post procedure, we have checked the position of the IABP catheter by CXR and by TEE, and in all these cases, the IABP tip was found to be properly positioned. Also, we have seen an improvement in the hemodynamics once the balloon is in the optimal position.

Moreover, the finding of IABP catheter migration has also led to a practice change in our hospital to remove the pillows from underneath the legs once the vein harvesting is over. From our experience so far, this technique has shown us that we do not require fluoroscopy or TEE for proper positioning of the IABP catheter once we are in the ICU or, for that matter, in the operating room. All that we require is a left radial arterial line.

Balloon movement is advocated only along a guidewire to avoid the tip of the balloon causing an iatrogenic dissection. Movement during inflation of the catheter can cause coiling of the distal portion of the IABP without any appreciable forward movement of the tip, so the balloon catheter is moved only during deflation.

DISCUSSION :

The appropriate performance of the IABP is dependent on proper position (1,2). Ideally, the tip of the balloon should be positioned 2–3 cm distal to the origin of the left subclavian artery (LSCA) (1,3). This position results in maximum augmentation of coronary artery flow although minimizing the risk of embolization to the cerebral vessels and occlusion of the LSCA (3). The aortic knob is thought to be the radiographic landmark of choice for proper positioning (3,4). The recommended position for the tip of the balloon is just distal to the aortic knob. The aortic knob is a broad shadow on the CXR and hence erroneous placement of IABP can occur using it as a landmark.

The carina was used as a radiographic landmark for positioning the IABP citing the fact that contrary to the aortic knob, the carina is a well-definable anatomic landmark on CXR. Also, the position of the carina relative to the aortic arch varies little when compared with the position of the aortic knob (5).

Inward migration of the intra-aortic balloon catheter creates the potential for occlusion of the subclavian or the carotid artery resulting in unequal or absent radial pulses and dampening or loss of the arterial waveform in the radial artery (6) .

If an indwelling left radial arterial catheter is functioning at the time of insertion, a reasonable estimate of position may be made by watching balloon-mediated alteration of the arterial pulse waveform (7). The technique we describe offers the possibility of optimally positioning the IABP catheter in a simple and reliable manner by just monitoring the LRA trace.

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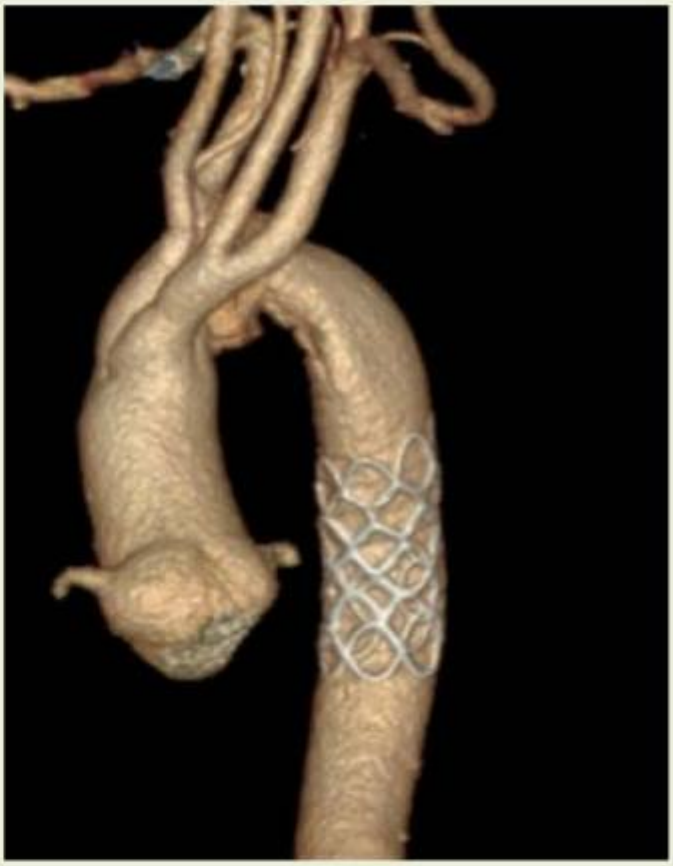
PERFUSION STRATEGIES FOR AORTIC ARCH SURGERIES



KEY POINTS TO REMEMBER

Mr P.V.S.Prakash, Mr Sam Immanuel, Mr Selvakumar, Ms Sitara, Mr Kalaimani

CEREBRAL PROTECTION

1. Cerebral protection remains crucial. Current trends indicate that Selective Antegrade Cerebral perfusion (SACP) at a moderate temperature (24 °C Nasal and 26 °C Rectal) is the way to go.

2. Cerebral metabolism can be estimated and monitored indirectly by the oxygen metabolic rate equation (CMROPI=RICBF x cerebral arterio-venous oxygen content difference/100).

3. TCA is formed at temperatures below 20 degree Celsius.

4. NIRS, EEG, BIS, and SVO2 are routinely monitored for aortic arch reconstructive procedures.

5. CSF is drained and Somato Sensory Evoked Potentials are stimulated periodically. These measures help to keep the intracranial pressure within the desirable range and avoid paraplegia.

6. We monitor the differential flow between the upper and lower body by incorporating a non-invasive ultrasonic flow sensor.

7. pH monitoring during the cooling phase and alpha monitoring during the rewarming phase. We employ mild hypercapnia during cooling for DHCA and alpha-stat normocapnia during the rewarming state.

8. Steroids are routinely administered as per protocol.

9. Hypo perfusion may result in CNS ischemia, and hyper perfusion will lead to cerebral oedema. It is recommended to flow corresponding to the NIRS and right radial blood pressure.

STRATEGIES FOR ASCENDING AND ARCH AORTIC ANEURYSM

1. We initiate CPB with bicaval venous and double arterial cannulation (axillary and femoral artery with an 8-mm graft).

2. Intravenous ABP monitoring via right radial and left femoral access.

3. NIRS monitoring is mandatory for all cases with an arch involving aneurysmal dissection.

4. At 18°C core temperature, safer DHCA takes less than 30 minutes.

5. During DHCA, cerebral reperfusion is re-established once the NIRS value reaches 20% less than the base line index.

6. The neurological outcome is better in DHCA with ACP when compared to DHCA without ACP.

7. ACP accounts for 10–20% of total cardiac output, with NIRS and a right radial pressure of 40–50 mmHg varying.

8. LCCA requires additional cannulation if the left NIRS is less than the baseline during ACP.

9. The recommended ACP duration is 90 minutes with a temperature difference of 18°C between the nasal (18°C) and rectal (22°C).
10. Myocardial protection with STS Cardioplegia is repeated at 25–40 min with respect to the patient's core temperature.

11. Once ACP time exceeds 40 minutes, femoral arterial flow is re-established after introducing an endoaortic clamp just distal to the left subclavian artery.

12. During ACP, SVC saturation is measured and is kept in a range of 70–80% with FiO2 adjustment in perfusate.

13. We employ mild hypercapnia (pH stat) during cooling for DHCA and alpha stat normocapnia during the rewarming phase.

14 Na Thiopental (STAT: 10-15mg/kg) and Propofol Infusion (7-10mg/kg/hr) are two commonly used anaesthetics for aortic arch reconstruction.

15. CSF is drained to decrease intracranial pressure, which avoids cerebral hypo perfusion.

16. Tranexamic acid (STAT 10 mg/kg) is administered, and an infusion of 1 mg/kg/hr is maintained on flow.

17. Effective deairing is accomplished by deep trendling position and bilateral carotid compression with TEE guidance.

18. During cooling and rewarming, the nasal and rectal differences should not exceed 4°C.

19. During profound hypothermia, we accept HCT up to 20%, and we come off bypass with no less than HCT 28%. Serum lactate during the CPB run is maintained at 4-6 mmol/l and the serum glucose level has to be maintained at 150-200 mg/dl.

MYOCARDIAL PROTECTION

1. RSPV venting and direct LV apical venting are routinely performed to avoid myocardial rewarming and distension if the heart fibrillates during cooling.

2. Cardioplegia is administered just before DHCA during profound hypothermia (18°C).

3. STS solution (4°C) is injected into both coronary ostia.

4. If coronary ostia are small and calcified, retrograde cardioplegia is preferred.

5. At a lower temperature (less than 20°C), STS cardioplegia is repeated once every 30–40 minutes, even during the ACP period.

6. After the implantation/repair of the aortic valve with coronary buttons, antegrade cardioplegia is given using a modified Foley's catheter in the neo-root (Graft).

VISCERAL ORGAN PROTECTION

1. Once ACP time exceeds 40 minutes, we re-establish the femoral flow to the visceral organs. This is performed when an Endoclamp catheter is deployed just after the left subclavian artery.

2. We monitor the difference between the upper and lower body perfusion by incorporating a non-invasive ultrasonic flow sensor.

3. We aim to achieve 0.5-1 ml/kg/hr. Urine output during the CPB run.

4. Frusemide 20 mg stat is administered during the rewarming phase.

5. Conventional ultrafiltration is performed during the rewarming phase and modified ultrafiltration is done for 10–15 minutes

6. CSF pressure increases during clamping, further decreasing the perfusion pressure of the spinal cord. The likelihood of paraplegia is increased.

PERFUSION STRATEGIES

1. An 8 mm graft with an EOPA cannula is used to perform double arterial cannulation with the right axillary/innominate and femoral arteries. Venous access with regular Bi-Caval cannulation

2. Plasmolyte A solution is the most preferred prime with additives of mannitol 50 ml and sodium bicarbonate 25 ml.

3. Two arterial limbs are prepared post-arterial filter in a sterile manner, one towards the right axillary and the other towards the femoral artery, along with a non-invasive ultrasonic flow sensor.

4. Cooling is started as soon as the bypass is performed, with the difference between nasal and rectal temperatures kept at 3–4 °Celsius.

5. If DHCA is indicated, the patient is cooled to an 18°C core temperature, while ACP is cooled to a 24°C core temperature.

6. All neuroprotective agents are administered 5 minutes before DHCA or ACP.

7. FiO2 levels are titrated in response to Sv02 during hypothermia.

8. The ACT is kept between 480 and 600 seconds.

9. The ABG is checked every half hour.

10. FFP is given as an infusion at 50ml/hr in the CPB circuit.

11. During profound hypothermia, we accept HCT up to 20%, and we come off bypass with less than HCT 28%.

12. Serum lactate during the CPB run is maintained at 4-6 mmol/l and the serum glucose level has to be maintained at 150-200 mg/dl.

EXTRA-CORPOREAL MEMBRANE OXYGENATION (ECMO)

Abhirami B, Fathima Suhana

2017 Batch

ABSTRACT :

Extra Corporeal Membrane Oxygenation (ECMO) indications and usage have strikingly progressed over the last 20 years; it has become an essential tool in the care of adults and children with severe cardiac and pulmonary dysfunction refractory to conventional management.

In this article, we will provide a review of ECMO development, clinical indications, patients' management, options and cannulation techniques, complications, outcomes, and the appropriate strategy for organ management while on ECMO.

INTRODUCTION :

Extra Corporeal Membrane Oxygenation (ECMO) is used to provide mechanical cardiopulmonary support to patients with refractory cardiac or pulmonary failure who are unresponsive to conventional medical therapies. The clinical use of ECMO as a mechanical support modality for cardiac and respiratory failure was propelled by the development of the artificial lung (oxygenator), innovation in cardio pulmonary bypass techniques, and cardiac surgery. In 1972, Hill et al. reported the first successful use of ECMO in adults with acute respiratory failure due to post traumatic acute respiratory distress syndrome (ARDS). Bartlett et al. reported successful use of ECMO to support a child with congenital heart disease after cardiac surgery in 1972, and subsequently a neonate with respiratory failure due to Meconium Aspiration Syndrome in 1975.

