

ABSTRACT

USEFULNESS OF DEL NIDO CARDIOPLEGIA IN ADULT CARDIAC SURGERY

Del Nido cardioplegia is a type of cardioplegic solution widely used for complex congenital paediatric cardiac surgery. Its use in adult cardiac surgery is extended now. In our institute we are using it for various adult cardiac surgery patients for past one year. In this study 59 patients who underwent cardiac surgery using del Nido cardioplegia for achieving cardiac arrest, on observation it is effective for 60 to 80 minutes in maintaining arrest without spontaneous electrical activity need of frequent dose is less, surgery can be performed without work flow interruption. Recovery after cross clamp is smooth need for DC shock is very less, post-operative inotropic support were minimal and post-operative ECG and ECHO shows no evidence of perioperative ischemia. From our observation we conclude that it can be used safely in adult cardiac surgery patients also according to surgeon's preference.

Key words: Del Nido cardioplegia, myocardial protection, DC shock, cardio pulmonary bypass.

INTRODUCTION

Cardioplegic solution is the means by which the ischemic myocardium is protected from cell death. This is achieved by immediate and sustained electromechanical quiescence, rapid and sustained homogenous myocardial cooling, maintenance of therapeutic additives in effective concentrations and periodic washout of metabolic inhibitors.

Cardioplegia is an essential requisite for many of the more complex cardiac surgical procedures in which the heart must be stopped. It is an integral method of myocardial protection for patients of all ages requiring cardiac surgery. Effective myocardial protection remains the most important factor deciding on the outcome of the cardiac surgeries. Injury to myocardium must be avoided at any cost.

Introduction of cardioplegic solutions, beginning in the mid-1960s, in its numerous variations has found broad clinical application in the field of cardiac surgery. Due to variations in institutional experience and individual surgeon's preference the myocardial protection afforded by various cardioplegic solutions differs as its composition.

There are many cardioplegic solutions such as St. Thomas' Solution, Bretschneider Solution, University of Wisconsin Solution, Custodiol HTK, Celsior., del Nido. The only vital additive in most solutions is potassium chloride in a 20-30 mmol/L concentration range. Other additives such as mannitol, sodium bicarbonate, procaine are of secondary importance. In the early 1990s, del Nido cardioplegia, a formulation was developed by the team, led by Pedro del Nido, Hung Cao-Danh, K. Eric Sommers and Akihiko Ohkado researchers at the University of Pittsburgh originally for the paediatric and infant cardiac surgeries. Its use in the adult cardiac surgeries is expanding now.

Del Nido cardioplegia requires less frequent dosing and has potential benefits in adult cardiac surgery and minimally invasive valve surgery which include decreased workflow interruptions, shorter aortic cross-clamp and bypass times and has better myocardial protection.

Hence this study is an attempt to evaluate the usefulness of del Nido cardioplegia in adult cardiac surgery so as to ascertain the nature of myocardial protection afforded by it which is key element in the cardiac surgery.

AIMS AND OBJECTIVES

- To assess the usefulness of del Nido cardioplegia in adult cardiac surgery
- To evaluate the aortic crossclamp time and bypass time
- To evaluate whether use of del nido cardioplegia will reduce the need for defibrillation
- To assess the myocardial protection with the use of del Nido cardioplegia.

REVIEW OF LITERATURE

HISTORICAL PERSPECTIVES IN CARDIAC SURGERY

The first successful heart operation was performed by **Dr.Ludwig Rehn**, a surgeon in Frankfurt, Germany. 1.5cm gaping right ventricular wound was closed in diastole after the bleeding was controlled with finger pressure.

Dr.Luther Martin Hill was the first American who repaired cardiac wound successfully in a 13 year old boy, a victim of multiple stab wounds.

Matin Kirschner was the first person to report a case who recovered completely after undergoing pulmonary embolectomy.

John Gibbon found that only 9 out of 142 who had undergone procedures worldwide were alive after the procedure. This made him think about the work on pump oxygenator which could maintain circulation. He initiated the use of extracorporeal circulation in open heart surgery which made it obvious that aortic cross clamping is necessary for providing bloodless field during the repair of intracardiac defects.

As there are many controversies in the field of cardiac surgery, there are many controversies regarding who is the first person to think in terms of myocardial management and myocardial protection. **Lillehei** et al in 1956 devised the first special method known as retrograde coronary perfusion for surgery on the aortic valve.

Melrose et al introduced “elective cardiac arrest” by injecting 2.5% potassium citrate solution in warm blood into the aortic root after aortic cross-clamping. Development of severe myocardial necrosis was associated with this technique.

Cardiopulmonary bypass

Cardiopulmonary bypass is usually in cardiac surgery when the heart has to be arrested during surgery.

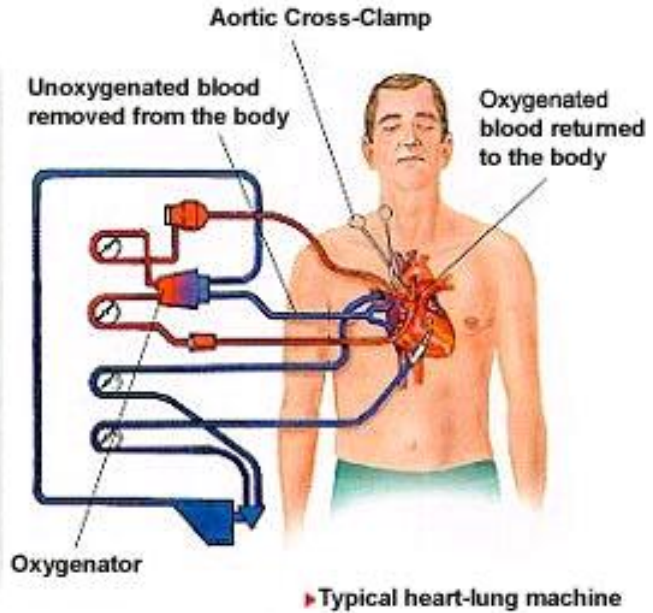


A heart lung machine in 1958

In 1926, the first heart lung machine was developed by **Sergei Brukhonenko** for total body perfusion. In the University of Minnesota Hospital, **Dr. Clarenc Dennis** and his team conducted the first operation, open cardiectomy with mechanical takeover of heart and lungs in April, 1951. The patient succumbed because of the congenital heart defect.

Forest Dewey Dodrill was the first person to use the mechanical support successfully for left ventricular function using a machine called as Dodrill-GMR .

John Gibbon on May 6, 1953 performed the first successful open heart procedure in a human heart, atrial septal defect closure in a 18 year old woman using the heart lung machine at Thomas Jefferson University Hospital in Philadelphia.



Heart lung machine at present

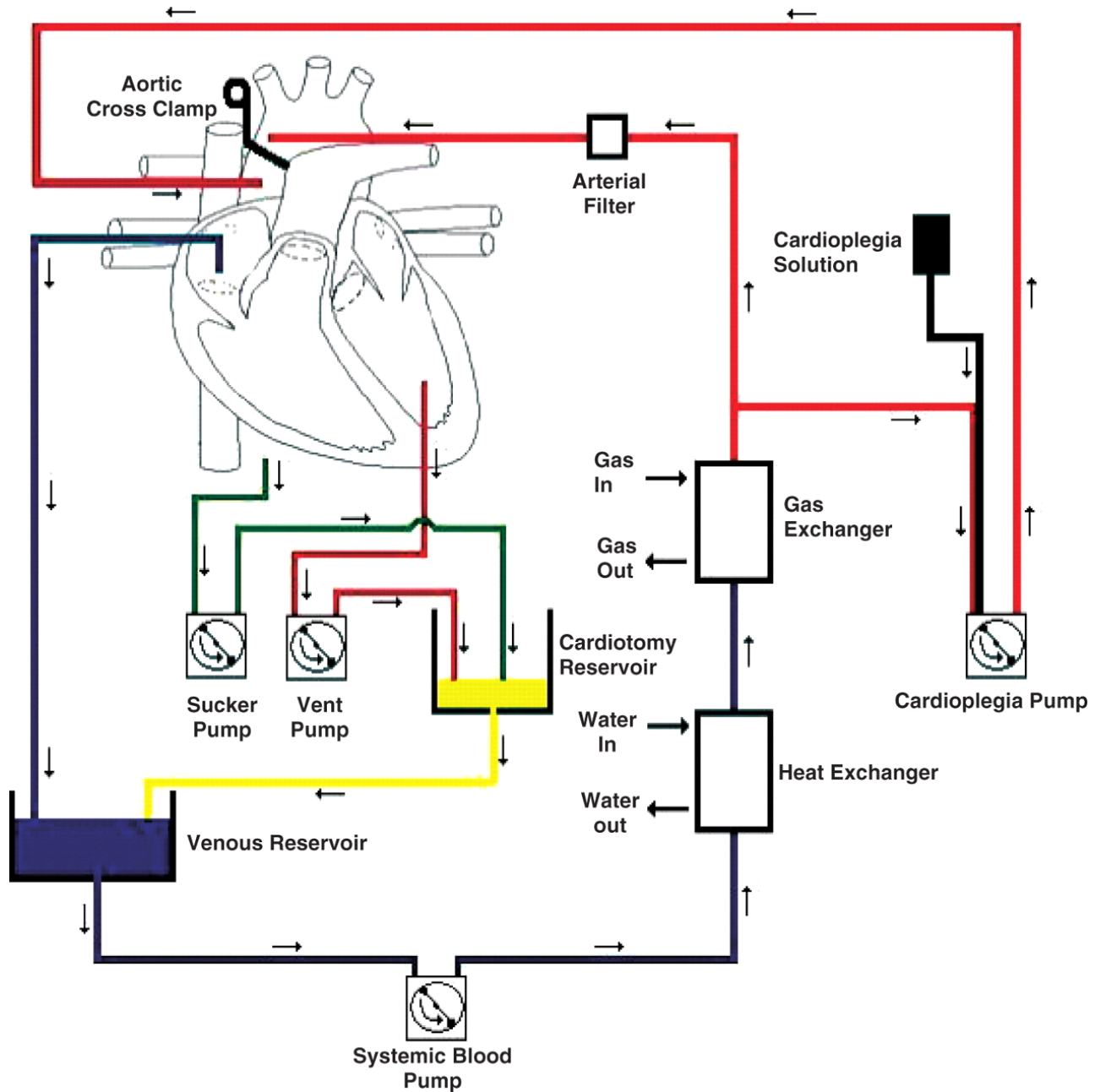


DIAGRAM SHOWING CARDIOPULMONARY BYPASS CIRCUIT

Oxygenators

In the 17th century, **Robert Hooke** was the first person to conceptualise oxygenator. In 19th century French and German physiologists developed practical extracorporeal oxygenators. Bubble oxygenators are direct contact oxygenators. In membrane oxygenators there is gas

permeable membrane which decreases the blood trauma of bubble oxygenators. Nowadays high performance microporous hollow –fibre oxygenators are present in cardiac theatres replacing the old oxygenators.

