# STUDY OF ACUTE MODERATE NORMOVOLEMIC HEMODILUTION IN GYNAECOLOGICAL SURGERIES

*Dissertation submitted to*

**THE TAMILNADU Dr. M.G.R MEDICAL UNIVERSITY**

***in Partial fulfillment for the award of the degree of***

**M.D. OBSTETRICS AND GYNAECOLOGY**

**BRANCH II**

**INSTITUTE OF OBSTETRICS AND GYNAECOLOGY**

**MADRAS MEDICAL COLLEGE**

**CHENNAI- 600 003.**

**MARCH 2009**

# ACKNOWLEDGEMENT

I am extremely thankful to **Dr. T.P. KALANITI M.D.,** Dean, Madras Medical College and Government General Hospital, Chennai and **Prof. Dr.K. SARASWATHI M.D, DGO.,** Director and Superintendent, Institute of Obstetrics and Gynaecology, Egmore for granting me permission to utilize the facilities of the Institute for my study.

I am immensely grateful to our Director and Superintendent **Prof. Dr. K. SARASWATHI MD DGO.,** Institute of Obstetrics and Gynaecology, Egmore, Chennai, for her concern and support in conducting this study.

I am extremely thankful to our Deputy Superintendent, **Prof.DR.T.K. RENUKA DEVI**, **MD, DGO.,** for her support in conducting this study.

I am thankful to **Dr. K. SARASWATHI M.D, DGO.,** Director and Superintendent, Institute of Obstetrics and Gynaecology, Egmore for her valuable guidance and immense support.

I am greatly indebted to **Prof. Dr. R. RAJENDRAN, MD. DA.,** Professor of Obstetric Anaesthesia Services, Institute of Obstetrics and Gynaecology, Madras Medical College and Research Institute for his valuable guidance and supervision in conducting this study.

I am thankful to our RMO and all UNIT CHIEFS for their support advice and

encouragement

I am thankful to all Assistant Professors and Teachers for their guidance and help. I am thankful to all my colleagues for the help rendered in carrying out this dissertation.

Last, but not the least, I thank all my patients for their kind co-operation who made this study feasible.

# CERTIFICATE

This is to certify that the dissertation entitled, **"STUDY OF ACUTE MODERATE NORMOVOLEMIC HEMODILUTION IN GYNAECOLOGICAL SURGERIES "** submitted by **Dr. R.VISHNU PRIYA,,** in partial fulfillment for the award of the degree of Doctor of Medicine in Obstetrics and Gynaecology by the Tamil Nadu Dr. M.G.R. Medical University, Chennai is a bonafide record of the work done by her in the Department of Obstetrics and Gynaecology, Madras Medical College, during the academic year 2006-2009.

**Dr. T.P. KALANITI , MD,**
DEAN,
MADRAS MEDICAL COLLEGE &
GOVT. GENERAL HOSPITAL,
CHENNAI- 600 003.

**DR. K. SARASWATHI, MD, DGO**
DIRECTOR SUPERINTENDENT,
INSTITUTE OF OBSTETRICS &
GYNAECOLOGY,
EGMORE, CHENNAI- 600 008.

# ETHICAL COMMITTEE CERTIFICATE

DATED : 25.2.2008.

I, Dr.R.VISHNU PRIYA apply for the ethical committee certificate for the project **"STUDY OF ACUTE NORMOVOLEMIC HEMODILUTION IN PATIENTS UNDERGOING GYNAECOLOGICAL SURGERIES - SAFETY & HEMODYNAMIC ALTERATIONS,COST FACTOR,TIME FACTOR, COMPLICATIONS."** Under the guidance of Dr.Saraswathy ,M.D. D.G.O., Director, Institute of Obstetrics and Gynaecology ,Egmore, Chennai-8.

I understand the implications of doing research with human subjects and will fully comply with the regulations and keep the dignity and protect the health of subjects at all costs.

R. Vishnu Priya

**SIGNATURE OF THE POSTGRADUATE STUDENT**

I have no objection to guiding this postgraduate student in the project mentioned above. I Shall supervise to the extent that all the human rights are protected and research is carried On with utmost humanitarian principles.

Saraswathy 25/2/08

**SIGNATURE OF THE GUIDE**

Director and Superintendent,
OG & Govt. Hospital for Women
and Children
MADRAS-600 008.