MODES OF ECMO SUPPORT :

The typical ECMO circuit consists of tubing, a mechanical blood pump, a membrane lung (oxygenator), cannulas for blood drainage (venous) and return (arterial), a reservoir (bladder), a heat exchanger, and pressure, flow, and oxygen saturation monitors.

To provide cardio-respiratory support, blood is drained from the venous circulation into the ECMO circuit. A pump then propels blood through the membrane oxygenator for gas exchange. The oxygenated blood is warmed to the desired body temperature and returned to the patient via the arterial cannula.

TYPES OF ECMO :

An ECMO circuit can be set up in three ways:

(i) Veno-arterial ECMO (VA-ECMO): allows gas exchange and haemodynamic support while blood is pumped from the venous to the arterial side;

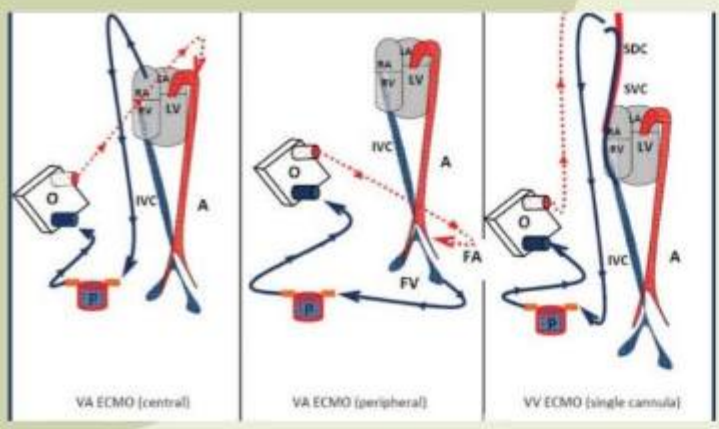
(ii)Veno-venous (VV-ECMO): facilitates gas exchange; blood is removed from the venous side and then pumped back into it, but does not provide haemodynamic support;

(iii)Arterio-venous ECMO (AV-ECMO): facilitates gas exchange by using the patient's own arterial pressure to pump the blood from the arterial to the venous side.

Veno-arterial ECMO :

In VA-ECMO, the drainage cannula is commonly placed in the inferior vena cava (IVC) or right atrium (RA). This can be done either via a sternotomy or percutaneously by inserting the cannula via the internal Jugular, or the femoral vein. Blood is returned to the patient through a cannula inserted into either the ascending aorta (central ECMO, inserted surgically) or the femoral artery (peripheral ECMO, either surgically or percutaneously inserted). When used immediately after CPB, central ECMO is a preferred option as the location of the cannulae is similar to that used during surgery.VA-ECMO support decreases cardiac work and reduces cardiac oxygen consumption while providing adequate systemic organ perfusion with oxygenated blood. If cardiac recovery is expected, it is important that distension of the ventricles be reduced; VA-ECMO can achieve this if the left ventricle continues to eject or a vent (drainage catheter) is inserted directly into the left ventricle. The diameter, length, and position of the cannulae used for vascular access determine potential flow that can be achieved.

In addition, venous filling or patient preload, systemic vascular resistance or patient afterload, tubing resistance to flow, and pump properties are important factors.VA-ECMO operates alongside the native system, and a proportion of the blood flow can continue to go through the lungs. Therefore, in a patient with impaired gas exchange, the proportion of blood going through the lungs will mix with the well-oxygenated blood provided by the ECMO circuit in the aorta. The final content of oxygen depends on the combination of ECMO and the patient's blood flow. This means that when using peripheral VA-ECMO, the neck vessels or coronaries may receive relatively poor oxygenated blood while the lower body receives better oxygenated blood



Veno-venous ECMO :

When the cardiac function is preserved, VV-ECMO is used to improve gas exchange. Traditionally, VV-ECMO required the insertion of at least two cannulae in large veins (jugular, femoral, or both), sometimes more to facilitate drainage and flow and therefore oxygenation. A recently introduced dual-chamber cannula (Avalon Laboratories, Rancho Dominguez, CA, USA) allows efficient drainage from the inferior and superior vena cava and return of the blood through the RA into the tricuspid valve. This new cannula decreases the incidence of recirculation (when oxygenated blood injected by the return cannula is drained immediately back to the ECMO by the drainage cannula) and bleeding issues, and allows for greater patient mobilization.

ECMO INDICATIONS :

ECMO Indications for cardiac support (VA ECMO only)

Cardiogenic shock and severe cardiac failure due to almost any cause:

- Acute coronary syndrome
- Cardiac arrhythmic storm refractory to other measures
- Sepsis with profound cardiac depression
- drug overdose/toxicity with profound cardiac depression
- Myocarditis
- Pulmonary embolism
- Isolated cardiac trauma
- Acute anaphylaxis
- Post-cardiotomy: inability to wean from Cardiopulmonary bypass after cardiac surgery
- Post heart transplant: primary graft failure after heart or heart-lung transplantation
- Chronic cardiomyopathy :
  - as a bridge to longer term VAD support
  - or as a bridge to decision
- Periprocedural support for high-risk percutaneous cardiac interventions
- Bridge to transplant

ECMO indications for respiratory support

- Acute respiratory distress syndrome:
  - Severe bacterial or viral pneumonia
  - Aspiration syndromes
  - Alveolar proteinosis
- Extracorporeal assistance to provide lung rest:
  - Airway obstruction
  - Pulmonary contusion
  - Smoke inhalation
- Lung transplant
  - Primary graft failure after lung transplantation
  - Bridge to lung transplant
  - Intaroperative ECMO
- Lung hyperinflation:
  - Status asthmaticus
- Pulmonary haemorrhage or massive haemoptysis
- Congenital diaphragmatic hernia, meconium aspiration

VENOUS CANNULA (19-28 Fr, 50-55 cm)

ARTERIAL CANNULA (16-20 Fr, 15-25 cm)

ECMO MANAGEMENT :

Haemodynamic management can be particularly challenging. Initially, most patients require intravascular volume expansion. However, the institution of ECMO can lead to a rapid reduction in the doses of inotropic and vasoconstrictor drugs, as gas exchange improves and intrathoracic pressures are decreased.

During ECMO, the goal is often to reduce the excess fluid that has accumulated in the extracellular space as a result of sepsis, inflammation, or cardiac failure. Fluid restriction and diuretics may be effective, although many patients will require extracorporeal haemofiltration. This can often be performed on blood from the ECMO circuit.

Anticoagulation is critical to avoid the formation of clots in the ECMO circuit while balancing the patient's risk of bleeding. Heparin is commonly used to keep the whole-blood activated clotting time (ACT) at a designated level (usually 1.5 times normal for the ACT measurement system). Thrombocytopenia is a common problem, and regular platelet transfusions may be necessary to keep the platelets account over an arbitrary limit to decrease the risk of spontaneous bleeding. If heparin-induced thrombotic thrombocytopenia is diagnosed, the use of alternative anticoagulants is required. It is possible to run ECMO without heparin, but this substantially increases the thrombotic risk.

CONTRAINDICATIONS :

Patients with irreversible organ damage, multiorgan failure, and those who are not candidates for transplantation will usually not benefit from ECMO support. ECMO is not generally recommended in patients who cannot be anticoagulated, but this is not an absolute contraindication.

Severe aortic regurgitation or aortic dissections are contraindications for VA-ECMO. ECMO therapy is continuously evolving, and it is preferable to involve an ECMO specialist in discussing indications and contraindications in each instance.

COMPLICATIONS :

Hemorrhage and infection are the two main complications related to ECMO. The majority of patients require continuous anticoagulation, and more than half will experience at least one hemorrhagic complication. Half of these relate to the cannulation site, and it is hoped that the development of new cannulae will reduce this risk. Arterial cannulation is related to a higher risk of bleeding. Hemorrhage can occur in any organ, with intracranial bleeding being the most devastating. Improvement in heparin-binding techniques and other materials allows interruption of systemic anticoagulation, sometimes for a few days. The pathogenesis of thromboembolism during ECMO is multifactorial (i.e., blood activation after contact with foreign surfaces, blood stasis in the cardiac chambers and the systemic veins, and disseminated intravascular coagulation). Thrombus in the circuit can affect the function of the pump or the oxygenator. In VA-ECMO, it can lead to strokes or leg ischemia. Interruption of blood flow distally to a femoral arterial cannula is a major issue that can be prevented by the insertion of a small cannula distally to the main cannula that allows part of the flow to be directed to the leg. ECMO management includes close coagulation monitoring, ensuring the best possible balance in coagulation homeostasis.

Infectious complications can be related to the indwelling lines, access sites, or primary pathology. Strict aseptic handling of lines is required.

ECMO circuit failure or breakage may lead to catastrophic failure, but this is unusual as long as all components are secure. Bedside staff are trained to check the circuit integrity regularly to prevent problems and to react promptly in the case of acute failure. Cannula displacement or malposition is a major issue as this affects blood flow and ECMO efficiency.

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MEASURING OXYGEN DELIVERY ON BYPASS OXYGEN EXTRACTION RATIO

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INTRODUCTION :

Adequacy of perfusion is the most important factor impacting the outcome of cardiopulmonary bypass. Adequate oxygen delivery to tissue has been shown to improve the quality of post-operative recovery and even the quality of life post-cardiac surgery. While earlier indices of adequacy of perfusion, like lactate levels,urine output, etc., should guide the perfusionist on bypass. These markers are reflective of changes occurring in the tissue, and changing trends indicate that changes have already occurred at the tissue level, maybe in an irreversible manner. This necessitates incorporation of real-time parameters for monitoring the adequacy of tissue perfusion. Advances in medicine have enabled clinicians to identify parameters that provide real-time clinical information, which will alert the team to

Advances in medicine have enabled clinicians to identify parameters that provide real-time clinical information, which will alert the team to introspect and intervene with a remedial measure should matters become worse. One such parameter is oxygen delivery (DO 2). This parameter has been proven to be the most important factor that will influence the overall outcome.

THE IMPORTANCE OF ESTIMATING OXYGEN DELIVERY

Oxygen facilitates the entire process of cellular respiration and metabolism. Oxygen bound by haemoglobin (oxy-hemoglobin) is virtually the elixir of life for cellular processes. Aerobic metabolism has been proven to generate ATP molecules in sufficient quantity for various biochemical processes occurring inside the tissue/organ in general and the cell in particular. On the contrary, anaerobic metabolism, while still

providing ATP, but in very small numbers, cannot fulfill the demands of the cell. The inadequacy of oxygen delivered to the tissues has a marked impact on cellular respiration and metabolism, which in turn negatively impacts organ function. Organ dysfunction, especially in the post-cardiac surgical settings, will have a negative impact on postoperative recovery. The brain, followed by the heart itself, are the two major organs which are most affected by the lack of adequate oxygen delivery. Hence, it is very important to measure oxygen delivery.

MEASURING OXYGEN DELIVERY :

The formula for calculating oxygen delivery is as follows:

DO2 (oxygen delivery) = CO X Cao2 X 10.