Myocardial protection

In 1883, antagonistic effects of calcium and potassium ions on cardiac contraction was described by **Ringer**.

Hooker reported the successful resuscitation of dogs with ventricular fibrillation by using potassium.

In 1930, **Wiggers** demonstrated that injections of potassium chloride was capable of arresting the heart in diastole and abrogating ventricular fibrillation. In addition he demonstrated the possibility of using calcium chloride and massage to revive the heart. **In 1960** – Normothermic ischemic arrest was advocated in uncomplicated cases with short ischemic periods. Stone heart syndrome was associated with the above said technique. Hence Intermittent aortic cross-clamping was attempted which involved the reperfusion of the coronary circulation for 5 minutes following 15minutes of ischemic arrest.

Later it became evident that intermittent reperfusion for normothermic ischemic periods up to 60 minutes has neither functional nor metabolic advantages. In spite of this Intermittent cross clamping with ventricular fibrillation continues to be used for coronary artery bypass surgery.

Fibrillatory arrest

Glenn, Sewell and Senning – to avoid air embolism electrically induced ventricular fibrillation with coronary perfusion. Subendocardial ischemia and necrosis was demonstrated by Buckberg et al and Hottenrott et al with this technique.

Continuous Coronary Perfusion

McGoon et al demonstrated that continuous coronary perfusion with a beating heart at normothermia or mild hypothermia at 32⁰C to prevent the onset of ventricular fibrillation. This technique is being used even today for complex aortic root surgery or for the special situations such as redo mitral valve surgery.

Hypothermia

Before the heart – lung machine came into scene, hypothermia was produced by surface cooling to protect the heart, brain and other organs during circulatory arrest.

Bigelow et al suggested the use of hypothermia as a form of anaesthesia to permit the surgeon to operate on a bloodless heart without recourse through extra corporeal pumps.

Shumway et al introduced profound local (topical) hypothermia, technique which involved the filling of pericardial sac with ice-cold saline. It is still used as an adjunct to other methods of myocardial protection.

Reintroduction of Cardioplegia

Bretschneider reported the principle using a low-sodium, calcium free solution to arrest the heart.

St.Thomas solution was developed by **Hearse** et al who studied the various components of cardioplegic solution. The components of this crystalloid solution is normal concentrations

sodium and calcium with the addition of potassium chloride (16mmol/L) and magnesium chloride (16mmol/L) to arrest the heart immediately.

In 1975, at St. Thomas Hospital, **Braimbridge** and colleagues introduced this solution in clinical practice.

Lower concentration of potassium chloride afforded the same degree of myocardial protection was demonstrated by **Gay and Ebert** experimentally.

In 1977, satisfactory protection in over 100 cardiac cases was demonstrated with potassium cardioplegia by **Tyres** et al.

The major controversy in 1980s was regarding the ideal composition of cardioplegic solution.

The chief variants at that time are

- Bretschneider solution – sodium, magnesium and procaine
- St. Thomas solution – Potassium, magnesium and procaine added to Ringer's solution
- Potassium-enriched solutions with no magnesium or procaine.

Blood cardioplegia was introduced coincidentally.

MYOCARDIAL PROTECTION

The goals of myocardial protection are

- To protect against ischemic injury
- To provide a motionless, bloodless field
- Allow effective post-ischemic myocardial resuscitation

CARDIOPLEGIA

Cardioplegia is a solution which contains a variety of chemical substances designed to

- Arrest the heart in diastole rapidly
- Create quiescent operating field
- Provide reliable protection against ischemia – reperfusion injury

Principles of Cardioplegic Protection

Arrest

Rapid and effective induction of arrest in diastole. To keep the heart arrested in relaxed state and to minimise the use of intracellular ATP.

Myocardial protection

To limit the reperfusion injury and to delay the occurrence of irreversible injury.

Reversibility

Prompt recovery of normal cardiac function from the effect of cardioplegia

Low toxicity

No toxic effects on other organs

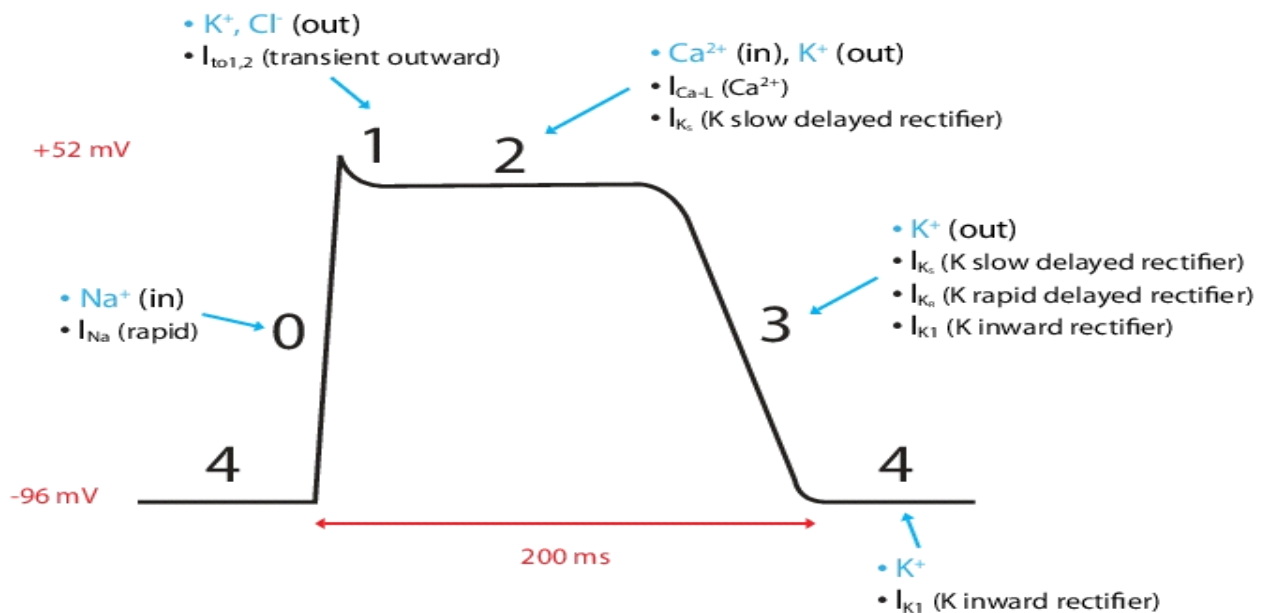
Mechanism of action of Cardioplegia

In most of the cardioplegic solutions, the high potassium concentration present decreases the resting membrane potential of cardiac cells. The normal resting membrane potential of ventricular myocyte is approximately -90mv. The channels which are present in the cell membrane has been tabulated as given below

PHYSIOLOGY OF ION CHANNELS PRESENT IN A CARDIAC MYOCYTE			
Current	Channel	Gating mechanism	Functional role
i_{K1}	K^+ channel (inward rectifier)	Voltage gated channel	Maintains high K^+ permeability during phase 4 Its decay contributes to diastolic depolarization Its suppression during phases 0 to 2 contribute to plateau
i_{Na}	Na^+ channel (fast)	Voltage gated channel	Accounts for phase 0 of action potential Inactivation may contribute to phase 1 of action potential
i_{To}	K^+ channel (transient outward)	Voltage gated channel	Contributes to phase 1 of action potential
i_{Ca}	Ca^{2+} channel (slow inward, L channels)	Voltage gated channel	Primarily responsible for phase 2 of action potential Inactivation may contribute to phase 3 of action potential Is enhanced by sympathetic stimulation and -adrenergic agents
i_K	K^+ channel (delayed rectifier)	Voltage gated channel	Causes phase 3 of action potential May be enhanced by increased

i_{KATP}	K ⁺ channel (ATP-sensitive)	Ligand gated channel	intracellular Ca ²⁺ Increases K ⁺ permeability when [ATP] is low
i_{KACH}	K ⁺ channel (acetylcholine-activated)	Ligand gated channel	Responsible for effects of vagal stimulation Decreases diastolic depolarization (and heart rate) Hyperpolarizes resting membrane potential Shortens phase 2 of the action potential
i_f ("funny")	Na ⁺ channel (pacemaker current) Both		Contributes to the diastolic depolarization Is enhanced by sympathetic stimulation and -adrenergic agents Is suppressed by vagal stimulation

Relationship Between Cardiac Action Potential and Ion Channel Currents



When the blood surrounding the cardiac myocytes are being replaced by a cardioplegic solution with high potassium concentrated solution prevents repolarisation. The cardiac myocyte are inexcitable to ordinary stimuli by raising the potassium concentration to 16.6mmol/l raises the resting membrane potential to -60mv.