**SEAL OF THE GUIDE**

I Certify that this project has been presented in front of the Ethical Committee duly formatted in this institution and that all the members of the ethical committee have given permission to conduct this research.

25/2/08

**CHAIRMAN ETHICAL COMMITTEE**

Professor & Head
Dept. of Community
Stanley Medical
Chennai - 600 001.

Date : 25. 2. 2008.

Seal

# CONTENTS

# INTRODUCTION

Blood has been used as a life saving product since the seventeenth century when the first blood transfusions were recorded. A large percentage of blood is administered to patients during surgery and it is usually homologous blood. Blood is a tissue and so blood transfusion like tissue transplantation carries complications. The non-availability of blood and blood products due to shortage of homologous blood is a limiting factor for surgery.

With the aim of providing maximum benefit and avoiding risks to patients a number of alternative techniques to homologous blood transfusion have been evolved.

Autologous blood transfusion is the most efficient among the alternative methods available. There are four types of Autologous blood transfusion

1. Preoperative Blood Donation
2. Acute Normovolemic Hemodilution
3. Acute Hypervolemic Hemodilution
4. Intraoperative &Postoperative Blood salvage

Patients can tolerate anemia with hematocrit of 25-30% as long as normovolemia is maintained.This forms the basis for Acute Normovolemic Hemodilution.This technique involves removal of predetermined quantity of blood from the patient before

or after induction of anaesthesia and maintaining isovolemic status with crystalloids or colloids .The blood withdrawn is returned to the patient after obtaining near normal hemostasis in the surgical field.

Acute normovolemic Hemodilution is safe, simpler, cost effective than other methods of autologous transfusion and is an effective strategy to replace homologous blood requirement. The surgeon and the anaesthesiologist play a key role in choosing their patients and adapting this technique to extract the maximum benefit out of it.

# AIM OF STUDY

The aim of dissertation is to study the safety, hemodynamic alterations associated with Acute Normovolemic Hemodilution in patients undergoing elective gynaecological surgeries with special references to cost effectiveness, time factor and complications.

# HISTORICAL REVIEW

In 1665, the first recorded successful blood transfusion occurs in England: Physician Richard Lower keeps dogs alive by transfusing blood from other dogs.

In 1795, American Physician, Philip Syng Physick, claims to perform the first human blood transfusion, although he doesn't publish this information.

The first instance of Autologous blood transfusion in man occurred in 1818 when **BLUNDELL** reinfused salvaged blood in to women with post partum haemorrhage. This was prior to discovery of bloodgroups and even allotransfusion.

In 1886, **DUNCAN** described a case of intraoperative blood salvage during lowerlimb amputations. Subsequently in addition to methods of intraoperative blood salvage other methods were developed for the reinfusion of autologous blood removed during weeks prior to operation.

This practice was first described by **GRANT** in 1921 in patients undergoing surgery for cerebral tumour.

Blood salvage was first reported in American literature in 1917. By 1936, 277 cases were reported. Sporadic reports of use of the technique in patients with hemothorax appeared in the surgical literature from 1931 through the early 1970s.

In 1966, Symbas undertook a series of laboratory & clinical studies leading to

adoption of an autotransfusion protocol for managing patients with acute traumatic hemothorax. This was employed in more than 400 patients between 1966 & 1978.

In 1968, a method of predonation by means of repeated donations within a 10 day period the so called “Leap Frog method” was developed through which a number of autologous units of blood could be acquired and used in the perioperative period.

Later blood was removed prior to surgery and the volume restored by infusion of colloids & crystalloids to produce intentional normovolemic hemodilution. This method represented an extension to the other surgical specialities of a technique initially used in heart surgery in the course of extra corporeal circulation. In those days it was thought that anemia caused by blood loss should be corrected to so called physiological values.

In 1970, the group of **MESSMER& SUNDER PLASSMANN** came to an entirely different conclusion they depicted that Normovolemic Hemodilution increased perfusion & oxygenation of tissues through a change in blood flow properties based on a decrease in blood viscosity.

Normovolemic Hemodilution was introduced in to surgical practice in 1973 as an alternative to transfusion of homologous blood. Since then it has been in use in various surgical fields were it has been proved as an efficient blood salvage procedure.

# REVIEW OF LITERATURE

**H.HINT (1968)** [19] postulated that a reduction in hematocrit is not necessarily followed by a decrease in O2 transport.