Where CO-Cardiac output, CaO2-arterial oxygen content,

CaO2 = (Hb X 1.39 X SaO2) + (PaO2 x 0.003)

Where Hb-Hemoglobin, SaO2-Arterial Oxygen saturation, PaO2-Partial Pressure of Oxygen in arterial blood gas.

From the formula, it is clear that oxygen delivery is dependent on two variables: hemoglobin and cardiac output (translated as blood pump output in L/min during CPB). This provides the perfusionist with two strategies to ensure a positive outcome: modulation of pump flows according to temperature and managing adequate hemoglobin levels on bypass-either through negating excessive hemodilution by hemofiltration or by transfusion of blood, especially packed RBCs.

THE DANGERS OF INADEQUATE OXYGEN DELIVERY :

In a landmark study by Ranucci et al., two points are highlighted: the effects of inadequate DO2 and the lowest numerical value of DO2-called the Nadir DO2. Inadequate DO2 has been shown to literally open a Pandora's Box in terms of the following sequelae, both peri-operatively and post-operatively: neurological deficit, axionic injury, stroke, myocardial infarction, acute renal failure, etc. A value of less than 300 mL/gm/minute has been demonstrated to independently improve the risk of morbidity and/or mortality by influencing these adverse incidents. Hence, the need for monitoring oxygen delivery is an imperative one.

After reaching a nasal temperature of 20 degrees and a rectal temperature of 25 degrees, the aorta was clamped distal to the innominate artery and the descending aorta to perform the distal aortic arch. Aneurysm clips were used to clip the left carotid and subclavian arteries. At this time, pump flow was adjusted to 50 ml/kg to perfuse the innominate artery and coronary heart.

IS THERE AN EASY WAY TO ESTIMATE OXYGEN DELIVERY?

While the formula for calculating DO2 can be used in real-time and there are devices which, if calibrated according to specifications, can non invasively measure DO2, performing mixed venous blood

gases can help with estimating the adequacy of DO2 in units where such specialised equipment is unavailable.

Oxygen extraction is the ratio of the difference in oxygen saturations in the arterial and venous systems. An increasing trend in oxygen extraction can indicate a demand-supply mismatch.

The formula for oxygen extraction is

ErO2 = 100-SvO2,

Where ErO2-oxygen extraction ratio and SvO2-venous blood gas saturaton.

Bearing the range of normal values of SvO2 in the equation, the safe limits for adequate oxygen extraction are between 25 and 30. While higher values can indicate adequacy of tissue perfusion and luxury perfusion, especially during hypothermic CPB, lower values certainly indicate a supply-demand mismatch, which directly hints at inadequate oxygen delivery necessitating suitable intervention.

CONCLUSION :

Adequate oxygen delivery during cardiopulmonary bypass singularly contributes to the onset of favourable outcomes for patients undergoing cardiac surgical procedures. Application of this parameter, hitherto used only in critical care units, in the cardiac OT settings has helped the perfusionist recognize trends and implement remedial measures with the aim of keeping the oxygen delivery adequate. While using specialized equipment to measure oxygen delivery is certainly beneficial in practice, monitoring venous blood gases at regular intervals can be just as effective in estimating oxygen delivery, albeit indirectly.

CHEMOTHERAPY

ECMO OUTCOME IN 5 FLUOROURACIL TOXICITY

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ABSTRACT :

Chemotherapy regimens based on 5-fluorouracil (5-FU) are frequently administered in the treatment of gastrointestinal malignancies, especially colorectal carcinomas. Fulminant myocarditis is a rare but potentially life-threatening illness caused by 5-FU cardiotoxicity. Commonly presenting as chest pain, cardiac toxicity has manifestations that can include ischemic changes evident upon electrocardiography and arrhythmias, myocardial infarction, heart failure, cardiogenic shock, and sudden death, with higher incidences in patients who have existing cardiac disease, although salvage extracorporeal membrane oxygenation has been used successfully to treat various forms of cardiogenic shock.

CASE SCENARIO :

A 45-year old female patient who has a K/C/O metastatic colonic adenocarcinoma with left ovarian metastasis underwent right hemicolonectomy + paraaortic LN biopsy + left ovariectomy in January 2019. On the second day of chemotherapy at a peripheral hospital with folfox, she developed generalized discomfort. She was shifted to the ICU where her Trop 1 was found to be elevated and a diagnosis of ACS with pulmonary edema was made. During her ICU stay, she had VT, started on an amiodarone infusion, and was shifted here from the nearby Cancer Hospital. On arrival at the ED, she had unstable hemodynamics and was electively intubated and ventilated. An echocardiogram revealed stunned myocardium with severe LV dysfunction, and a CXR revealed right-sided pneumoniae. She was diagnosed as having toxic myocarditis drug induced (5 Fluro Uracil) with refractory heart failure and cardiogenic shock. It was decided to initiate ECMO after the Multidisciplinary Meet.

The patient was in a moribund state. After team discussions and discussions with the family, the decision was made to put the patient on ECMO in spite of the metastatic malignancy.

The patient had persistent hypotension and recurrent VT, which were being treated percutaneously with DC vert.

ECMO CANNULATUION AND CONDUCT :

Left femoral transverse incision. Femoral artery and vein dissected. Venous cannulation is done using 30/33 Edwards cannula under TEE guidance and positioned on the RASVC junction. Femoral artery cannulation is done using 20 Fr Edwards Cannula. Then went to CPB and the plan was to switch to ECMO once the hardware was available.

The patient improved overall on bypass with kidneys starting to functioning, Stiff inotropes were weaned & the heart looked better once offloaded. After 12:12 hours of CPB, her clinical condition improved a lot and then she was switched over to VA ECMO using the same cannulas with special precaution to de-air the circuit while switching.

Perfusion management & monitoring management, which is closely interlinked management of a patient's underlying condition, remains as a standard critical care protocol. Before starting ECMO, it is essential to do the proper planning of the goals of ECMO and the strategy and management of patients on ECMO includes multisystem management and circuit management.

PERFUSION PLAN :

ECMO machine:-medos *(delta stream MDC)
prime :-crystalloid
oxygenator:-medos (ECMO/ECLS hillite 7000LT and DP3 heparin coated)
ACT range:-160-250 sec RPM:-5500-6300
Flow rate:-2.0-4.0 L/min(gradually decreased).

She was maintained on ECMO for 6 days(144 hours).ECMO was initiated via femoral artery and vein with 4L/min flow. She needed multiple pericardiocentesis, Albumin & blood transfusions in line with the usual ECMO protocol.

MANAGEMENT OF PATIENT ON ECMO :

Post procedure day, she was on AF with FVR and was treated with IV cordarone.

The next day, her blood count was found to be elevated. Initially, it started on IV piptaz, which was changed to IV meropenem and levoflox.

Her CXR and echocardiogram were repeated daily and were monitored. On the 2nd day, her echocardiogram revealed pericardial effusion. Picc tail was inserted and was drained.

Gastroenterology consultation was sought for raised liver enzymes and was managed accordingly with NAC protocol.

A gynecology consultation was sought for vaginal bleeding. She was in her menstrual cycle and was advised to have conservative management. She had platelet depletion on ECMO and was transfused with multiple blood and blood products during the ICU stay.

Serial Echo was done and her myocardial function was improving and hemodynamics was maintained without inotropes.

Radiology :- doppler study was satisfactory
Neurology :- neurology consultation was taken for critical illness myopathy, and was

active physiotherapy and conservative management
Pulmonology :-Bronchoscopy was done on alternate days for better tracheal toileting.As she was not tolerating orally, RT feeds were promoted.

PLAN TO WEAN OFF :

It is a process of gradually decreasing the total extracorporeal membrane oxygenation support in an effort to take away mechanical support. She was weaned off from ECMO on the 6th day.

Her femoral decannulation was uneventful and direct closure was done. Hemodynamics were maintained on minimal inotropes. In spite of antibiotics and antipyretics, the patient developed fever and her BAL culture revealed growth of Klebsiella pneumoniae and candida species. Hence, IV colistin and fluconazole were added. Her lung compliance improved and she was extubated on the 8th day (186 hours)and was kept on intermittent NIV. Bronchoscopy was done on alternate days for better tracheal toileting.

At between 160-250 Sec she improved symptomatically and was shifted to the ward after one week of weaning off event(vascular injury).

On the 17th day, she had massive bleeding from the femoral wound, which was not controlled by applying pressure. She was electively shifted to OT, femoral wound re-exploration done, and a femoral artery which was partially necroed was repaired using the Dacron patch. She was shifted to the ICU in a hemodynamically stable condition. On the next day she was extubated and was shifted to ward.

Her IV antibiotics were discontinued and repeated blood, urine and sputum culture were sent as she developed fever during the hospital stay. Her blood culture was found to be sterile, whereas sputum and urine culture revealed growth of Klebsiella and candida species. Hence, IV colistin and fluconazole were continued for 2 weeks. She was tolerating oral feeding well and Ryle's tube was removed. The urinary catheter was also removed and she is able to void urine. At the time of discharge stability, she is fully stable with independent mobility and hemodynamic stability. Her wounds were all clean.

CONCLUSION :

This case shows that full myocardial recovery is possible in patients who present with cardiogenic shock from fulminant myocarditis induced by 5-FU cardiotoxicity. One must recognize the causal association promptly and maintain adequate tissue perfusion and oxygenation.

We propose that ECMO be considered in such patients with life-threatening, but temporary, cardiac dysfunction.

ACKNOWLEDGMENTS :

In the preparation of this case report, we acknowledge the contributions of 2 esteemed colleague perfusionists, Aju James, Ansar S.

MYOCARDIAL PRESERVATION TECHNIQUE DURING CARDIAC SURGERY

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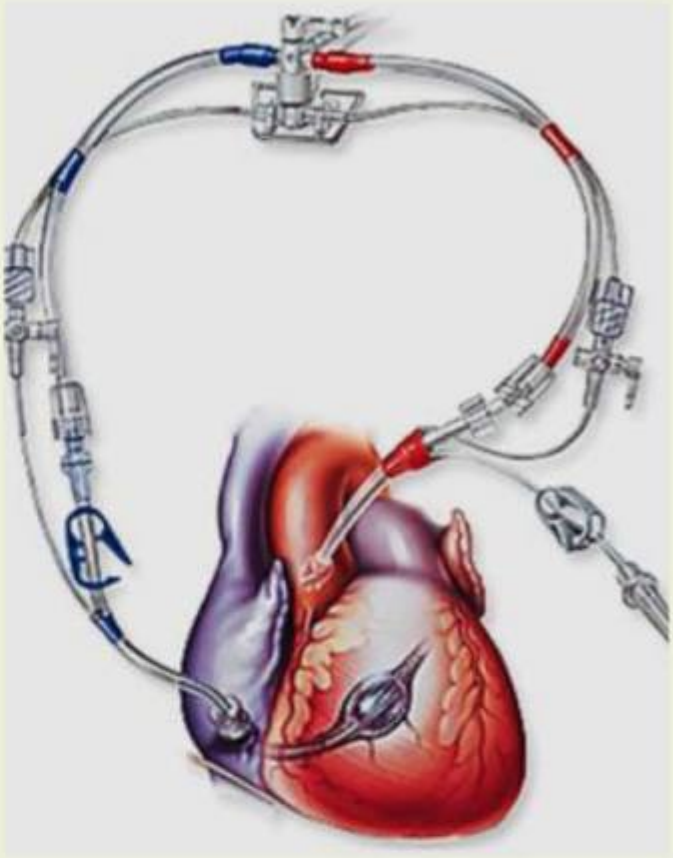
2018 Batch

INTRODUCTION :

One of the major concerns in open heart surgery is the protection of the myocardium during the operation. Surgery of the heart is of no use if the myocardium is inadequately protected. Therefore, cardioplegia is an essential component of cardiopulmonary bypass. Along with its cardioprotective role, it also provides a relatively bloodless and motionless field.