The other cations Na^+ and Ca^{2+} , can be used to cause cardioplegia. However the removal of Na^+ ions will not let the action potential to occur but at the same time the resting membrane potential will not be altered. Removal of extracellular Ca^{2+} results in a cardiac arrest in diastole due to decrease in heart's contractility. Stone heart or rigor will result when the Ca^{2+} concentration is elevated.

Types of cardioplegia

- Crystalloid cardioplegia
- Blood cardioplegia

Crystalloid cardioplegia

It was introduced with the aim to provide cardioprotection and to provide a bloodless field to the surgeons. The ingredients varies in different solutions and rationale is behind these ingredients is

- Rapid induction of cardiac arrest
- Conservation of intracellular ATPs
- Maintain intracellular homeostasis
- Reduce myocardial oxygen consumption

- Enhance energy production by both aerobic and anaerobic pathway
- Stabilisation of pH using buffers
- Hypocalcemic environment and adding magnesium
- Addition of mannitol to maintain normal oncotic pressure and to prevent cellular edema

Types of crystalloid cardioplegia

- Intracellular type
 - Absent or low concentration of sodium and calcium
- Extracellular type
 - Higher concentration of sodium, calcium and magnesium

Cold blood cardioplegia

This cardioplegia uses blood as a vehicle for hypothermic potassium – induced cardiac arrest. Basis for using blood is

- It provides an oxygenated environment
- Intermittent reoxygenation during cardiac arrest
- Limits hemodilution
- Buffering capacity is better than crystalloid cardioplegia

- Presence of endogenous antioxidants and free-radical scavengers

Formulation:

Combining autologous blood in extracorporeal circuit with the crystalloid cardioplegic solution that contains citrate – phosphate – dextrose, tris-hydroxymethylaminomethane or bicarbonate and potassium chloride. Rapid arrest is by initial induction followed by intermittent or continuous infusion. Ratio of blood to crystalloid varies among centres from 8:1, 4:1, and 2:1.

Miniplegia

Use of undiluted blood cardioplegia is called as miniplegia.

Petrucci and his colleagues studied the use of blood miniplegia in comparison with crystalloid cardioplegia and concluded that use of blood miniplegia is superior in acutely ischemic heart.

Velez and colleagues found that an all blood cardioplegia with ratio of 66:1 is superior to 4:1 blood cardioplegia delivered in a retrograde fashion

Rousou et al. found that it is the level of hypothermia that is important and not necessarily the haematocrit.

Many studies indicate the fact that cold blood cardioplegia is superior to cold crystalloid cardioplegia. Contrary to the abovesaid fact there are studies which have shown that crystalloid cardioplegia offers better cardioprotection compared with that of blood cardioplegia and it is said to be cost effective.

In 2006, Guru and his colleagues reported a lower incidence of low cardiac output syndrome and CK-MB release in patients with cold blood cardioplegia in comparison with crystalloid cardioplegia.

An analysis of clinical data by Jacob et al. showed 8 trials favouring blood cardioplegia and 5 showed significant differences favouring one over the other.

Warm Blood Cardioplegia

In 1982, Rosenkranz et al reported that induction with normothermic warm blood cardioplegia which was then supplemented with multidoses of intermittent cold blood cardioplegia was found to be better cardioprotective than cold blood cardioplegia.

Teoh et al in 1986 came up with an experimental evidence that warm blood cardioplegia just before removing the cross clamp was more cardioprotective than other methods.

In 1991, **Lichtenstein** and colleagues reported that normothermic blood cardioplegia is an effective cardioprotective approach in humans.

Tepid blood cardioplegia

Hayashida et al as attempt to find an optimum temperature as there were many advantages and disadvantages for both warm and cold cardioplegia, found specifically efficient tepid blood cardioplegia at 29°C. In this study 72 patients undergoing CABG were randomly assigned to receive either antegrade or retrograde warm cardioplegia at 37°C or antegrade or retrograde cold cardioplegia at 8°C or antegrade or retrograde tepid cardioplegia at 29°C. The myocardial protection afforded by the three were equivocal whereas tepid antegrade cardioplegia was effective in reducing lactate release by anaerobic glycolysis.

Though there are many single centred studies supporting the use of tepid blood cardioplegia but long term study with more number of subjects is yet to come for the proof of it to be the most effective.

Type of cardioplegia	Advantages	Limitations
Crystalloid	Inexpensive Availability Simplicity	Large volume of crystalloid No buffering or oxygen carrying capacity
Blood	Presence of blood buffers Presence of antioxidants Oxygen carrying capacity	Complex procedure and cost
Technique	Advantages	Limitations
Microplegia	Large volume but minimal crystalloid Ability to modify and quantify the additives	Complex procedure

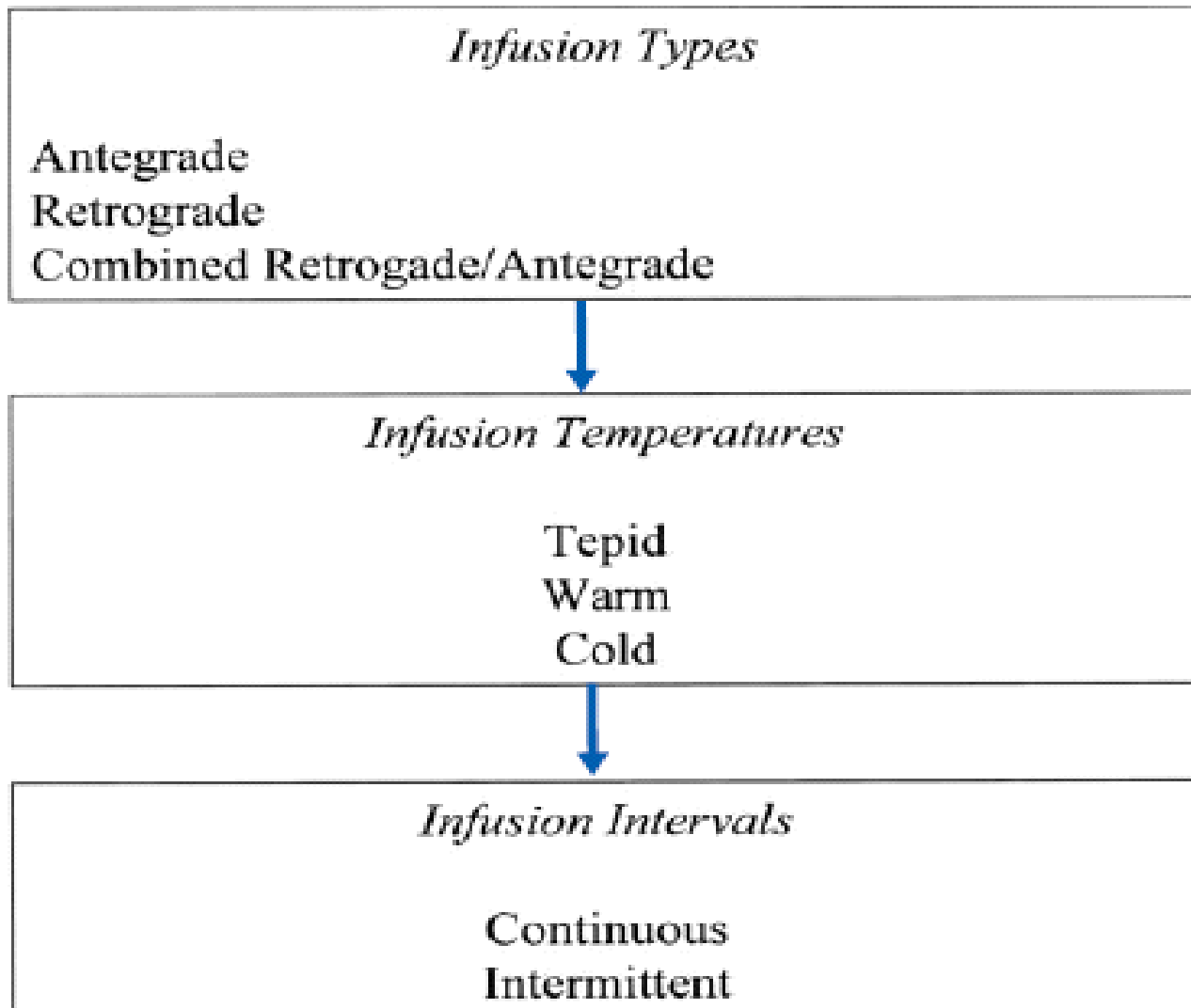
Methods of delivery

As there are many controversies in the temperature there are controversies in the method of delivery too. The various methods by which it can be delivered are as follows

- Intermittent antegrade
- Antegrade via the graft

- Continuous antegrade
- Continuous retrograde
- Intermittent retrograde
- Antegrade followed by retrograde
- Simultaneous antegrade and retrograde

All these methods are equally good and the comparison is a cumbersome process with numerous confounding factors such as composition and temperature of the cardioplegia, duration of infusion, pressure at which the infusion is delivered, type and complexity of the surgical method, the expected aortic cross clamp time.



Retrograde technique is the most frequently used method of delivery. In 1898, Pratt showed that ischemic myocardium could be supplied with oxygenated blood via coronary venous system. Retrograde coronary sinus perfusion was used by Lillihei and his colleagues for aortic valve surgeries 60 years later.