**SUNDER – PLASSMANN(1971)** in their experimental data found that the $O_2$ transport is at its maximum when the hematocrit is between 25-30% i.e. well below the physiological values.

**ROBERT PILON et al(1973)** [29] studied the effects of acute normovolemic hemodilution on hemodynamics , oxygen transport, tissue perfusion & blood volume.Patients undergoing total hip replacement were chosen and hematocrit was reduced to 29%and 21% by bleeding in two steps.The major compensation observed was a rise in cardiac output to 123% and 136% respectively.

**K.MESSMER (1975)** [22] studied hematocrit-viscosity relationship at different shear rates of blood flow. Linear changes in hematocrit are followed by disproportional increments or decrements in blood viscosity.A decrease in hematocrit from 40% to 20% decreases viscosity by 50% in both arteries & veins.

**SALMA ZAFAR et al** [30] in their study of intraoperative hemodilution carried on in patients undergoing major elective surgery concluded that the method was safe & requirement of homologous blood was reduced by another 90%.

**W.P.KLOEVEKORN et al(1974)** demonstrated that in ANH the increased venous return and decreased afterload resulting from the decrease of viscosity cause an increase in cardiac output without significant changes in heart rate.

**D.ROSE et al (1979)** [12] in their study of ANH in major cancer surgeries had noted an increase in cardiac output with no changes in mean arterial pressure.During the procedure no changes in electrolyte values or clotting factors was noticed.

**EIKE MARTIN et al (1987)** [14] concluded that intraoperative and preoperative dilution can be well tolerated up to a hematocrit of 25% under a constant circulating normovolemic volume.

**AUDIBERT,G.DONNER.M.et al (1993)** [3] compared the influence of various plasma substitutes administered for preoperative hemodilution on blood rheology..He studied 4% albumin, 35%dextran 40%gelatin, and HES after hemodilution to hematocrit of 30%.Erythrocyte aggregation markedly decreased in albumin and dextran, unchanged in HES,increased in gelatin. They suggested albumin and dextran 40 as plasma substitutes of choice for ANH, when this technique aims to improve rheological conditions.

**OBERHAUSER et al (1996)** [27] in their clinical trial on Acute Normovolemic Hemodilution on patients undergoing major gynaecological operations found that ANH was a safe, easy to handle procedure . No ischemic events or perioperative

complications were observed.It was an effective procedure to avoid homologous blood transfusion.

**C.F.HOGMAN F et al (1999)** [20] studied the stored whole blood before transfusion and the effect of temperature on RBC 2,3 DPG .When blood was stored at 30°C 2,3DPG concentration decreased from 858±106 to 316±172mmol/molecule of hemoglobin(63%decreased), 99% was lost within 8 hours. No loss of 2,3 DPG was observed at 4°C and 10°C storage. No difference was attributable to the anticoagulant used.

**HETTEROGODS et al(1997)** [18] carried out ANH in patients undergoing Coronary artery bypass grafting.They had analysed the effects of ANH in maintaining $O_2$ perfusion and changes in ECG noticed during the procedure. They demonstrated that there was no ST segment changes among the patients undergoing hemodilution.

**MIRHASEMI et al (1999)** [25] carried out a study of intraoperative autologous blood transfusion on patients undergoing Type 3 Radical hysterectomy. Their procedure was one of the moderate ANH. Isovolemic hemodilution brought about significant reduction in transfusion and they observed that recurrence of tumour metastasis was less among the study group.

**J.L.CARLSON et al (1999)** [6] studied the risk of bacterial infection associated with allogenic blood transfusion in patients undergoing hip fracture repair .There was a

35% greater risk of serious bacterial infection and 52% greater risk of pneumonia.

**FERRARIO CARLIS M (1995)** studied the mechanism of systemic vasodilatation during normovolemic hemodilution. They concluded that neural reflexes do not modulate systemic vascular response to hemodilution. Nitric oxide (EDRF) is the most likely cause of systemic vasodilatation in ANH.

**GOODNOUGH LT et al (2000)[23]** in their randomized trial compared ANH and preoperative autologous blood donation in hip arthroplasty. ANH was safe and was less costly than preoperative blood donation.(ANH:US $151±154) PABD (US $680±253) respectively .ANH was equivalent to PABD in effectively reducing exposure to allogenic RBC s.

**LISANDER et al (1996)[23]** of Sweden used the technique of ANH on patients undergoing spinal surgery. 1150 ml was shed from the patients and normovolemia maintained. They concluded that ANH was effective in conserving the allogenic blood resources.