The word "cardioplegia" combines the Greek "cardio", meaning the heart, and "plegia," meaning paralysis.



The primary goal is to reduce myocardial oxygen demand by creating electrical quiescence and cooling the heart to reduce the ischemic effects of being on bypass. Cardioplegia provides an intentional and temporary cessation of cardiac activity. Adequate delivery of cardioplegia is required to all areas of the heart in order to optimize myocardial protection. the first solution used during CPB was reported by Dr. Melrose in the early 1950s, who identified that high levels of potassium citrate induced a reversible cardiac arrest. A cardioplegia solution is a high potassium-containing solution which is administered either in a crystalloid or a colloidal (blood) vehicle.

CRYSTALLOID CARDIOPLEGIA:

For many years, crystalloid cardioplegia solutions consisted of a crystalloid solution with potassium and various additives.

The initial dose typically contains a higher potassium (20-30 meq/l) concentration than subsequent maintenance doses (5-10 meq/l). Crystalloid cardioplegia is of two types: extracellular and intracellular.

Extracellular cardioplegia :

St. Thomas solution (plegiocard, plegiosol) :

It is a type of cardioplegia solution that requires short intervals(~20 minutes).

Composition :

- Mgcl-16 meq (calcium channel blocker)
- Kcl-16 meq (arresting the heart)
- Procaine hydrochloride-1 mmol (membrane stabilizer)

Delnido solution :

It was developed by Dr. Pedro Delnido and was patented in 1995.The basis of the solution is plasmalyte. The salient compositional features of Delnido are

- Mannitol (free radical scavenging)
- MgsO4 (calcium antagonist)
- Sodium bicarbonate (buffer)
- Lignocaine (a membrane stabilizer)
- Potassium chloride (arrests the heart)

Intracellular Cardioplegia :

HTK solution or custodial cardioplegia are the most common.
It is the former bretishneider solution, also called histidine, tryptophan, and ketoglutarate.
used for perfusing and flushing of organs from the donor, preservation of organs for transplant and for cardioplegia in cardiac surgery.
Low sodium and calcium concentrations result in reduced action potential, leading to diastolic cardiac arrest.

BLOOD CARDIOPLEGIA:

Buckberg cardioplegia:

It provides trace elements, proteins, and enzymes that may not be found in the analogue of interstitial fluid. It provides protein buffer for acidosis, natural nutrients for the heart as well as large quantities of oxygen.

WARM BLOOD CARDIOPLEGIA :

It has been proposed as a safe and reliable technique for myocardial protection.
It helps in eliminating hypothermic myocardial ischemia and reperfusion injury.

It has been shown to improve metabolic recovery.
It improves oxygen delivery and dissociation, decreases intracellular swelling, decreases RBC deformation and rouleaux formation, and decreases impairment of ATP-dependent cellular processes.
It also improves membrane stabilization.

DELIVERY SITES FOR CARDIOPLEGIA :

The cardioplegia delivery sites vary according to the surgical preference and include antegrade and retrograde techniques.

Antegrade caedioplegia :

Antegradely, the cardioplegia is given through the aortic root, coronary ostia directly through the coronary graft. It is most commonly undertaken through the placement of a cardioplegic cannula.
During antegrade cardioplegia, pressure must be maintained at 80-100 mmHg and flow must be 250-300 ml/min. Antegrade simply means that the solution runs down the right and left coronary arteries and supplies the myocardium in the same distribution as blood would normally.

Retrograde cardioplegia :

Retrograde cardioplegia is administered through the coronary sinus. Aortic regurgitation negates retrograde administration.

During retrograde cardioplegia, pressure must be maintained at 35-45 mmHg and flow must be 200 ml/min.

Due to the anterior cardiac veins draining directly into the right atrium and the coronary sinus, using only retrograde cardioplegia into the coronary sinus may be insufficient for adequate myocardial protection to the right ventricle

Anatomical variants may make the placement of either the antegrade or retrograde cardioplegia catheter technically difficult, or the placement of an aortic cross clamp may be contraindicated. Severe ascending aortic calcifications or unstable atheroma increase the risk of dissection and stroke following the removal of the aortic cross clamp. It is necessary to understand the electrolyte abnormalities and myocardial stunning and PH imbalance that may occur secondary to cardioplegia administration.

CARDIOPLEGIA DELIVERY SYSTEM :

Cardioplegia delivery systems contain an infusion system, a heat exchanger for cold and warm perfusion, and a temperature monitoring port. The water source for this heat exchanger is independently regulated from the one used for the oxygenator that controls body temperature.

Microplegia :

Blood is diverted from a specific built-in port of the oxygenator through an occlusive roller pump. Downstream of the roller pump, an arresting agent is added through the use of a syringe pump. The result is a mixture of oxygenated blood and one part of crystalloid cardioplegia solution. Compared to standard blood cardioplegia, hemodilution is less in microplegia.

Hot Shot :

Terminal dose of cardioplegia or reanimation cardioplegia. It washes out metabolites and improves post ischemic metabolic disorders that may have occurred during arrest. It also acts as a vehicle for the delivery of drugs specifically targeted at reperfusion injury. It decreases the instabilities associated with a cold-warm interface if the temperature is gradually ramped to normothermia.

CONCLUSION :

Cardioplegic solution is the means by which the ischemic myocardium is protected from cell death. Warm cardioplegia and cold cardioplegia result in similar short-term mortality rates, but warm cardioplegia may reduce adverse postoperative events and morbidity. Warm cardioplegia protects the myocardium adequately during cardiopulmonary bypass operations, and its use should be continued. Voltage-gated channels are targeted with cardioplegia to induce cardiac arrest. The persistence of potassium reduces the membrane potential and does not allow for adequate repolarization. This, in turn, causes a diastolic cardiac arrest.

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MANAGEMENT OF CPB AND TOTAL CIRCULATORY ARREST IN A HEPARIN-INDUCED THROMBOCYTOPENIA PATIENT UNDERGOING PULMONARY THROMBOENDARTERECTOMY

CASE REPORT

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Narayana Hrudayalaya

ABSTRACT :

To report the successful management of CPB and TCA in a case of a pulmonary thromboendarterectomy patient having heparin-induced thrombocytopenia.

We report a case of a 50-year old female weighing 64 KG, diagnosed to have chronic pulmonary thromboembolism with severe RV dysfunction and severe PAH having HIT.

Heparin-induced thrombocytopenia (HIT) is the development of thrombocytopenia due to the administration of various forms of heparin. HIT is predisposed to thrombosis, the abnormal formation of blood clots inside a blood vessel by the formation of abnormal antibodies that activate platelets. A diagnosis of HIT includes a blood test and a quantitative heparin assay. Thromboembolism surgery necessitates DHCA and the cessation of circulation.

We used Bivalirudin as an anticoagulant, but the stagnancy of the blood anywhere in the circuit leads to thrombosis. TCA is very difficult and challenging.

The successful outcome, challenges involved in going on TCA, and the techniques of avoiding stagnancy throughout the surgery, and the modifications required in delivering cardioplegia are described below.

INTRODUCTION :

The management of a HIT patient on CPB is a very difficult task. We are discussing the management of emergency pulmonary thromboembolism patients on TCA and CPB. Routine CPB was established with Bilivarudin as an alternative anticoagulant. The patient was cooled to 18 degree Celsius using full flows and vasodilators. The ACT was maintained at appropriate levels. During TCA, certain modifications were made to the flows to avoid stagnancy in the circuit.

Intermittent, short-duration TCA was performed to remove the pulmonary clots. The patient was rewarmed and came off of CPB uneventfully. MUF was done. The patient had a smooth recovery and was discharged from the hospital on the 8th post-operative day.

CASE REPORT :

A 50-year old female patient weighing 64 kg was diagnosed with chronic pulmonary thromboembolism, severe PAH, severe RV dysfunction, right lower limb deep vein thrombosis, and anti-phospholipid antibody syndrome. For thrombolysis in preoperative days, they administered low molecular weight Heparin because this patient had developed Heparin-induced thrombocytopenia (HIT). The patient was referred for an emergency pulmonary thromboendarterectomy (PTE).

Because the patient's condition was very sick, we decided to do the surgery. Because of its short half-life period, we have used Bivalirudin as an alternative anticoagulant. I added 50 mg of Bivalirudin into the pump prime and circulated. Bivalirudin was given at a dose of 1.5 mg/kg body weight, and the ACT was measured. As soon as venous cannulation is over, the bypass is over. connected the bivalirudin infusion to the pump and started cooling. While cooling, I titrated the bivalirudin infusion rate. At 36 to 32 degrees centigrade, kept at an infusion rate of 2.5 mg/kg/hr. At 32 to 28 degrees centigrade, 2 mg/kg/hr. Below 25 degrees Celsius, 1 mg/kg/hr. The ACT was checked every half an hour. While cooling, the patient was fibrillated at 24 degrees centigrade, cross clamped, and administered cold blood cardioplegia at 20ml/kg.

Once achieved, the temperature of 18 degrees kept the ACT 2.5 times higher than the normal ACT. administered the cerebral protective drug (thiopentone sodium 10mg/kg body weight). I hyperventilated and went on TCA because the pulmonary clots were very deep. The surgeon took 7 minutes to remove the clots from the right lung, and after that, reperfused for another 20 minutes, and then went on TCA again to remove the clots from the left lung. It took another 8 minutes. After that, it started to rewarm. While rewarming, we also titrated the bivalirudin dosage according to the temperature and ACT. I checked the ACT every 30 minutes, and I brought the ACT down to the 500 to 600 range. In order to bring down the ACT, we have titrated the Bivalirudin infusion rate, maintained good urine output, and started hemofiltration because these can eliminate free Bivalirudin molecules. A low-flow technique was used to remove the superficial clots from the pulmonary artery. Rewarmed fully (nasal temperature of 36 degrees centigrade and rectal temperature of 33.3 degrees centigrade). I checked the ACT and ABG. Checked protocols to terminate the CPB. The bivalirudin infusion was discontinued 30 minutes prior to terminating the CPB. I checked the ACT and at 480 sec started to terminate the CPB. After the termination of CPB, they started modified ultrafiltration. During modified ultrafiltration, the oxygenator recirculated. MUF has been done for 15 minutes and has helped to reduce the pulmonary arterial pressure. Total CPB time was 229 minutes and cross clamp time was 166 minutes. Because there is no antidote for bivalirudin after the termination of CPB, it has taken one hour for ACT to return to normal.

DISCUSSION :

Pulmonary thromboendarterectomy surgery is more complex and requires careful assessment and visualization, and it is associated with higher mortality and morbidity. Usually, pulmonary thromboendarterectomy surgery requires Total Circulatory Arrest (TCA) for better visualization of clots in the pulmonary artery. For that, you need to cool down to 18 degree Celsius.

In this particular case, the patient developed heparin-induced thrombocytopenia (HIT) due to pre-operative heparin therapy. The patient was very sick, so they needed to operate immediately. Because of its short half-life period, we have used Bivalirudin as a Heparin alternative.