The advantages of retrograde cardioplegia are

- Aortic root and valve surgery

- Decreased risk of embolization from the saphenous grafts
- Continuous delivery of cardioplegia

The limitations of retrograde cardioplegia is that there is heterogeneity in the distribution of cardioplegia due to the variations in the anatomy of coronary sinus morphology and the fact that right ventricle is not drained by coronary sinus.

Inhken et al reported the feasibility and safety of administering both antegrade and retrograde cardioplegia. Sonicated albumen and transesophageal echocardiography was done intraoperatively by Cohen and colleagues and they demonstrated that anterior left and right ventricles were perfused in a simultaneous technique using both routes of administration.

Cardioplegia delivery techniques

Technique	Advantages	Limitations
Antegrade	<ul style="list-style-type: none"> • Simple • Resembles normal coronary flow 	<ul style="list-style-type: none"> • Aortic valve must be competent • Advanced CAD
Retrograde Through conduits	<ul style="list-style-type: none"> • Can be preferred in aortic insufficiency and advanced CAD • Does not impede the conduct of case • Augments deairing • Allows antegrade protection of areas of CAD • Obviates limitations from aortic insufficiency and advanced CAD • Allows delivery without need to 	<ul style="list-style-type: none"> • Placement of catheter is difficult • Complex • Conduits are required • Complex • Right coronaries are not perfused properly

	pressurise aortic root or interrupt surgery	
Integrated	<ul style="list-style-type: none"> • More uniform distribution of cardioplegia 	<ul style="list-style-type: none"> • Complexity

In comparison with the intermittent and continuous method of administration, intermittent has the ability to achieve and sustain a quiescent heart preoperatively. The continuous system has an advantage of reducing ischemia if it is oxygenated.

Technique	Advantages	Limitations
Intermittent	<ul style="list-style-type: none"> • Improved exposure • Lower cardioplegia volume 	<ul style="list-style-type: none"> • Increased interdose myocardial acidosis
Continuous	<ul style="list-style-type: none"> • Normal perfusion • Increased postoperative LV performance • Decreased postoperative inotropic requirement 	<ul style="list-style-type: none"> • Operative field will not be dry • Complex

Cardioplegia additives

Nicorandil

Potassium has a deleterious effect to the coronary vascular endothelium. Nicorandil, an adenosine triphosphate sensitive potassium channel opener K_{ATP} . The advantages of using nicorandil are as follows

- Selective K_{ATP} channel opener, cardiac arrest is achieved with minimal dose of cardioplegia.
- Protective against peroperative coronary vasospasm
- Preconditioning agent.

Hayashi and colleagues demonstrated that when people received multiple doses of nicorandil, they required less doses of cardioplegia. They were also found to recover spontaneously and less postoperative segmental S-T changes. They had lower levels of malondialdehyde, creatine kinase band and required less doses of catecholamines postoperatively.

L-Arginine

L-Arginine is a nitric oxide donor.

Carrier and his colleagues were able to demonstrate that with the use of L-Arginine, the enzyme released by myocardium was found to be reduced.

Reduction in the levels of postoperative myocardial enzymes and post operative cytokine release were noted by Colagrande et al.

Insulin

Insulin is added as adjunct to cardioplegia to improve the myocardial performance.

Infusion of insulin-glucose-potassium solutions to mitigate the infarct changes in the myocardium.

Rao et al in their randomised control study conclude that insulin enhanced cardioplegia is not superior in providing myocardial protection compared to the noninsulin preparations

CARDIOPLEGIC ADDITIVES

Additive	Advantages	Limitations
Nicorandil	<ul style="list-style-type: none">• Requirement of less cardioplegia• Requirement of less potassium chloride• Decreased perioperative coronary vasospasm• Preconditioning agent• Reduction in the dosages of postoperative catecholamines	<ul style="list-style-type: none">• Cost
L-arginine	<ul style="list-style-type: none">• Decreased myocardial enzyme release	<ul style="list-style-type: none">• Cost• Complexity

	<ul style="list-style-type: none"> • Decreased postoperative cytokine levels • Decreased pulmonary artery wedge pressure 	
Insulin	<ul style="list-style-type: none"> • Some studies document improvement in myocardial performance 	<ul style="list-style-type: none"> • Complexity • Efficacy not clear

DAMAGE FROM GLOBAL MYOCARDIAL ISCHEMIA

There are substantial evidence stating that ischemic injury can result irreversible damage known as myocardial necrosis when there is ischemia as little as 20 minutes to the subendocardium. Studies have also indicated heterogeneity in the behaviour of the myocardial cells to ischemia in their ability to switch from aerobic to anaerobic metabolism.

Global myocardial ischemia is a term used to describe a situation when the aorta is clamped and the myocardium is devoid of blood supply except minimally from non-coronary source.

MYOCARDIAL STUNNING

Prolonged period of both systolic and diastolic dysfunction without muscle necrosis is myocardial stunning. Duration may vary from minutes to days. It may be related to incomplete

reperfusion of microvasculature. They respond well to inotropics indicating the presence of ATPs. It may be due to the injury caused by free-radicals which could be averted by use of free-radical scavengers.

MYOCARDIAL HIBERNATION

It is a condition in which both perfusion and contraction are low. Here it is a segmental contractile dysfunction which is chronic in nature. It is due to a decrease in calcium ion transients at a cellular level.

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DEL NIDO CARDIOPLEGIA

History of del Nido cardioplegia

Initially, cardioplegia was the same for adults, infants and paediatric patients. The flow, volume and pressure were adjusted in accordance to the body weight appropriately. St. Thomas cardioplegia solution was used widely in 1980 and 1990 and is still being widely used. Researchers at the University of Pittsburgh felt the need for a cardioplegic solution specific for the paediatric and infant cardiac patients especially to address the needs of an immature heart.

There were many contradictions described reporting that an immature heart is both better tolerant than an adult heart and less tolerant to ischemia than an adult heart. There were contradictions regarding the use of St. Thomas solution also with some studies reporting that

there is no difference between the adult and paediatric heart and some presenting with the fact that it is ineffective. Further it was shown experimentally that the neonatal heart behaved differently from an adult to a n ischemic insult while other experimental studies concluded that there was no such difference noted between the adult and paediatric heart.

The above listed contradictions were partly attributed that most of the experiments were done in animal models which when transformed into reality had totally a different scenario.

Supportive theory for the development of del Nido cardioplegia

High energy phosphates, maintenance of intracellular ionic and cell membrane homeostasis is the basis for normal contractile function of myocardium. This contributes for the aerobic metabolism within the cell. Disruption of this intracellular homeostasis leads to cardiac ischemia and irreversible damage to myocardium if the insult ensues.

During the arrest period, promotion of anaerobic glycolysis, oxygen free- radicals handling intracellularly and prevention of intracellular accumulation of high amounts of calcium should be limited or prevented per se in order to preserve the function.

Cardioplegic solutions usually create a metabolic arrest coupled with hypothermia. The main advantage of using high concentrations of potassium usually to cause myocardial arrest is simplicity and rapid onset of action. Further it was realised that hyperpolarised cell has lower metabolic demands and has found to have lower accumulation of intracellular calcium ions. Polarising agents such as procaine, lidocaine was used along with magnesium which competes with calcium. Red blood cells were added in varying proportions to release oxygen and energy during that ischemic episode.

This del Nido cardioplegia has been prepared with a protocol keeping all the issues above said in mind and to address the needs of immature myocardium.

Crystalloid component of del Nido cardioplegia solution

1 L plasma – Lyte A Base solution to which the following things are added	
Mannitol 20%	16.3ml
Magnesium sulphate 50%	4ml
Sodium bicarbonate 8.4%	13ml
Potassium chloride(2mEq/L)	13ml
Lidocaine 1%	13ml

Base solution of Plasma-Lyte A

Base solution in del Nido cardioplegia is Plasma-Lyte A. It has electrolyte composition as follows:

Name of the electrolyte	Concentration of the electrolyte
Sodium	140 mEq/L
Potassium	5 mEq/L
Magnesium	3 mEq/L

Chloride	98 mEq/L
Acetate	27 mEq/L
Gluconate	23 mEq/L

pH of the solution is 7.4 which is identical to that of plasma.

This crystalloid component is mixed with the blood in the ratio of four parts of crystalloid to one part of blood which is fully oxygenated patient whole blood.

Though there is no calcium in the base solution, final calcium concentration of calcium ion in the cardioplegia is found to be traces as there will be calcium in the blood which is being added. This is found to be beneficial and better than without calcium or normal levels of calcium.

Mannitol

Myocardial injury may occur either during cardioplegic arrest or during subsequent reperfusion. This may be partly due to the oxygen- free radicals such as superoxide anion, hydrogen peroxide and hydroxyl ion. This will be dealt by the intracellular enzymatic anti-oxidant systems which will nullify the destructive effect of the free radicals, but they are inhibited by the myocardial arrest. Myocardial edema has also been noted. Hence in order to counteract both i.e., intracellular edema and scavenge the free radicals, mannitol has been added. In Boston's Hospital where del Nido was formulated and used in paedric cases, 0.5g/Kg mannitol is delivered to the bypass circuit shortly before the removal of the cross clamp.

Magnesium Sulfate

Intracellular calcium concentration is a major factor in relation to myocardial contractility. On the other hand if calcium accumulates intracellularly relaxation of myocardium will be interrupted, hence magnesium is added to the cardioplegic solution which is an effective natural blocker of calcium channels.