# ACUTE NORMOVOLEMIC HEMODILUTION

**DEFINITION :**

Acute Normovolemic Hemodilution is defined as the removal of blood from a patient immediately before operation ,either before or shortly after induction of anaesthesia and simultaneous replacement with an appropriate volume of crystalloids or colloid, alone or in combination, such as to maintain the circulating volume.

**ANH as a blood conservation strategy :**

ANH is one among the many options available to clinicians to minimize perioperative exposure to allogenic blood products.The volume of blood conserved is directly proportional to the differences between the original and postdilution hematocrit values.The only blood conservation technique that results in fresh whole autologous blood is ANH and it is endorsed by the National Institutes of Health Consensus Conference on Perioperative Red Blood Cell Transfusion and American Society of Anesthesiologists.This accessible and easily institutable technique should be considered for all surgical patients, although its suitability and efficacy will depend on the clinical situation.

In 1972, a study found that until a hematocrit value of 30% was reached ,the decreased viscosity and the increased cardiac output (C.O) provided maintenance of a maximal oxygen delivery to the tissues during hemodilution. Further studies on the

rheological, hemodynamic, metabolic and cardiovascular consequences of hemorrhagic shock provided additional information .ANH is considered to be a viable alternative to transfusion with allogenic blood products and is used since 1970 for surgical patients.

**CLASSIFICATION OF HEMODILUTION :**

Hemodilution refers to decrease in hematocrit or hemoglobin concentration as a result of dilution of RBC s (dilutional anemia) . Several types of hemodilution have been described

(1) Hypervolemic hemodilution
(2) Hypovolemic hemodilution and
(3) Normovolemic hemodilution

**Hypervolemic hemodilution :**

A therapeutic decrease in whole blood viscosity occurs with no change in plasma viscosity accompanied by an increase in circulating blood volume .Hypervolemic hemodilution has been used with success in patients with chronic occlusive arterial disease and stroke patients.

**Hypovolemic hemodilution :**

During hypovolemic hemodilution if an individual is healthy, no crystalloid or colloid is administered during preoperative blood donation.It should be borne in mind

that normalization of blood volume occurs within 12 to 24 hours via compensatory physiological phenomena.

**Normovolemic Hemodilution :**

Normovolemic hemodilution causes an intentional decrease of hemoglobin concentration by withdrawal of a calculated volume of the patients blood and by simultaneous administration of cell free substitute, near normal blood volume is maintained.

The rationale behind the use of ANH as a method for blood conservation is that if intraoperative blood loss is relatively constant , the loss of blood constituents ,especially RBCs would be reduced if the blood is diluted by a plasma expander.The patient's own fresh blood is reinfused after obtaining near normal hemostasis in the surgical field i.e. after major blood loss has ceased.

**GUIDELINES FOR ANH :**

**PATIENT SELECTION :**

The most critical step deciding the outcome of ANH is proper patient selection. The decision to recommend ANH for an individual patient should lie with the surgeon and anaesthetist.

**AGE :**

The technique of ANH has no age bar .It has been employed in paediatric as well as elderly patients. But one should be cautious of the complications related to unsuspected atheromatous disease as age advances.

**HEMOGLOBIN STATUS :**

Preoperative Hb of the patient should be >11gm/dl.

**BLOOD LOSS :**

ANH is considered in surgeries where blood loss is likely to be greater than 20% of blood volume. It is suitable for Elective as well as Emergency procedures.

**MEDICAL DISORDERS :**

Patients with cardiac, pulmonary, renal, and liver disorders cannot tolerate ANH.

**JEHOVAH'S WITNESS :**

Some members of Jehovah's witness faith will agree to hemodilution if the blood is maintained in a closed circuit continuous flow system.

**SCREENING :**

Patients need not be routinely screened for viral markers.Universal precautions to protect staff from the risks of virus transmission must always be observed.

**CONTRAINDICATIONS :**

**ANEMIA :**

It is a major contraindication to hemodilution.It is inappropriate to employ this technique when the Hb is less than 11gm/dl.

**CARDIAC DISEASE :**

Patients with cardiac dysfunction undergoing noncardiac surgery are not suitable candidates. Because an increase in cardiac output may neither be possible nor desirable.The technique can however be used during cardiac surgery because pump flow can be altered to compensate for volume changes.