But, it was very challenging because if we are using Bivalirudin, we should avoid stagnancy because if blood is stagnant, there is a chance of clot formation. The major areas of stagnancy of blood are recirculation lines, blood cardioplegia delivery systems including delivery lines and cannula, and suction and vent lines. In order to avoid stagnation, we flushed out the BCD and delivery line with normal saline and decannulated the aortic root cardioplegia delivery needle and snugged and kept it. To avoid stagnation, all recirculation lines are opened and circulated through every 7 minutes. All the suction lines and vent lines are cleaned every 10 minutes with saline.

The other possible chance of stagnation is during the TCA, because there won't be any circulation in the body and some parts of the circuit. During TCA, we can recirculate the venous reservoir, arterial filter, and oxygenator. Otherwise, we decannulate and put a "Y" connector and circulate, but at that time, body circulation won't be there. So we need to reduce the TCA time. We have kept a TCA time of 10 minutes. We can even use a low-flow technique to remove the superficial clots. This protocol was followed throughout the case. The patient was neurologically fit in the post-operative period and was awake within 4 hours. We can also use crystalloid cardioplegia like HTK solution to avoid stagnancy in the BCD unit.

CONCLUSION :

This case report describes our experience with the management of a heparin-induced thrombocytopenia patient on total circulatory arrest and cardiopulmonary bypass. When we are using Bivalirudin, we should be careful about stagnation and it should be avoided. We can also use the low flow technique to avoid stagnation. Usage of crystalloid cardioplegia also helps to avoid stagnancy and complexity in perfusion management.

HEART PRESERVATION

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2017 Batch

INTRODUCTION :

Donor heart preservation is aimed at minimizing graft dysfunction caused by ischemia-reperfusion injury (IRI), which inevitably occurs during the ex vivo transport interval. Successful cardiac transplantation is dependent on the safe procurement and preservation of the donor heart. Current techniques of heart preservation allow a 4–6 hour period of safe ischemic storage in most cases. Cardiac transplantation is different from other solid organ transplants in that immediate function of the donor organ is necessary for recipient survival. This limits the ability to use marginal donors and makes optimal preservation mandatory.

While the optimal method for heart preservation has yet to be identified, many of the mechanisms by which cells are involved in cell injury and death during organ preservation have been identified.

HISTORICAL HIGHLIGHTS:

According to lower and Shumway studies about heart preservation, hypothermia has subsequently proved to be the most important unifying concept in organ preservation. Hypothermia reportedly reduces the tissue metabolic rate and cooling decreases the cellular enzyme activity. Even today, hypothermia remains the time-proven central component of organ preservation of all solid organs.

In 1969, Robicsek introduced ex vivo continuous perfusion of organs with normothermic blood to mimic the native condition.

Donor core cooling on cardio pulmonary bypass was initially introduced for combined heart lung transplantation to uniformly cool the donor. It carries the beneficial properties afforded by using

blood as a perfusate in that it is a colloid, contains free radical scavengers, natural buffers, oxygen, and metabolic substrates, and avoids unequal distribution of the flush solution and organ cooling that can occur with single flush techniques.

The single-flush technique emerged in the 1970s, coincident with the explosion of coronary artery surgery. The essential components of this technique consist of clamping the aorta and perfusing the heart with a potassium-containing solution to arrest the heart and render it asaguinous and hypothermic before it is excised and stored in a hypothermic crystalloid solution. The combination of electromechanical silence and organ cooling was felt to reduce the metabolic rate to allow an extended period of ischemic tolerance and enable successful distal procurement. A variety of cardioplegic solutions have evolved that were successfully employed in the laboratory and later in clinical transplantation. The development of new solutions or modifications of known solutions has remained a central focus of organ preservation research for much of the last two decades.

SINGLE FLUSH TECHNIQUE

Surgical technique :

The heart is visually inspected and palpated to identify areas of hypokinesis, confusion, palpable coronary artery disease, or the unexpected thrill of a valvular lesion or congenital abnormality. The aorta, superior vena cava (SVC), and inferior venue cava (IVC) are encircled with vessel loops. The donor is systematically heparinized (30 ml/kg).

By locating the SVC and clamping the IVC at the diaphragm, inflow occlusion is then achieved. The aorta is cross-clamped, and the heart is allowed to beat on empty. The flush solution is infused into the ascending aorta. The IVC is proximal to the clamp, and the left atrial appendage, or pulmonary vein, is incised to allow egress of blood and flush solutions. Several liters of cold saline are poured over the heart to initiate cooling. Once the flush solution is delivered, the heart is excised and packaged for storage in a sterile container containing the storage solution. If the lungs are to be simultaneously harvested, intravenous prostaglandin E1 (PGE1) is infused prior to the cross-clamping at rates varying from 20–50ng/kg/min until there is a significant (i.e., 20%) drop in systemic blood pressure. At that point, inflow occlusion is initiated and the aorta is clamped. Additional PGE1 (i.e., 500 micrograms) can be injected into the main pulmonary artery, or the entire dose can be delivered via that root prior to initiating the pulmonary flush. The lungs are flushed with a solution through a catheter in the main pulmonary artery, which is simultaneous to the cardiac flush.

Flush and storage solutions :

Variables in the single-flush technique begin with the flush (cardioplegia) and storage solutions. A clear distinction should be made between the two. The primary goal of the flush solution is to arrest the heart and to begin cooling the tissue to decrease energy use. Additional goals are to create a milieu in which cellular damage is minimized, to provide glucose and other substrates as a source of energy, and to render the heart asanguinous.

The goals of the storage solution are to achieve and maintain hypothermia, provide insulation between the cold source (ice) and the organ, provide a non injurious milieu for storage, and provide glucose and other substrates for energy. The effect of using different solutions for flushing and storage is unknown and has not been extensively studied.

The ideal temperature of the preservation solution for flushing and storage is unknown. It is generally believed that the optimal temperature is around 10 °C for heart preservation. The ideal temperature will sufficiently decrease cellular metabolism but will allow critical cellular precession to continue. Although myocardial temperatures lower than 100°C impair vasomotor function and affect calcium homeostasis and other cellular transport mechanisms by impairing membrane-bound enzymes, temperatures above 100°C impair the effect of some preservation solutions and provide inferior preservation. Excessive cooling to temperatures below 100 degree Celsius can result in serious injury and should be avoided. Unmonitored, it can happen in as little as 60 minutes in a standard saline solution stored on ice.

Volume :

The optimal volume of flush solution is unknown. A single dose of antegrade flushing is standard. The methodology used to determine the volume delivered varies gently. Some methods deliver a set volume or a set volume per body weight; other methods choose continuous flushing until the coronary sinus or left atrial effluent appears clear. For heart transplantation, a volume of 500cc to 2 L, or 10 to 20 mL, has been given. Antegrade delivery is most commonly used.

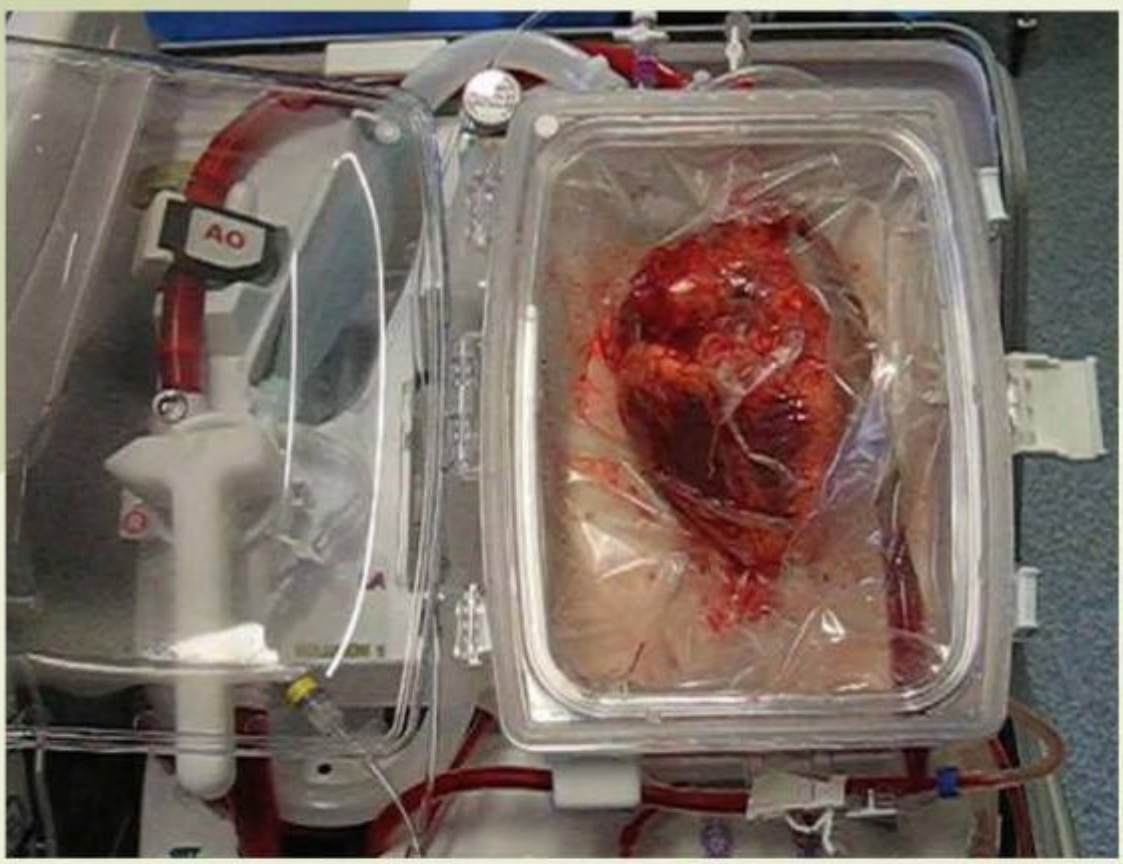
Pressure :

Ideal pressure is also unknown. Some centers deliver the flush through a pump apparatus at a given pressure; most centers, however, hang the bag of flush solution at a prescribed height (i.e., 30–80 cm) or in a pressure bag inflated to a pressure of 150–250 mmHg, which reflects the pressure used to infuse cardioplegia solutions for coronary artery surgery, are commonly employed for the heart.

NEW AND FUTURE TECHNIQUES

Ischemic preconditioning :

The general hypothesis of ischemic preconditioning is that a brief period of ischemic will activate protective mechanisms and increase ischemic tolerance. Animal studies shows preservation of high-energy phosphates of, decreased creatine kinase leakage, and improve contractile function after global
hypothermic ischemia in cardiac models, and reduced repercussion injury in lung models. Activation of ATP sensitive potassium channels has been postulated as providing endogenous protection against
myocardial ischemic and is thought to play a pivotal role in the cardioprotective of ischemic preconditioning. A number of potassium channel opening drugs exist that are cardioprotective in setting of myocardial ischemia. While ischemic preconditioning is impractical in the setting of multiorgan procurement, pharmacologic preconditioning is not and may be particularly relevant in the use of non-beating-heart donors.



Continuous perfusion :

The concept of continuous mechanical perfusion was recently re-introduced experimentally with the hope that low-pressure perfusion with a high colloid osmotic pressure perfusate would prevent the tissue edema seen with earlier systems. Perfusion systems have been successful in resuscitating and preserving renal allografts. Although encouraging laboratory data on perfusion preservation of cardiac allografts using donor blood and preservation solution has been reported, clinical data has not been reported to date.