Sodium bicarbonate

Anaerobic metabolism has to be supported during the period of cardiac arrest. This metabolism i.e., anaerobic glycolysis will be inhibited in the presence of excess of hydrogen ions. Sodium bicarbonate which is present in the del Nido cardioplegia will perform the role of scavenging the excess hydrogen ions and it will help in promoting the anaerobic metabolism as well as in maintaining the intracellular pH.

Red blood cells have carbonic anhydrase which will be exchanging hydrogen ions for bicarbonate and produce carbon dioxide and water. This role of red blood cells is very important.

Potassium chloride

Rapid arrest and reliable recovery will be produced by hyperkalemia but it has its own limitations. The myocardial arrest has been done in a depolarised state which will lead to accumulation of intracellular sodium and calcium. Lidocaine is found to inhibit the above said mechanism and it is found to prolong the period of electromechanical quiescence.

Potassium level in del Nido cardioplegia is found to be 24 mEq/L.

$(0.8 \text{ crystalloid component}) \times (26 \text{ MEQ added } K^{+*} + 5 \text{ mEq** Plasmalyte } K^{+}) + (0.2 \text{ blood component})(4.5 \text{ mEq/l } K^{+***}) = 24 \text{ mEq/l } K^{+}$.

* Potassium added to the plasmalyte base solution 13 ml or 26mEq. Total solution

volume 1059ml

** 5mEq is the potassium concentration in the plasmalyte base solution used to formulate the del Nido solution.

*** 4.5mEq/L is an estimate of the patients serum potassium level

Lidocaine

It is classified as a sodium channel blocker which is usually as an antiarrhythmic. It increases the refractory period of the cardiac myocyte. When cardioplegia is given in an ideal environment without washout, the action of lidocaine is prolonged. It prevents the intracellular accumulation of sodium and calcium. In 2009, study by O'Brien and his colleagues showed that del Nido cardioplegia reduced calcium intracellularly. Hence del Nido cardioplegia because of the properties of lidocaine and magnesium, can called as modified depolarising agent.

Patient blood Additive

20% by volume fully oxygenated patient blood is added to del Nido cardioplegia which is being delivered. This supports aerobic metabolism for a finite period of time. It

provides buffering for the anaerobic metabolism as well. Blood is found to improve the coronary perfusion during cardioplegia delivery. It preserves the myocardial metabolism as well as it myocyte function. It results in less ischemic stress and reperfusion injury.

The cardioplegia haematocrit can be calculated as follows

Blood component haematocrit x 20% portion

The delivery haematocrit of del Nido cardioplegia if the 20% blood portion has a haematocrit of 30% is 6%.

Hypothermia

Hypothermia decreases oxygen requirement of cardiac myocyte. The delivery method of del Nido cardioplegia is usually between 8-12°C.

Cardioplegia protocol in Boston's Children Hospital

- Recirculating system of cardioplegia is being used in Boston Children's Hospital.
- This system has no direct connection with the bypass circuit and it does not draw blood from it directly.
- The system has a dead space volume of just 1ml.
- This is an important design consideration.
- The dead space volume may be equal to significant amount of delivery dose when harbouring poorly mixed and room temperature cardioplegia solution.

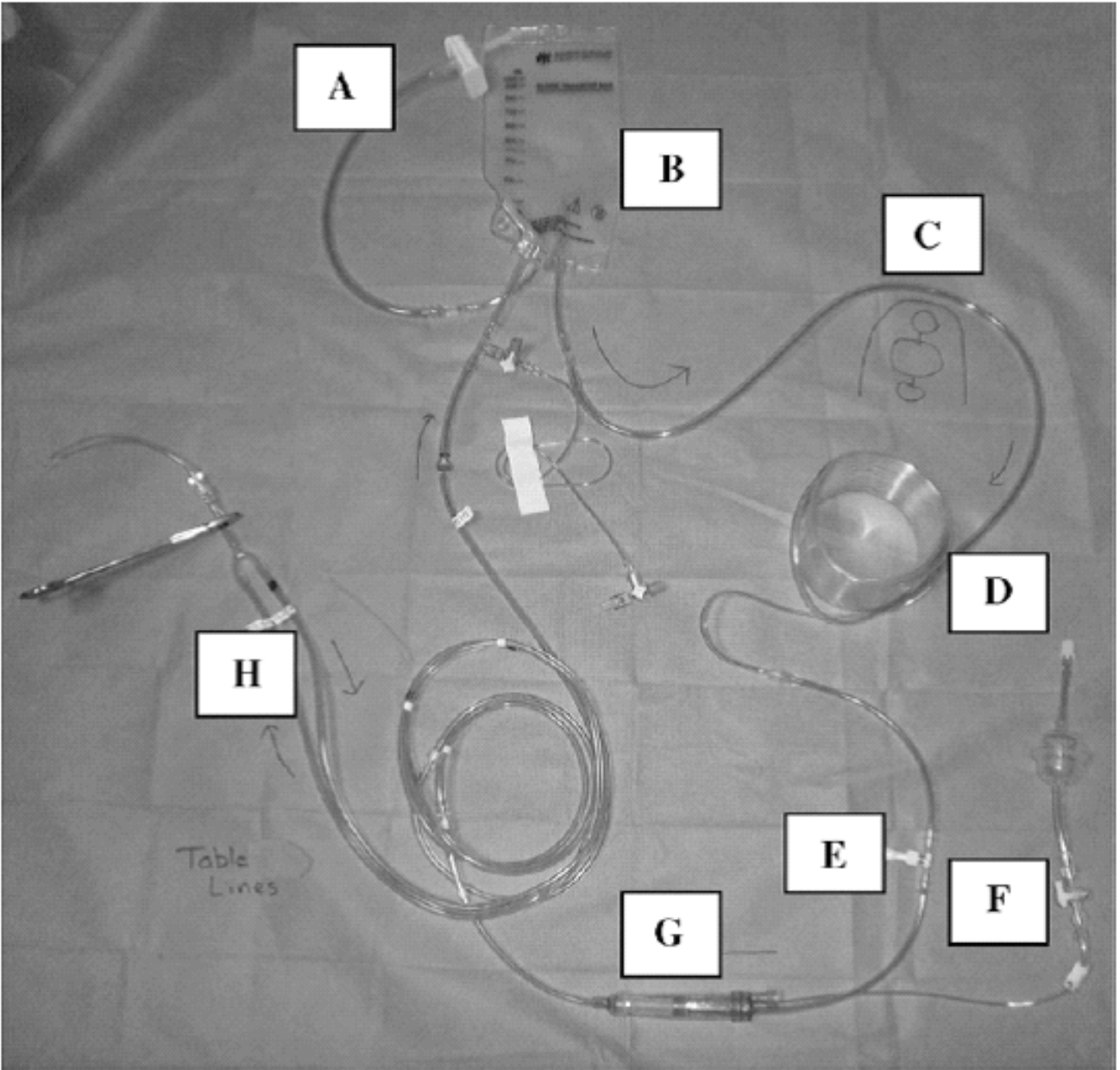


Figure 1. (A) Cardioplegia bag connection line with an integral .2- μ m crystalloid filter. (B) Cardioplegia reservoir. (C) Pump loop. (D) Cooling coil. (E) Temperature monitoring site. (F) Pressure monitoring site. (G) Bubble trap with an integral 270- μ m filter. (H) Sterile field table lines shown connected to circuit.

Custom disposable tubing set used in Boston’s children hospital consists of the following

- Cardioplegia bag connection line with 0.2 μ m crystalloid filter
- Cardioplegia reservoir
- Pump loop
- Cooling coil
- Temperature monitoring site
- Pressure monitoring site
- Bubble trap with an integral 270 μ m filter
- Delivery is through 14Fr or 18Fr aortic root needle

Retrograde coronary sinus cardioplegia is being used. 125 ml prime for the entire cardioplegia circuit is used. 25 ml is present in the cardiac reservoir which totals to 150ml.