**PULMONARY DISEASE :**

Pulmonary dysfunction which impairs oxygenation of blood are contraindications to ANH.

**RENAL DYSFUNCTION :**

Impaired renal function interferes with the excretion of diluent fluids. This results in pulmonary edema.

**LIVER DISORDER :**

Hepatic dysfunction is associated with low levels of clotting factors and during hemodilution the factor levels might decrease below critical levels thus predisposing the patient to hemorrhage.

**HEMOSTATIC DISORDERS :**

Hemodilution might lead to decrease in clotting factor levels below critical limits leading to hemorrhagic complications.

**ADVANTAGES OF ANH :**

- Blood returned to the patient contains functional red cells,clotting factors and platelets.
- Red blood cell loss is decreased when ANH is employed.
- Eliminates the risk of transfusion reactions, transfer of infectious disease, immunomodulatory effects.
- Provides a safe means of transfusion in patients with multiple antibodies.
- Patients with rare blood group can undergo surgery utilizing this technique.
- ANH leads to improved tissue perfusion and oxygen delivery which may be most important in patients with peripheral vascular and cerebrovascular disease.
- Hemodilution as a ‘point of care strategy’ in the operating room obviates the need for blood bank facilities.
- Obviates the need for blood screening, storage and crossmatching.

- Blood drawn during ANH doesn't undergo biochemical alterations associated with stored bank blood.

- Avoids the risk of clerical error , mistransfusion and bacterial contamination.

- The presence of malignancy may contraindicate the use of intraoperative blood salvage but not ANH.

- Some patients of Jehovah's witness agree to ANH as long as blood is maintained in a close circuit system.

- ANH is a cost effective blood conservation technique that reduces the demand on homologous blood.

- Gives patient the psychological benefit of actively participating in their treatment.

## COMPLICATIONS :

### Hemodynamic imbalance :

Blood withdrawal and administration of diluent fluids should parallel each other to maintain normovolemia.Excess of fluids lead to pulmonary edema whereas underfilling leads to hypovolemia.

### Myocardial Ischemia :

This is a potential complication of ANH.Elderly patients who often have a silent atheromatous disease are more prone.In these patients the augmented cardiac output increases myocardial O2 consumption whereas oxygen content of the blood supplying the myocardium is inadequate.

### Coagulopathy :

Coagulopathy related to dilution of clotting factors and increased bleeding due to enhanced capillary blood flow are proposed to be complications of ANH ; however experience suggests that these are theoretical rather than clinical problems.

**PLASMA SUBSTITUTES USED IN ANH :**

During Acute Normovolemic Hemodilution crystalloids, colloids and combinations of both have been used as diluents to maintain normovolemia.The most common crystalloid used is Lactated Ringers solution .A number of colloids are in use including hydroxy ethyl starch Gelofusine ,Dextran, 3%polygeline and natural colloid albumin.

**Crystalloids vs Colloids :**

The advantage of crystalloids is that they are cheaper,lack the adverse reactions associated with colloids.But the principle shortcoming is their tendency to traverse the vascular endothelium and leave the vascular compartment .When they are used as sole replacement fluids they should be administerd in a 3:1 ratio to that of blood withdrawn.

Colloids on the other hand are retained longer in the circulation,thereby maintaining colloid osmotic pressure and plasma volume for several hours;hence inferring that crystalloids have a greater tendency to cause pulmonary edema than colloids.But the amount of fluid administered and the vigilance in monitoring the hemodynamic variables are more important in the development of pulmonary edema than the choice of the fluid.

## COMPARISION BETWEEN DILUENT FLUIDS USED.

| | CRYSTALLOID | COLLOID |
|---|---|---|
| Volume required | 3 times volume of shed blood | 1-2 times volume of shed blood |
| Plasma volume | 80% leaves intravascular compartment in 2 hours | Retains longer in the circulation- a better plasma expander. |
| Colloid osmotic pressure | Reduced | Maintained |
| Chance of edema | More chance of peripheral and Pulmonary edema | Less chance |
| Postoperative Hematocrit | Higher | Lower |
| Coagulation defect | None | May occur with excessive colloids (Dextran) |
| Cost | Cheaper | Expensive |

## PHYSIOLOGICAL CHANGES ASSOCIATED WITH ANH:

### Effects on Blood viscosity and flow resistance:

Hemodilution brings about a decrease in blood viscosity. This is achieved mainly through reduction in the hematocrit. The formation of red cell aggregates is hampered and the rouleaux formation are less stable,therefore becomes easily disaggregated, thus the viscosity of blood is reduced.