Gene therapy:-

Gene therapy has many potential applications in transplantation. Gene transfer has been accomplished during hypothermic storage in both hearts and lungs. In a model of murine cardiac ischemia reperfusion, transgenic overexpression of superoxide dismutase conferred significant functional benefit over control animals. In another study, the gene that codes for heat shock protein was successfully transferred to donor lungs and decreased ischemic reperfusion injury .

CONCLUSION :

The current acceptable period of cardiac preservation is 4–6 hours when using the single flush technique and hypothermia storage. The ideal method and ideal solution for cardiac preservation have yet to be identified.

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LEFT HEART BYPASS IN THORACO-ABDOMINAL ANEURYSM

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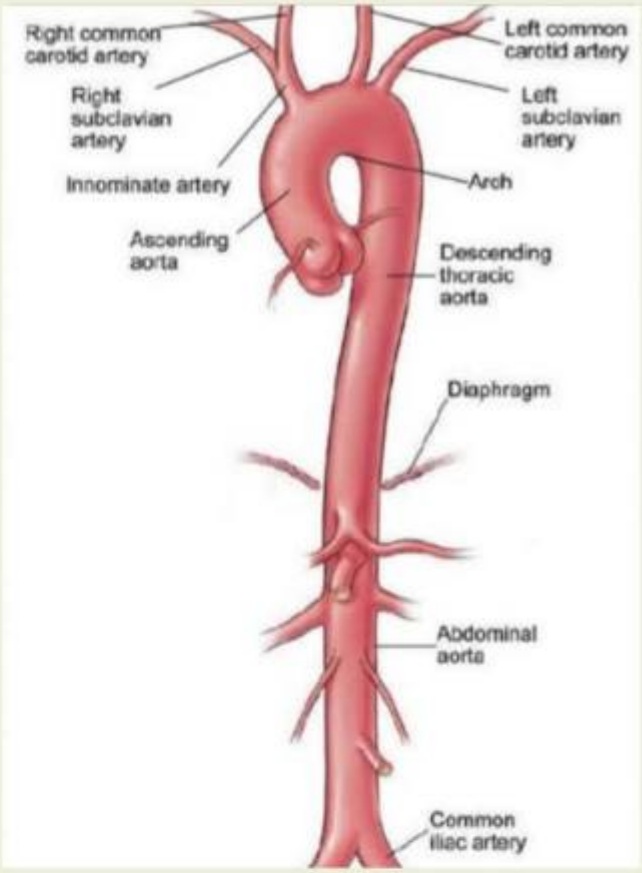


The thoraco-abdominal aortic repair's main objectives include avoidance of damage to the distal organ during and after surgery. There are various surgical techniques used for the repair, all aimed at reducing the afterload on the heart and preserving the end organ.

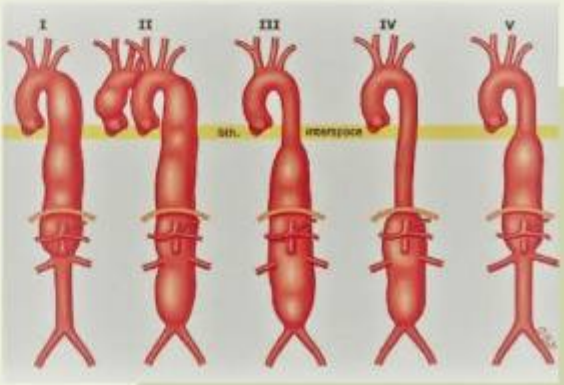
Simple cross clamping was used by Stacy Crawford. 30 years ago, no matter how fast the surgeon proceeds, does not provide this protection. Therefore, along with cross clamping systems to support circulation, they were also introduced. One of the major technique is left heart bypass.

CRAWFORD CLASSIFICATION OF TAAA

• TAAA is characterized by continuous dilation of the descending thoracic aorta that extends to the abdominal aorta.

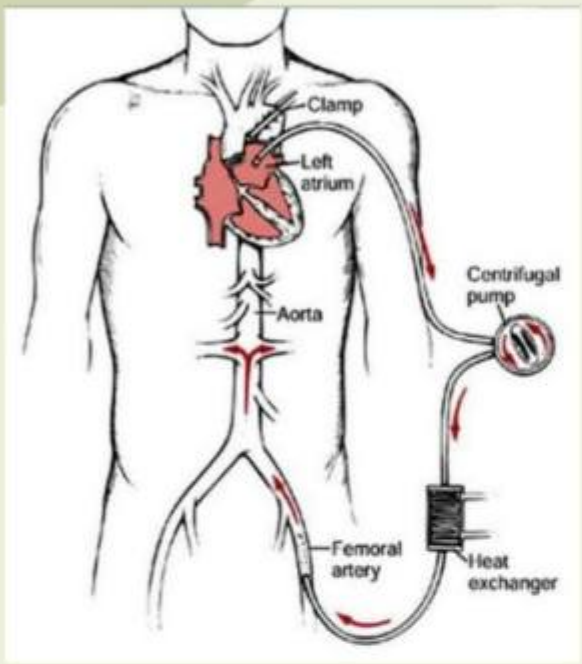
• Crawford classification was based on the aneurysm's anatomical extension.

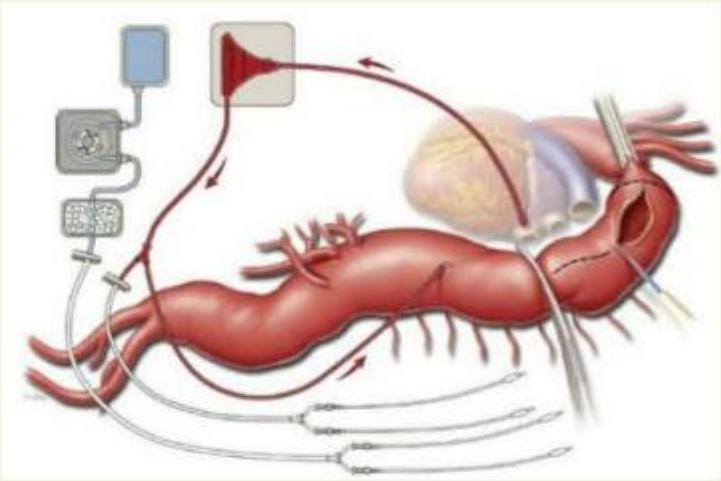
- TYPE 1 : From left subclavian to suprarenal AA
- TYPE 2 : From subclavian to aorta-iliac bifurcation
- TYPE 3 :From distal aorta to aorta-iliac bifurcation
- TYPE 4: Are limited to abdominal aorta below diaphragm



LEFT HEART BYPASS :

Left heart bypass, also known as proximal aorta bypass, is a commonly used technique in descending thoracic abdominal surgery. The patient's left ventricle supplies blood to the aorta proximal to the clamp, and the left heart bypass circuit supplies blood distal to the clamp. In this technique, either the aorta is cross clamped or plegia is delivered.





AIMS :

To reduce the risk of end-organ ischemia and post operative paraplegia, and to support the heart and also to control proximal hypertension during the procedure.

CANNULATION TECHNIQUE :

The cannulation of LHB is essentially the withdrawal of oxygenated blood from the left side of the heart like

- Left atrium via the left atrial appendage (extremely fragile)
- Left pulmonary vein
- Apex of the left ventricle (aneurysm, rupture....)
- Aorta or one of its side branches

Then the oxygenated blood is shunted to distal circulation below the distal aortic cross clamp.

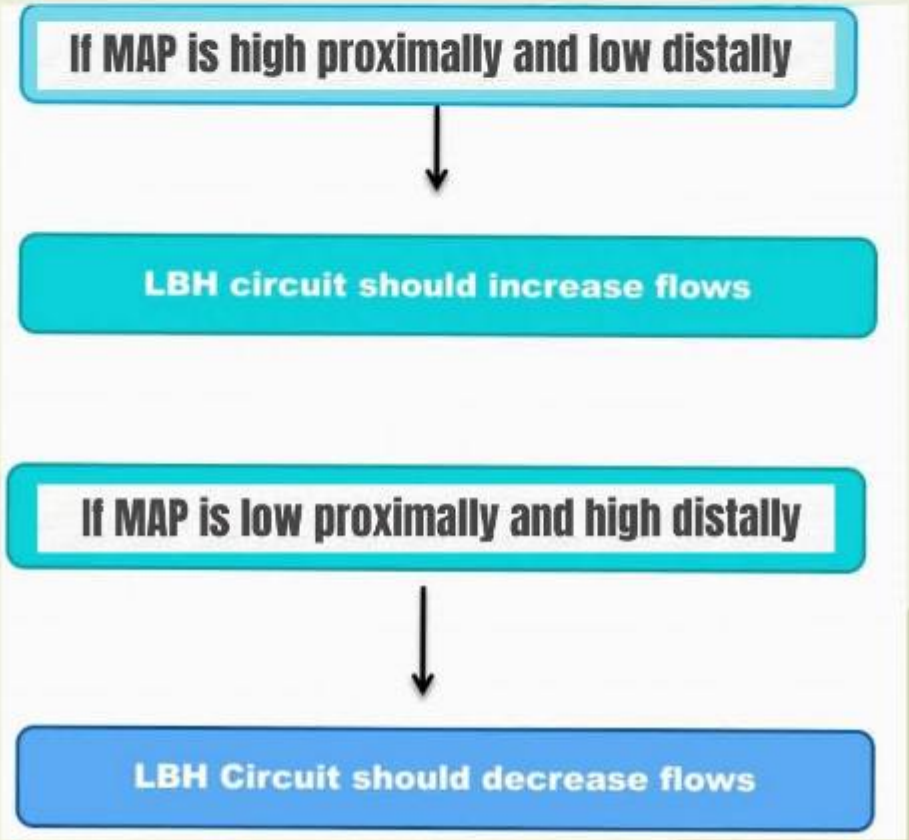
- Left common femoral artery (through graft)
- Left common iliac artery
- Abdominal aorta
- Or distal aneurysm itself

CONDUCT OF LHB :

The left atrium is cannulated and oxygenated blood is siphoned into a reservoir and propelled by a peristaltic roller pump into the arterial line for the femoral artery. There is no need for an oxygenator as the blood is already oxygenated by the lungs. Flows are to be maintained at 75% of full flows, i.e., two thirds of 2.4LPM/M2 or approximately 1.6lpm/Mz, and the rest is pumped by LV to the upper body. Arterial pressure distal to the clamp is maintained at 55-66 mmHg. The patient is cooled passively, 100 U/kg heparin is given, and the ACT is maintained above 200 sec. The ACT should be repeated every 30 minutes. A venous reservoir can be used, but it requires full heparinization. The use of LBH demands optimal interactions among the surgeon, anaesthetist, and perfusionist as the amount of blood shunted away from the left heart is not available for upper body perfusion, including the brain and heart. The reduction in the pump flow may result in increased blood pressure and vice versa. The success of LBH completely depends on understanding this correlation.

MONITORING DURING LHB :

The arterial pressure should be measured in the radial or brachial artery for the proximal and right femoral for the distal aorta. This will permit the assessment of the adequacy of flow to each organ, where as the CVP and PA pressure will assess the filling of the two ventricles. TEE is helpful in assessing the filling of chambers and the position of cannulas. If the arterial pressure is too high proximally and too low distally, the LHB circuit should pump more blood, and if the arterial pressure is too low proximally and too high distally, the LHB circuit should pump less blood.