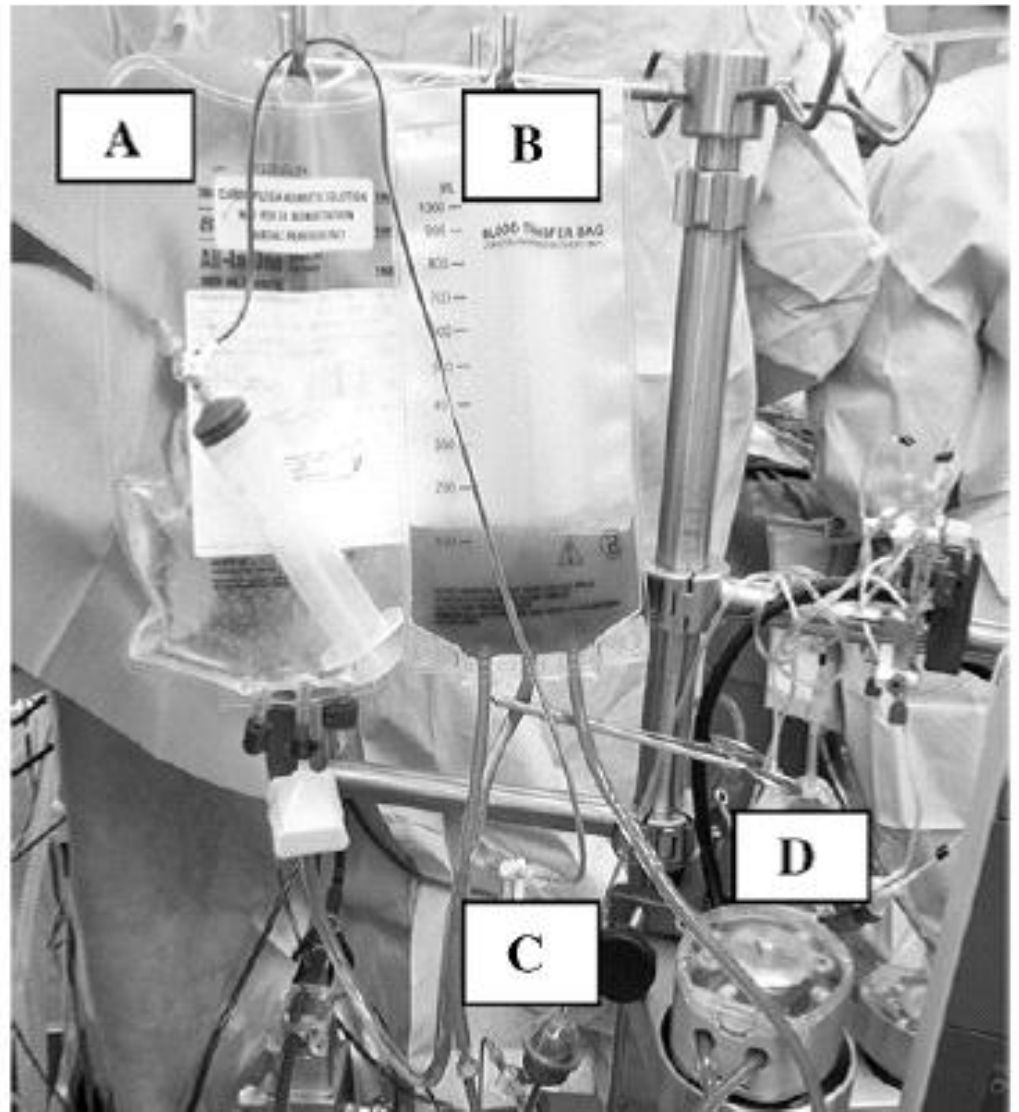


Figure 2. (A) Cardioplegia bag with crystalloid component as prepared by pharmacy. (B) Cardioplegia reservoir bag where the 4:1 (crystalloid:blood) components are mixed and recirculated. (C) Stopcock, line, and syringe used to inject bypass circuit blood into the cardioplegia line. (D) Cardioplegia roller head.

Dose

- Usually given as a single dose as 20 ml/kg usually limited to 1l for patients larger than 50kg
- Additional volume has to be supplemented for hypertrophied hearts such as aortic insufficiency or known case of coronary disease or surgeon preference
- Subsequent doses very rarely given which is subjected to surgeon's discretion.
- Four parts of crystalloid to be mixed with 1 part of patient's blood correctly
- $20\text{ml/kg body weight} = \text{total cardioplegia dose(A)}$
- $\text{Total cardioplegia dose(A)} + 150\text{ml} = \text{total dose}$
- $\text{Total dose}/5 = \text{amount of blood to be added(B)}$
- $(\text{Total cardioplegia dose(A)} + 25\text{ml minimal reservoir volume}) - (\text{B blood component volume}) = \text{Crystalloid cardioplegia volume(C)}$ in the reservoir before the addition of blood that will result in the proper 4:1 mixture
- The perfusionist will have the proper dose amount, recirculating volume C in the reservoir before bypass and then adding volume (B) of the patient whole blood once on bypass.

Delivery

- It is initiated by the surgeon's removal of the clamp on the table lines from the outlet limb
- Flow is controlled by the perfusionist.

- 20ml/kg is given over a period of 1-2minutes with a system pressure of 100-200mmHg
- Cardioplegia flow is adjusted from the initial flow based on the observation of the surgeon regarding the heart and electrical activity.

O'Blenes and colleagues experimentally showed that del Nido cardioplegia results in lowering of intracellular calcium during myocardial arrest and less frequent spontaneous contractions in senescent rat heart models.

Charette and his colleagues published a retrospective study which showed no significant differences in postoperative complications with del Nido cardioplegia with their routine multidose cardioplegia.

Though significant progress has been made in every possible step in the cardiac surgery there are many things yet to be discovered such as an ideal cardioplegic solution, techniques and delivery methods. The lacunae or the controversies are in part due to the complex nature of the behaviour of the myocardium in response to ischemia and reperfusion injury. The studies usually do not take into consideration the long term morbidity factors such as the manifestations in the cardiac function may take years to appear.

MATERIAL AND METHODS

This prospective study was undertaken in Department of cardiothoracic surgery, Rajiv Gandhi Government General Hospital, Madras Medical College, Chennai after obtaining consent from the Institutional Ethics Committee, Madras Medical College Chennai.

Adult Patients undergoing cardiac surgery using del Nido cardioplegia during the study period was studied for the usefulness of del Nido cardioplegia.

Inclusion Criteria

All patients undergoing Adult cardiac surgery using del Nido cardioplegia during the study period in the age group of 15 – 60 years

Exclusion Criteria

Patients with evidence of

- Age more than 60 years

In patients more than 60 years of age there will be coexistence of other confounding factors such as comorbid conditions which would affect the outcome of surgery.

- Coronary Artery Disease

In patients with coronary artery disease, previous injury to the myocardium due to ischemia or infarction can alter the outcome of surgery.

- Poor LV function

Patients with poor left ventricular function will have lower myocardial reserve.

- Hepatic or renal failure

Methodology

The preoperative, peroperative and postoperative details of the patients enrolled for the study were collected personally by the investigator.

The following parameters were taken into consideration during the study

- Name, age and sex of the patient
- NYHA classification preoperatively and postoperatively
- Cardiopulmonary bypass time
- Number of del Nido cardioplegic dosages administered during surgery
- Assessment of total aortic crossclamp time
- Requirement of DC shock - Whether required or not
- Postoperative ventilator support – Duration of support
- Postoperative inotropic support

- Postoperative duration in ICU
- Postoperative ECHO – Done after 5th postoperative day
- Total duration(days) postoperatively
- Mortality(if any) – Cause was evaluated with respect to technical reasons or postoperative low cardiac output which was assessed in terms of myocardial protection.

Statistical Analysis

Appropriate statistical analytical methods were used.

RESULTS

In this study dealing with “Usefulness of del Nido cardioplegia in adult cardiac surgery”, the details which were observed during the course of the study are summated and given below.

AGE:

AGE IN YEARS	NO. OF PATIENTS ENROLLED FOR THE STUDY
less than 20	5
20- 40	27
40 - 60	27
Total	59

The patients enrolled for the study included 5 patients less than 20 years of age , 27 each belonging to 20 – 40 years age group and 40 – 60 years age group respectively.

SEX:

SEX	NO. OF PATIENTS ENROLLED FOR THE STUDY
MALE	29
FEMALE	30

29 male patients and 30 female patients were enrolled for the study.

VALVULAR HEART SURGERIES PERFORMED USING DEL NIDO CARDIOPLEGIA

VALVULAR HEART SURGERIES	NO. OF SURGERIES
--------------------------	------------------

PERFORMED	PERFORMED
AVR	8
DVR	14
MVR	37
MVR,OTV	1

NEED FOR DEFIBRILLATION

Out of 59 valvular heart surgeries performed using del Nido cardioplegia, the need for defibrillation was found only in 5 cases. Amongst the 5 cases, 4 were aortic valve replacement and 1 was double valve replacement surgery.

NEED FOR DEFIBRILLATION

NEED FOR DEFIBRILLATION AMONGST VALVULAR HEART SURGERIES

CARDIOPULMONARY BYPASS DURATION WHILE USING DEL NIDO CARDIOPLEGIA

VALVULAR HEART SURGERY	MEAN CPB DURATION(MIN)
MITRAL VALVE REPLACEMENT	128
AORTIC VALVE REPLACEMENT	182
DOUBLE VALVE REPLACEMENT	217

The mean cardiopulmonary bypass duration for mitral valve replacement, aortic valve replacement and double valve replacement using del Nido cardioplegia is 128minutes, 182 minutes and 217 minutes respectively.

AORTIC CROSS CLAMP TIME FOR VALVULAR HEART SURGERIES USING DEL NIDO CARDIOPLEGIA

VALVULAR HEART SURGERY	MEAN AORTIC CROSS CLAMP TIME(MIN)
MITRAL VALVE REPLACEMENT	80
AORTIC VALVE REPLACEMENT	93
DOUBLE VALVE REPLACEMENT	155

The mean aortic cross clamp time while using del Nido cardioplegia for mitral valve replacement, aortic valve replacement and double valve replacement is 80 minutes, 93 minutes and 155 minutes respectively.

Number of doses of del Nido cardioplegia during valvular cardiac surgery

VALVULAR HEART SURGERY	NO. OF DOSES OF DEL NIDO CARDIOPLEGIA
MVR	1.3
AVR	1.5
DVR	2.61

The mean number of doses of del Nido cardioplegia required for adult valvular cardiac surgeries such as mitral valve replacement, aortic valve replacement and double valve replacement is 1.3, 1.5 and 2.61 respectively.

POSTOPERATIVE ICU STAY:

VALVULAR HEART SURGERY	MEAN POSTOPERATIVE ICU STAY
MVR	2 DAYS
AVR	3 DAYS
DVR	4 DAYS

The mean postoperative ICU stay is 2 days, 3days and 4 days for Mitral valve replacement, aortic valve replacement and double valve replacement respectively

POSTOPERATIVE ECG:

Postoperatively ECG did not show any evidence of peroperative ischemic insult such as development of Q wave or any other significant changes consistent with the development of cardiac ischemia.

POSTOPERATIVE ECHO:

No Regional wall motion abnormality was detected in postoperative cases which indicates a good myocardial protection.

MORTALITY:

Out of 59 cases in which del Nido cardioplegia was used as an agent to arrest the heart while on cardiopulmonary bypass, 7 deaths were noted. The cause of death in all the 7 cases were primarily not attributed to use of del Nido cardioplegia.