The decrease in blood viscosity has graded effects at different levels of vascular compartment which in turn is related to the shear conditions. The most pronounced decrease of blood viscosity occurs within the post capillary venules when the hematocrit is decreased to approximately 25-30%.Acute reductions in hematocrit reduce the viscous resistance which in turn decreases the resistance to flow, especially within the post capillary venules, resulting in an increase in venous return.

Guyton and Richardson were able to prove that venous return increases significantly when the hematocrit is reduced under isovolemic conditions.

**Hemodilution → Decrease in viscosity → Lowers the flow resistance → Increase in venous return.**

**EFFECTS ON CARDIAC OUTPUT AND ORGAN BLOOD FLOW:**

Under conditions of acutely induced normovolemic hemodilution, the linear reduction in hematocrit leads to a prompt raise in cardiac output. The increase in venous return and decreased peripheral resistance are responsible for the raised cardiac output with the heart rate changing only slightly.A distinct increase in heart rate with a relatively small increase in cardiac output per unit hematocrit decrease is indicative of an impeded venous return due to hypovolemia.

The reduced peripheral resistance in addition to decreased viscosity is also because of reflex vasodilatation or local regulatory factors such as endogenous release of Nitric Oxide.

**Increase in venous return + decreased afterload → Increased cardiac output → Maintains $O_2$ transport.**

As first reported by Race and Dedichan, total blood flow to most organs rises in direct proportion to the increase in cardiac output. This has been confirmed for cerebral blood flow to normal brain tissue as well as to areas with impaired cerebral vasoregulation, for renal blood flow, hepatic arterial and total liver blood flow.

**TISSUE OXYGENATION :**

Due to reduction in red cell mass and thus the decrease in hemoglobin concentration hemodilution necessarily diminishes the oxygen content of blood.

But the decrease in arterial oxygen content is not translated to decrease in tissue oxygenation.Because the following 3 different mechanisms compensate for the decrease in oxygen content.

1. **Increase in nutritional flow.**
2. **Enhanced oxygen extraction by the tissues.**
3. **Shift of oxygen dissociation curve to the right.**

**NUTRITIONAL FLOW :**

Hemodilution leads to a decrease in blood viscosity which in turn maintains a more homogenous distribution of microcirculatory flow.Tissue nutritional flow has been investigated in resting skeletal muscles.**Gaethgens et al** in their study on the effect of

normovolemic hemodilution on skeletal muscle during enhanced metabolic activity observed that the increase in nutritional flow is sufficient to compensate for the reduction in oxygen content. ANH improves the nutritional flow to the tissues which is apparent from tissue pO2 measurements.

**OXYGEN EXTRACTION :**

The maintainence of normal tissue oxygenation during limited hemodilution originates from the well developed red cell flux per time unit even though the number of red cells per unit blood is reduced.Local oxygen supply to the tissues is not impaired by limited normovolemic hemodilution but,in contrast becomes more homogenous.

The second mechanism that maintains adequate oxygenation is the increase in oxygen extraction by the tissues .The mechanism is utilized as soon as the oxygen demand is increased and also whenever hypovolemia comes into play.

Buckberg could demonstrate that oxygen delivery to the entire left ventricle remains adequate over a wide range of hemoglobin levels,He analysed the myocardial blood flow distribution by means of radioactive microspheres during ANH.

**DECREASE IN OXYGEN AFFINITY :**

The predominant adaptational mechanism for the acute decrease in blood oxygen content during acute normovolemic hemodilution is an increase in cardiac output and

nutritional flow to various organs. But the decrease in oxygen affinity of hemoglobin facilitates oxygen release at the tissue level.There is a linear correlation between affinity changes and the intraerythrocytic 2,3 DPG concentration.

Therefore from the above discussion we conclude that limited normovolemic hemodilution doesn’t jeopardize the tissue oxygen supply as it is maintained by the physiological compensatory mechanisms.

# PROCEDURE DESCRIPTION OF ANH

ANH is characterized as either moderate or severe hemodilution, depending on whether the hematocrit is 25-30% (moderate or limited) or 15-20% (severe or extreme). ANH involves the active withdrawal of the patients blood and the temporary acceptance of a lower hemoglobin. The collected blood is temporarily stored and subsequently transfused to the patient as indicated.