CONSIDERATION OF LHB :

To prevent the retrograde flow in LHB, the pump is started at 100 rotations per minute and then tubing clamps can be removed. The proximal aortic cross clamp is placed at the aortic arch distal to the left carotid artery or at the descending thoracic aorta distal to the left subclavian artery. The distal aortic clamp is placed at the mid thoracic aorta between T4 and T7, then the distal aortic perfusion can be increased to a rate of 1.5–2 liters per minute. The mean proximal aortic pressure is maintained at approximately 70 mmHg and the mean PA pressure is maintained at around 20 mmHg. Mild hypothermia with a temperature of 32 to 34 degrees Celsius can be maintained. Prevention of acidosis can be done by the continued administration of sodium bicarbonate at a rate of 2 to 3 meq/kg while the aorta is clamped.

TERMINATAION OF LHB :

When the aneurysm repair is finished, LHB is discontinued and all cannulas are removed starting from the left atrial cannula. All the blood in the circuit is reinfused into the patient through the femoral cannula. LHB can be combined with other adjuncts like cell saver, spinal fluid drainage, rapid infusion systems, and moderate hypothermia.

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MODIFICATION IN CANNULATION AND PERFUSION TECHNIQUES FOR NEONATAL AORTIC ARCH SURGERIES

CASE REPORT

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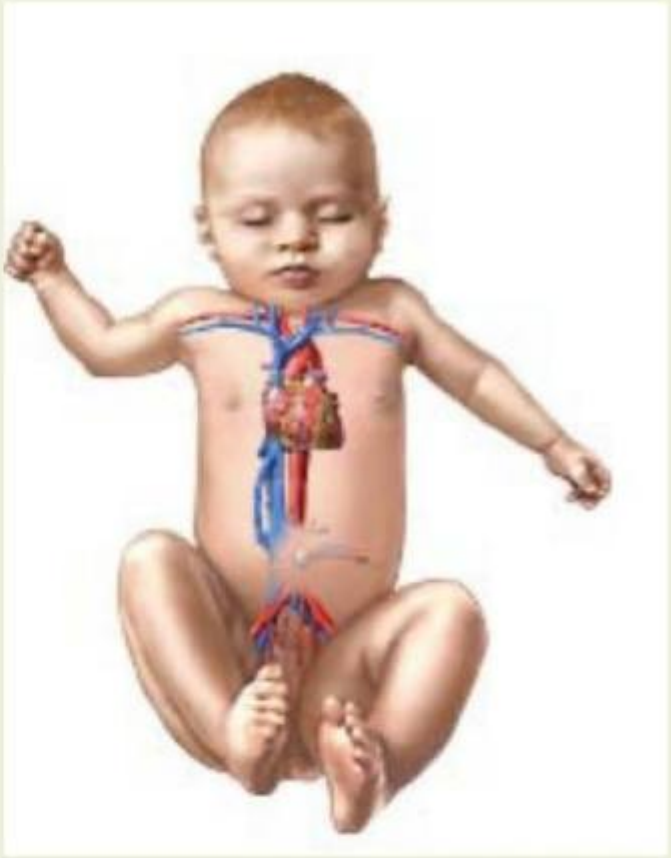
INTRODUCTION :

Cannulation techniques for neonatal aortic arch surgeries are challenging because of the anatomy of the aorta. The size and site of the cannula are compromised, which means we may be forced to go into a deep hypothermic circulatory arrest. Here we are discussing modified techniques for cannulation, which make the surgery easier for both the surgeon and the perfusionist.

Arterio venous MUF in neonatal arch surgeries may be harmful because the chances of cannula obstruction and cavitation are very high and it may steal the blood from the cardiac output. Veno-arterial MUF may be a good choice for this patient population because of the safety it provides.



CASE REPORT :

An 18-day old male kid was diagnosed with severe coarctation of the aorta, hypoplastic transverse arch, and sub pulmonic ventricular septal defect with posterior deviation of the conal septum, and it was decided to go for surgery (aortic arch repair + vsd closure).

Patient details :

Weight - 2.2 kg
Height - 45 cm
BSA - 17m
Hemoglobin - 12.5 gm/dl

planned for single-stage repair of the aortic arch and VSD closure. The cannulation was modified to innominate the artery through a Gore-Tex graft for the convenience of arch repair. Cardioplegia delivery through an aortic cannula was planned to avoid additional incisions in the aorta. Arteriovenous MUF was impossible because of the chance of cerebral stealing due to

innominate cannulation, so we decided to do veno-arterial MUF.

PERFUSION CIRCUIT :

The perfusion circuit was assembled with a Maquet quadrox 10000 oxygenator and a neonatal custom pack. The hemofilter circuit was modified for arterio-venous modified ultra filtration and cardioplegia delivery. The main circuit was assembled and the MUF circuit was kept completely separate. The inflow to the MUF pump was taken from a 150 cm extension with a 3 way connector to a 1/4*1/4 luerlock connector in the venous cannula. The 3 way part of the extension is connected to a 1/4 with luerlock prior to the MUF pump, which is connected to the maxlife hemofilter, and pressure was monitored prior to the filter. The post filter 3/16 tubing was connected to a 3/6 luerlock connector, which was connected to a 3 way, which was again connected to the 3 way part of the 100 cm extension connected directly to the aortic cannula through a 1/4*1/4 connector with luerlock. This modification was for the delivery of cardioplegia directly through the aortic cannula.

The perfusion circuit was primed and deaired with sterofundin and 200 ml of blood was added along with 45 ml of albumin, 10 ml of sodium bicarbonate, and 5 ml of mannitol. The crystalloid volume was chased to its maximum and the total priming volume was 325 ml, aiming for a 30% hematocrit on CPB.

CANNULATION :

For the convenience of repairing the aortic arch and giving antegrade cerebral perfusion, the aortic cannulation was done with an 8 Fr Biomedicus cannula in the innominate artery through a 3 mm Gore-Tex graft. Cardioplegia delivery was planned through the aortic cannula. A 1/4 x 1/4 connector with luerlock was attached to the arterial line just prior to the cannula.

Venous cannulation was done in the right atrial appendage with a single stage Medtronic dlp light house tip cannula.

Went on bypass with 2.8 lit/min/m and started cooling after dividing the patent ductus arteriosus. The aortic line pressure was below 140 mmHg, with a mean right radial pressure of 45 mmHg and a femoral pressure of 30 mmHg. Because of the coarctation of the aorta, the cooling gradient between patient and hemotherm was kept between 6 and 8 degrees, and the gradient between patient and nasopharyngeal temperature was kept at 5 degrees. In 20 minutes, the targeted nasopharyngeal temperature of 20 degrees and the rectal temperature of 25 degrees were achieved. To keep the pressures stable, the sodium nitroprusside infusion was activated. The first hematocrit on CPB was 32% and was gradually hemodiluted accordingly to keep a 24% hematocrit in deep hypothermia. The alpha stat management was followed to maintain the ph.

After reaching a nasal temperature of 20 degrees and a rectal temperature of 25 degrees, the aorta was clamped distal to the innominate artery and the descending aorta to perform the distal aortic arch. Aneurysm clips were used to clip the left carotid and subclavian arteries. At this time, pump flow was adjusted to 50 ml/kg to perfuse the innominate artery and coronary heart.

Once the distal arch repair is completed, we have taken a minute of total circulatory arrest and arterial line clamped to deliver cardioplegia, a clamp was placed in the innominate artery above the level of cannula position. Cardioplegia is delivered through the 100 cm extension with 3 ways attached to the aortic cannula. An extra volume of 15 ml of cardioplegia is given in consideration of circuit priming volume.

Once the delivery is done, the clamp in the innominate artery is replaced down to the cannula to start antegrade cerebral perfusion through the isolated innominate artery. The pump flow is adjusted to 30 ml/kg at this point of time. After completing the arch repair, the descending aortic clamp is taken off and deairing is done retrogradely. The aortic cross clamp was placed as normal, the clips in the arch vessels were removed, and the systemic perfusion resumed. After inspecting the deviated coronal septum and ventricular septal defect, a short TCA of 5 minutes is taken. After 6 minutes of systemic perfusion, the ventricular septal defect is closed through the pulmonary artery while slow rewarming to 24 degrees. Cross-clamp was removed after VSD closure, and the pulmonary artery incision was sutured while the patient was slowly rewarming to 35.8 degrees nasopharyngeal and 35.5 degrees rectal temperature, with CUF performed during this time was weaned off of CPB with stable hemodynamics.

Heart rate - 140 bpm
Arterial pressure - 55/30 mmHg
PA Pressure - 30/17 mmHg
CVP - 8 mmHg
Saturation - 99%
Hematocrit -27%

Ionotrope supports.

Adrenaline-0.05mics/kg/min
Milrinone-0.3 mics/kg/min
Calcium-100 mg/hour.

CPB DETAILS :

CPB time-176 min
Cross clamp time-70 min
TCA time-1+4+5 min
Coronary+innominate perfusion time- 48 min
Selective innominate perfusion times- 21 min.
Conventional ultrafiltration volume -100 ml.

Veno-arterial MUF started after making sure that the circuit is free of air.

MUF performed for 15 minutes, during this time MUF pump kept 30 ml/min and arterial pump giving 10ml/min.

There was no hemodynamic disturbances during MUF.

AFTER MUF :

Heart rate-140 bpm
Arterial pressure-62/37 mmHg
PA pressure-21/11mmHg
CVP-5 mmHg
Hematocrit-42%

On MUF 170 ml volume was given and a total volume of 255 ml was taken out..

Transmembrane pressure was kept between 150mmHg to 230 mmHg.

Patient was extubated after 73 hours of ventilation without any events.

Total transfusion received by the patient was...

PRBC-280 ml.
Platelet-50 ml.
Cryoprecipitate-25 ml.

DISCUSSION :

Innominate graft cannulation in aortic arch repair will increase the convenience of both the surgeon and the perfusionist It avoids long TCA times during the arch surgery and avoids the complications of pushing the cannula into the innominate artery. We experienced less resistance in the aortic cannula in this technique. Giving cardioplegia through the aortic cannula will avoid another incision in the aorta, and at the same time, we can make use of the MUF circuit for cardioplegia delivery. The use of 100 and 150 cm extensions for MUF reduces the priming volume of the circuit and improves the hemoconcentration rate. It also causes less temperature drift during MUF.

Doing arteriovenous in innominate cannulation increases the risk of cerebral stealing, but it has less risk of .

Medicines Related to Perfusion

Fayisa Sadeem,Hudha Jaleel
Fathimath Nusrin

2019 Batch

Cardiac surgery performed using a CPB (cardiopulmonary bypass),Practitioners should be aware that CPB profoundly affects the way drugs are distributed and cleared by the body (i.e., drug pharmacokinetics [PK]) and how they interact with the body to produce their effects (i.e., pharmacodynamics (PD)).

01. Atenolol Tenormin

Adrenergic Antagonists

Atenolol is a beta-adrenergic blocking agent that blocks the effects of adrenergic chemicals.

For example, adrenaline or epinephrine are released by nerves of the sympathetic nervous system. One of the important functions of beta adrenergic nerves is to stimulate the heart muscle to beat more rapidly. By blocking the stimulation of these nerves, atenolol reduces the heart rate and is useful in treating abnormally rapid heart rhythms.

Atenolol also reduces the force of contraction of heart muscles and lowers blood pressure. By reducing the heart rate, the force of muscle contraction, and the blood pressure against which the heart must pump, atenolol reduces the work of the heart muscle and the need for oxygen.