DISCUSSION

In our institution, cardiac surgeries such as Mitral Valve Replacement, Aortic Valve Replacement or Double Valve Replacement, repair of adult congenital cardiac defects and CABG are being routinely performed. This study deals with usefulness of del Nido cardioplegia in adult cardiac surgery being performed in the Department of Cardiothoracic Surgery.

Adult valvular cardiac surgeries are done under cardiopulmonary bypass in arrested heart. To arrest the heart different cardioplegic solutions are being used. St.Thomas cardioplegic solution is being routinely used by us to produce cardioplegic arrest. St.Thomas cardioplegic

solution is a multidose cardioplegia which has to repeated every 20 to 30 minutes during surgery.

It contains the following composition

Procaine hydrochloride	13.64mg
Potassium chloride	59.65mg
Magnesium chloride	162.65mg
Sodium metabisulphite	2mg
Disodium edetate	0.1mg
Water for injection	1ml

This cardioplegia has blood to crystalloid in the ratio of 4:1. It is given as cold blood cardioplegia at a temperature between 15 – 20°C

For the past 1 year, del Nido cardioplegic solution has been is in use for the adult valvular cardiac surgeries as some surgeons prefer it as it has duration longer than multidose cardioplegia.

This study, which deals with the usefulness of del Nido cardioplegia in adult cardiac surgery has been conducted in the Department of Cardiothoracic Surgery from March 2013 to March 2014.

Background for this study

This study has been taken with the background from the observations of Gregory S.Matte et al which reported beneficial effects of del Nido cardioplegia a unique solution which

comprises of four parts of crystalloid to one part of whole blood mostly as a single dose in paediatric congenital cardiac surgeries.

In Virginia Commonwealth University, R Ramanathan et al conducted a retrospective analysis of adult patients who underwent cardiac surgeries using del Nido cardioplegia and Buckberg's cardioplegia and compared their outcomes taking a subset of mitral valve surgeries in them. Results demonstrated that del Nido cardioplegia has potentially more benefits such as fewer doses of cardioplegia and less need for defibrillation compared to that of Buckberg's cardioplegia.

59 adult patients with the valvular lesions in the age group from 15 – 60 years were enrolled in this study. Patients aged above 60 years were excluded from study because of the possibility of coexisting co morbid conditions which could alter the outcome of the surgery.

The patients enrolled for the study included 5 patients less than 20 years of age, 27 each belonging to 20 – 40 years age group and 40 – 60 years age group respectively.

Out of 59 patients , 29 male patients and 30 female patients were enrolled for the study.

During valvular heart surgery, the patient was put on cardiopulmonary bypass .Del Nido cardioplegia was used for induction of cardioplegia in all the patients enrolled in the study.

Del Nido cardioplegia is an in house preparation which has the following composition

Ringer lactate	800 ml
Potassium chloride 2mEq/ml	13ml
Mannitol 20%	16.3ml
Magnesium sulphate 50%	4ml

Sodium bicarbonate 1mEq/ml	13ml
Lidocaine 1%	13ml

The above crystalloid is mixed with blood in the ratio of crystalloid 4parts is to 1 part of whole blood.

After establishing cardiopulmonary bypass, core cooled to 32°C, aortic cross clamp is applied and del Nido cardioplegia is given as antegrade cold cardioplegia in a temperature of 15 - 20 °C. The dosage is adjusted to bodyweight i.e, 20ml/Kg of body weight. Initially it is given at a pressure of 100mmHg for about 2 minutes followed by 40mmHg for about 4 minutes. The Cardioplegia dose is repeated after an interval of about 60 – 70 minutes as and when required according to the electrical activity of the heart.

In this study, it was found that with the mean total cardiopulmonary bypass time for Mitral Valve Replacement, Aortic Valve Replacement and Double Valve Replacement is 128minutes, 182 minutes and 217 minutes respectively.

The mean aortic cross clamp time is Mitral Valve Replacement, Aortic Valve Replacement and Double Valve Replacement is 80 minutes, 93 minutes and 155 minutes respectively.

The mean number of doses of del Nido cardioplegia required for adult valvular cardiac surgeries such as mitral valve replacement, aortic valve replacement and double valve replacement is 1.3, 1.5 and 2.61 respectively.

In this study, the number of doses of del Nido cardioplegia needed for the valvular heart surgeries is less because it has cardioplegic effect for about 60 minutes which is considered to be the likely duration of most single valvular replacement surgeries. This is highly advantageous during surgery because there is less work flow interruptions compared to the routinely used conventional multidose cardioplegia which has duration of about 20 minutes.

When multidose cardioplegia is used after about 20 minutes, the surgical procedure has to be interrupted for the instillation of cardioplegic solution which will add up to the total cardiopulmonary bypass time and aortic cross clamp time. Sometimes in order to avoid the use of additional dose of cardioplegia, the procedure will be hastened.

Out of 60 cases, defibrillation at the end of surgery was required only in 5 cases. In those 5 cases, 4 were aortic valve replacement and one was double valve replacement. The etiology for the cases which needed the defibrillation was found to have aortic stenosis in common. Hence it could be hypothesised that the need for defibrillation could be attributed to the left ventricular hypertrophy.

This result coincides with the findings of R Ramanathan et al which reported that del Nido cardioplegia has potentially more benefits such as fewer doses of cardioplegia and less need for defibrillation compared to that of Buckberg's cardioplegia.

Postoperatively ECG did not show any evidence of perioperative ischemic insult such as development of Q wave or any other significant changes consistent with the development of cardiac ischemia.

Postoperatively ECHO was done and no Regional wall motion abnormality was detected in most of the cases which indicates a good myocardial protection.

Out of 59 cases in which del Nido cardioplegia was used as an agent to arrest the heart while on cardiopulmonary bypass, 7 deaths were noted. The cause of death in all the 7 cases were primarily not attributed to use of del Nido cardioplegia and it is related to the surgical procedure.

From this study it is clear that the myocardial protection afforded by del Nido Cardioplegia is better which is the key element in the outcome of cardiac surgery with cardiopulmonary bypass.

LIMITATIONS OF THE STUDY

- The sample size is less.
- It is not a randomised control study
- Del Nido cardioplegia is currently being used only in 2 surgical units.

- The variations in the outcome of the surgery is due to individual variations in the operative techniques followed by different surgeons, postoperative management such as postoperative inotropic support, weaning of postoperative ventilator support,etc
- Myocardial protection is assessed in this study with the help of the following indicators
 - Need for defibrillation
 - Postoperative inotropic support
 - Postoperative ICU stay
 - Postoperative ECG
 - Postoperative ECHO
- The non – availability the enzyme assay such as CK-MB, Troponin – T adds to the limitation of this study as it is warranted to clearly document regarding the myocardial protection.
- Long term follow up is not available.

CONCLUSION

From this study it could be concluded that del Nido cardioplegia could be safely used in adult cardiac surgery since it has the following advantages

- Less frequent dosages needed
- Less workflow interruptions
- Smooth recovery from the cardiopulmonary bypass
- Need for defibrillation is very less
- Can be prepared locally in the hospital

FUTURE SCOPE OF THIS STUDY

In future,

- A prospective study has been planned.

It will include a large group of patients from all age groups.

Long term follow up to assess the late myocardial manifestations which may result from use of del Nido cardioplegia.

- A comparative analysis between multidose and del Nido cardioplegia has to be done.
- An analysis based on the data collected from various cardiac surgeons using del Nido cardioplegia to assess the potential benefits.

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The Tamil Nadu Dr. M.G.R. Medic... Medical - DUE 31-Mar-2014

Originality GradeMark PeerMark

USEFULNESS OF DELNIDO CARDIOPLEGIA SOLUTION IN ADULAT CARDIAC
BY 18111002 - M.CH. CARDIO THORACIC SURGERY NANDHA KUMAR R. RAMAMURTHY

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INTRODUCTION

Cardioplegic solution is the means by which the ischemic myocardium is protected from cell death. This is achieved by immediate and sustained electromechanical quiescence, rapid and sustained homogenous myocardial cooling, maintenance of therapeutic additives in effective concentrations and periodic washout of metabolic inhibitors.

Cardioplegia is an essential requisite for many of the more complex cardiac surgical procedures in which the heart must be stopped. It is an integral method of myocardial protection for patients of all ages requiring cardiac surgery. Effective myocardial protection remains the most important factor deciding on the outcome of the cardiac surgeries. Injury to myocardium must be avoided at any cost.

Introduction of cardioplegic solutions, beginning in the mid-1960s, in its numerous

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26-03-2014

INFORMED CONSENT FORM

Title of the study: “Usefulness of del Nido cardioplegia in adult cardiac surgery”.

Name of the Participant:

_____.

Name of the Principal (Co-Investigator): Dr. R. Nandhakumar.

_____.

Name of the Institution: Rajivgandhi govt. general hospital, Chennai.

_____.

Name and address of the sponsor / agency (ies) (if any):_____

_____.

Documentation of the informed consent

I _____ have read the information in this form (or it has been read to me).

I was free to ask any questions and they have been answered. I am over 18 years of age and, exercising my free power of choice, hereby give my consent to be included as a participant in “Usefulness of Del Nido Cardioplegia in adult Cardiac surgery”.