Side Effects:

CHF ,severe bradycardia, heart block, bronchospasm, and MI/angina exacerbation if abrupt d/c

Doses :

The dose for treating high blood pressure or angina is 25–100 mg once daily. Acute myocardial infarction (heart attack) is treated with two 5 mg injections administered 10 minutes apart, followed by treatment with 100 mg of atenolol taken orally for 6–9 days. If atenolol injections are not appropriate, patients may be treated with 100 mg daily of oral atenolol for 7 days.

Nursing Considerations:

Monitor vital signs, hold medication if heart rate is less than 60 bpm or if BP systolic is less than 90, monitor for orthostatic hypotension.

02. Benazepril Lotensin

Angiotensin-Converting Enzyme (ACE) Inhibitors

Natural vasoconstrictor with strong antihypertensive properties. ACE is an enzyme in the body that causes the formation of angiotensin II.ACE inhibitors like benazepril lower blood pressure by inhibiting the formation of angiotensin II, thus relaxing the arteries. Relaxing the arteries not only lowers blood pressure but also improves the pumping efficiency of a failing heart, thereby benefiting patients with heart failure.

Side Effects:

Hypotension, renal impairment/failure, anemia, pancreatitis, dry hacking cough .

Doses :

The usual starting dose of benazepril is 10 mg daily. If patients are taking a diuretic (water pill), the starting dose is 5 mg daily. Doses may be increased to 20-40 mg once daily or divided and administered twice daily.

Nursing Considerations:

First dose may cause severe hypotension. Monitor BP. First dose is to be administered at bedtime. Monitor blood levels of potassium. NSAIDS may reduce the effects .

03. Digoxin Lanoxin

Cardiac Glycosides

Digoxin increases the strength and efficiency of heart contractions and is useful in the treatment of heart failure. Digoxin increases the force of contraction of the heart muscle. Digoxin also slows electrical conduction between the atria and the ventricles of the heart.

Side Effects:

AV Block, severe bradycardia, ventricular arrhythmias, hallucinations.

Doses :

The usual starting dose is 0.0625-0.25 mg daily. The dose may be increased every two weeks to achieve the desired response. The usual maintenance dose is 0.125 to 0.5 mg per day.

Nursing Considerations:

Monitor serum potassium levels (3.5–5).Be cautious when administering to elderly people, children, and those who have had a post-myocardial infarction or who have an incomplete heart block.

04. Diltiazem Cardizem

Calcium Channel Blockers

It is used to treat angina, high blood pressure, and abnormal heart rhythms.

Side Effects:

Bradycardia, AV block, arrhythmias, hypotension, syncope, cardiac failure, hepatic injury.

Doses :

Adult oral: 120-540 mg/day Immediate release tablets are administered up to 4 times a day, while extended release tablets are administered once daily and should not be chewed or crushed.

Tablets (immediate release): 30, 60, 90, and 120 mg.

Tablets (extended release): 120, 180, 240, 300, 360, 420 mg.

Capsules (extended release): 120, 180, 240, 300, 360, 420 mg.

injection dose of 5 mg/ml. Powder for injection: 100 mg. Injectable Solution: 5, 10, 50, 125 mg/ml

Nursing Considerations:

Administration of diltiazem with digoxin can increase digoxin blood levels. Concurrent Administration of diltiazem with an anti-seizure medication like carbamazepine can increase blood levels of the seizure medication and occasionally lead to toxicity. Teach the client to avoid grapefruit juice.

05. Furosemide Lasix

Antihypertensives

Furosemide reduces vessel fluid volume and potassium wasting (3.5–5; normal K+). The diuretic effect of furosemide can cause the depletion of sodium, chloride, body water and other minerals.urosemide is a powerful diurectic that isused to treat excess accumulation of fluid and/or swelling (edema) of the body caused by heart failure, cirrhosis, chronic kidney failure, and the nephrotic syndrome.

Side Effects:

Hypokalemia, electrolyte imbalance, metabolic alkalosis, dehydration, ototoxicity

Doses :

The usual starting oral dose for the treatment of edema in adults is 20–80 mg as a single dose. The same dose or an increased dose may be administered 6–8 hours later. Doses may be increased to 20-40 mg every 6-8 hours until the desired effect occurs. The effective dose may be administered once or twice daily. Some patients may requires 600 mg daily.

Nursing Considerations:

Furosemide competes with aspirin for elimination in the urine by the kidneys.
Monitor serum electrolyte levels, assess hydration status, and change positions slowly (hypo orthostatic).

06. Hydralazine Apresoline

Vasodilators

They treat high blood pressure by lowering it and help to prevent strokes, heart attacks, and kidney problems. They work by relaxing blood vessels, allowing blood to flow more easily through the body.

Side Effects:

MI, neutropenia, blood dyscrasia, peripheral neuritis.

Doses :

Start with 10 mg four times daily for the first 2-4 days, then increase to 25 mg four times daily for the balance of the first week. For the second and subsequent weeks, increase the dosage to 50 mg four times daily. For maintenance, adjust the dosage to the lowest effective level.

Nursing Considerations:

They may produce reflex tachycardia or angina in clients with coronary artery disease. Monitor for sodium and water retention.

07. Lovastatin Mevacor

Statins

A cholesterol-lowering drug, by inhibiting an enzyme in the liver that is necessary for the production of cholesterol. In the blood, statins lower total cholesterol and low density lipoprotein (LDL) cholesterol ("bad"cholesterol) and triglycerides.

Side Effects:

Acute renal failure, pancreatitis, anaphylaxis, leukopenia (hard on the liver).

Nursing Considerations:

Asses total cholesterol, LDL, and HDL.Monitor liver function tests and avoid them in clients with liver disease or heavy alcohol consumption.

08. Milrinone Primacor

Phosphodiesterase Inhibitors

It is for the short-term treatment of CHF. It is given by injection into a vein.

Side Effects:

Ventricular arrhythmias, anaphylaxis, headache, chest pain, slight fever.

Doses :

0.375-0.75 mcg/kg/min intravenous .

Nursing Considerations:

Assess the serum potassium level. Monitor for dysrhythmias during IV administration and monitor for ventricular dysrhythmias.

09. Nitroglycerin Nitrostat

Nitrate

It corrects the imbalance between the flow of blood and oxygen to the heart and the heart's function by dilating (widening) the arteries and veins in the body. Dilation of the veins reduces the amount of blood

that returns to the heart so that the heart does less work and requires minimal blood and oxygen.

Side Effects:

Hypotension, bradycardia, and throbbing headache are all symptoms of severe hypotension.

Doses :

One tablet is allowed to be dissolved under the tongue or in the buccal pouch, 0.3-0.6 mg SL/min.

Nursing Considerations:

Monitor blood pressure frequently for hypotension, have the client lie down while taking medication to avoid falls or dizziness, and teach the client to take medication if they have chest pain.

10. Reteplase Retavase

Thrombolytics

Administered to resolve clots resulting in myocardial infarction or stroke, with quick restoration of circulation. Improvement of ventricular function following AMI

Side Effects:

Intracranial hemorrhage, severe bleeding, arrhythmias, anaphylaxis, and cholesterol embolism.

Doses :

Given by intravenous only, 10+10 unit double bonus injection-administered over 2 minutes where the second bolus is given 30 minutes after the initiation of the first bolus. Administered by itself with no other IV meds.

Nursing Considerations:

It must be administered within 12 hours of the onset of symptoms, and is best if administered within 4 hours. Monitor clients for bleeding. All clots are dissolved. Do not administer to clients who have fallen within the past 2 weeks.

Have you ever been through anything traumatic?

Reference :

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-Christina T. Mora

Best wishes

to

PERFIND 2K22

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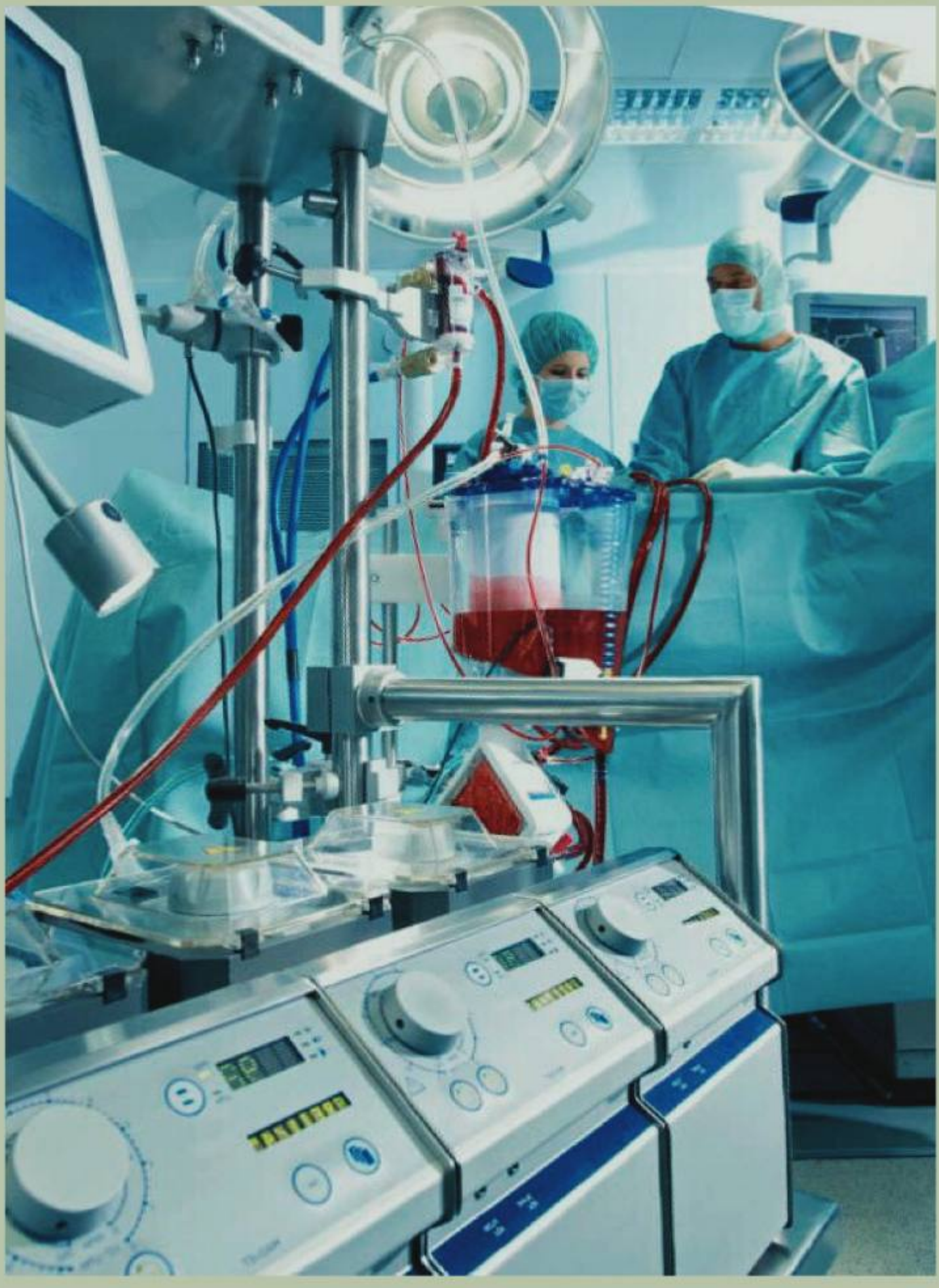

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