1. I have read and understood this consent form and the information provided to me.
2. I have had the consent document explained to me.
3. I have been explained about the nature of the study.
4. I have been explained about my rights and responsibilities by the investigator.
5. I have been informed the investigator of all the treatments I am taking or have taken in the past _____ months including any native (alternative) treatment.
6. I have been advised about the risks associated with my participation in this study.*
7. I agree to cooperate with the investigator and I will inform him/her immediately if I suffer unusual symptoms. *
8. I have not participated in any research study within the past _____ month(s). *
9. I have not donated blood within the past _____ months—Add if the study involves extensive blood sampling. *
10. I am aware of the fact that I can opt out of the study at any time without having to give any reason and this will not affect my future treatment in this hospital. *

11. I am also aware that the investigator may terminate my participation in the study at any time, for any reason, without my consent. *

12. I hereby give permission to the investigators to release the information obtained from me as result of participation in this study to the sponsors, regulatory authorities, Govt. agencies, and IEC. I understand that they are publicly presented.

13. I have understand that my identity will be kept confidential if my data are publicly presented

14. I have had my questions answered to my satisfaction.

15. I have decided to be in the research study.

I am aware that if I have any question during this study, I should contact the investigator. By signing this consent form I attest that the information given in this document has been clearly explained to me and understood by me, I will be given a copy of this consent document.

For adult participants:

Name and signature / thumb impression of the participant (or legal representative if participantincompetent)

Name _____ Signature_____

Date_____

Name and Signature of impartial witness (required for illiterate patients):

Name _____ Signature_____

Date_____

Address and contact number of the impartial witness:

Name and Signature of the investigator or his representative obtaining consent:

Name _____ Signature_____

Date_____

Usefulness of delNidocardioplegia in adult cardiac surgery

S.No.	Name	Ip No	Age	Sex	Diagnosis	Surgery	CPB Duration	Cross clamp duration	No.of CP	Defibrillation Yes/No	Inotropic Support	Postoperative ICU stay (days)	Postoperative ECHO/ECG	Postoperative period
1	Tamilarasi	44578	43	F	MS(S)	MVR	110	72	1	NO	MINIMAL	2	NORMAL	Uneventful
2	Ravi	59353	45	M	MS/MR/AS	DVR	187	149	2 1/2	NO	MINIMAL	4	NORMAL	Uneventful
3	Malliga	73940	45	F	MS(S)	MVR	120	62	1	NO	MINIMAL	3	NORMAL	Uneventful
4	Ramaiya	60644	55	M	MS,AS	DVR	179	150	3	NO	MINIMAL	5	NORMAL	Uneventful
5	Veeran	61943	18	M	MS, MR,AS,AR	DVR	159	123	2	NO	MINIMAL	4	NORMAL	Uneventful
6	Vanmathi	78839	51	F	MRS	MVR	90	63	1	NO				
7	Magamayi	78316	42	F	RHDMS	MVR	103	72	1	NO	MINIMAL	2	NORMAL	Uneventful
8	Dhatvani	81435	40	F	MS,MR	MVR	124	53	1	NO	MINIMAL	2	NORMAL	Uneventful
9	Balaji	61303	15	M	MR,AR	DVR	226	195	3	NO	MINIMAL	5	NORMAL	Uneventful
10	Alagesan	84009	29	M	MR(S)	MVR	116	74	1	NO	MINIMAL	2	NORMAL	Uneventful
11	Venketasan	81411	22	M	MRS	MVR	108	86	1	NO	MINIMAL	3	NORMAL	Uneventful
12	Dhanavel	89094	45	M	MS(S)	MVR	108	76	1	NO	MINIMAL	3	NORMAL	Uneventful
13	Parasuraman	92861	60	M	AS(S)	AVR	122	72	1	YES	MINIMAL	3	NORMAL	Uneventful
14	Malar	92933	37	F	MRS	MVR	118	88	1 1/2	NO	MINIMAL	3	NORMAL	Uneventful
15	Yasodha	77119	44	F	MRS	MVR	111	68	1	NO	MINIMAL	3	NORMAL	Uneventful
16	Shamiam Begum	101374	48	F	MRS	MVR	240	101	1 1/2	NO				
17	Sathyaraj	103013	22	M	MS,MR,AR	DVR	162	106	2	NO	MINIMAL	4	NORMAL	Uneventful
18	Arunachalam	99652	49	M	RHDMS,AS	DVR	246	185	3	YES	MINIMAL	4	NORMAL	Uneventful
19	Anbukannan	107366	27	M	RHD, MS, PHT	MVR	178	72	1	NO	MINIMAL	2	NORMAL	Uneventful
20	Thangaraj	92892	60	M	RHD,AS	AVR	503	155	3	YES				
21	Muniyammal	98849	30	F	RHD,MS	MVR	102	69	1	NO	MINIMAL	2	NORMAL	Uneventful
22	Ayyammal	111070	25	F	RHD,MS,MR	MVR	133	98	2	NO	MINIMAL	3	NORMAL	Uneventful
23	Malliga	112428	50	F	AS,AR	AVR	131	81	1	YES	MINIMAL	4	NORMAL	Uneventful
24	Banumathi	108805	40	F	RHD,MS(S)	MVR	110	76	1	NO	MINIMAL	2	NORMAL	Uneventful
25	Muhammed	114903	54	M	RHD,AS	AVR	104	73	1	NO	MINIMAL	3	NORMAL	Uneventful
26	Thenmozhi	115308	30	M	RHD,MS	MVR	136	71	1	NO	MINIMAL	4	NORMAL	Uneventful
27	Parashakthi	83604	23	F	RHD,MS,AR	DVR	180	139	2	NO	MINIMAL	4	NORMAL	Uneventful
28	Sekar	122059	39	M	RHD,AS,AR	AVR	153	103	2	NO	MINIMAL	4	NORMAL	Uneventful
29	Udhayakumar	108698	45	M	RHD,MS	MVR	102	66	1	NO	MINIMAL	2	NORMAL	Uneventful

30	Lakshmi	105165	45	F	RHD,MS	MVR	205	118	2	NO				
31	Jeevitha	11099	23	F	RHD,MS,AS,AR	DVR	188	139	2	NO	MINIMAL	4	NORMAL	Uneventful
32	Kannan	121888	60	M	RHD,MS	MVR	101	75	1	NO	MINIMAL	2	NORMAL	Uneventful
33	Gowri	23348	37	F	RHD,MS	MVR	190	112	3	NO				
34	Thangaraj	116034	55	M	RHD MS	MVR	106	69	1	NO	MINIMAL	2	NORMAL	Uneventful
35	Prabhu	118250	40	M	RH MS AR	DVR	172	120	2	NO	MINIMAL	4	NORMAL	Uneventful
36	Tirupathy	1247	25	M	RHD MS	MVR	129	75	1	NO	MINIMAL	2	NORMAL	Uneventful
37	Thulasidas	116157	52	M	RHD AS MR	DVR	581	239	4	NO				
38	Sasirekha	7145	25	F	RHD MS	MVR	136	90	1 1/2	NO	MINIMAL	2	NORMAL	Uneventful
39	Panchali	122033	30	F	RHD MS	MVR	145	91	1 1/2	NO	MINIMAL	2	NORMAL	Uneventful
40	Govindhammal	109852	55	F	RHD MS	MVR	175	100	1 1/2	NO				
41	Kaliammal	7098	45	F	RHD MS	MVR	106	69	1	NO	MINIMAL	3	NORMAL	Uneventful
42	Priya	8988	19	F	RHD MS	MVR	100	72	1	NO	MINIMAL	2	NORMAL	Uneventful
43	Jeeva	4803	45	F	RHD MS	MVR	138	92	1 1/2	NO	MINIMAL	2	NORMAL	Uneventful
44	Selvi	89	44	F	RHD MS	MVR	121	88	1 1/2	NO	MINIMAL	2	NORMAL	Uneventful
45	Ajithraj	7140	25	M	RHD AS	AVR	136	78	1	YES	MINIMAL	3	NORMAL	Uneventful
46	Manjula	11296	43	F	RHD MS	MVR	99	61	1	NO	MINIMAL	2	NORMAL	Uneventful
47	Pappathy	117785	50	F	RHD MS	MVR	148	96	1 1/2	NO	MINIMAL	2	NORMAL	Uneventful
48	Babu	12800	48	M	RHD MS	MVR	138	89	1 1/2	NO	MINIMAL	2	NORMAL	Uneventful
49	Prema	1153	21	F	RHD MS AR	DVR	146	107	2	NO	MINIMAL	4	NORMAL	Uneventful
50	Inbaraj	13794	19	M	RHD AS AR	AVR	128	88	1 1/2	NO	MINIMAL	3	NORMAL	Uneventful
51	Valli Kumar	12056	37	M	RHD MS AS	DVR	200	161	3	NO	MINIMAL	4	NORMAL	Uneventful
52	Sumathi	11390	25	F	RHD MS	MVR	91	60	1	NO	MINIMAL	2	NORMAL	Uneventful
53	Alex	12264	14	M	RHD MS	MVR	108	75	1	NO	MINIMAL	2	NORMAL	Uneventful
54	Padmavathy	13976	32	F	RHD MS AR	DVR	150	130	2	NO	MINIMAL	4	NORMAL	Uneventful
55	Raja	122954	27	M	RHD MS AR	DVR	264	226	4	NO	MINIMAL	5	NORMAL	Uneventful
56	Jayalakshmi	7138	37	F	RHD MS TS	MVR OTV	125	90	1 1/2	NO	MINIMAL	3	NORMAL	Uneventful
57	Jeevanantham	16234	40	M	RHD MS	MVR	125	84	1 1/2	NO	MINIMAL	2	NORMAL	Uneventful
58	Ramdoss	2072	24	M	RHD MS	MVR	173	120	2	NO	MINIMAL	3	NORMAL	Uneventful
59	Backiyam	12120	52	F	RHD MS	MVR	102	45	1	NO	MINIMAL	2	NORMAL	Uneventful