Before the withdrawal of blood, adequate intravenous access is necessary. A urinary catheter, pulse oximeter for continuous monitoring of hemoglobin saturation and ECG monitor should be in place. Some authors have advocated the use of a central venous catheter or pulmonary artery catheter for assessing ventricular, filling or approximating the adequacy of tissue oxygenation.

Blood is withdrawn from a peripheral vein where an automated blood pressure cuff may facilitate collection. Blood drains into standard blood collection bags containing an anticoagulant such as Acid citrate dextrose or citrate phosphate dextrose.

The collection of fresh whole blood should require above 10 minutes per unit. Strict adherence to sterile technique should be maintained. The blood should not leave the operating room so that there is little chance of administering it to the wrong patient, The blood should remain at room temperature in the operating room; if removed from the operating room, it must be appropriately labelled and stored at 4-6°C. The blood should be re-administered in reverse order of collection, a method that ensures that the most hemodiluted unit is given first and the one with the most clotting factors and

RBCs will be given last.

There are several formulas to guide the process of withdrawing the predetermined amount of blood:

**V = EBV X Hcti - Hctf / average Hct,**

Where the average Hct = (Hcti - Hctf )2 + Hctf where EBV is the estimated blood volume, V is the volume to be collected, Hcti is the initial Hct, and Hctf is the final desired Hcf. An alternate formula that is.an accurate guide to determine the volume of blood to withdraw for ANH is

**V = EBV ((Hcti-Hctf) (3-avgHct)**

During ANH, large amounts of fluid are frequently necessary to maintain normovolemia, although the net fluid increase may be insignificant compared with the usual transfusion requirements. Complications associated with the increased fluid include peripheral edema, pulmonary edema, abnormal would healing, and worsened . postoperative pulmonary function. Peripheral edema is relatively common with ANH, but pulmonary edema is not common. In most patients with good ventricular function, the increased fluid is well tolerated and usually resolves in 72 hours. Left ventricular hypertrophy or dysfunction is the factor that reduces the tolerance to the increased fluid volumes.

Because the withdrawn blood must be adequately replaced with crystalloid or colloid fluid, comparisons have been performed to determine the optimal type of fluid

replacement for ANH. Although crystalloid alone is acceptable, either colloid alone or a combination of crystalloid and colloid is favoured .Albumin, hydroxyethyl starch, and dextran are the colloids that have been successfully used for ANH.

Crystalloid is usually given as a 3 to 4-mL replacement per mL of withdrawn blood. Colloid is usually given at 1-2 mL per mL of blood withdrawn.

The primary indication for ANH in surgical patients is the reduction of allogeneic blood transfusion. Perioperative transfusion of RBC and other blood products have been decreased with ANH. As important, the percentage of patients who do not receive any blood products is increased from 13% to 42%, if ANH is combined with other blood salvage procedures during cardiac and noncardiac operations.

## MATERIALS AND METHODS

SETTING :Institute of Obstetrics and Gynaecology, Egmore, Chennai.

YEAR OF STUDY : April 2007 - April 2008

NATURE OF STUDY : Prospective study.

30 patients posted to undergo elective gynaecological surgeries were chartered in to the study. Informed consent was obtained from the patients. This study was approved by the board of ethical committee.

**INCLUSION CRITERIA :**

- Age : 20 – 60 years

- Preoperative Hb : > 11 gm/dl
- Hematocrit : 30%
- Absence of Cardiac, Pulmonary, Renal, Liver disease
- Absence of uncontrolled hypertension and other comorbid conditions.
- Absence of Hemostatic disorders.
- Absence of infection

**EXCLUSION CRITERIA :**

- Age : <20 or >60 years
- Anemia : Hb < 11 gm/dl
- Hematocrit <30%
- Untreated hypertension
- Impaired cardiac, pulmonary, renal ,hepatic function.
- Coagulation disorders
- Hypoalbuminemia.
- Presence of infection

**Pre operative evaluation :**

1. Patients awaiting elective gynaecological surgery were evaluated for anaesthetic fitness and criteria to be fulfilled to undergo ANH was analysed.

2. Procedural details were explained to the patients.

3. Informed consent was obtained from the patients.

**INVESTIGATIONS :**

Urine - Protein

Sugar

Microscopy

Blood Hb%

PCV

Total count

Differential count

ESR

Platelet count.

Blood Urea

Sugar

Serum creatinine

Serum Electrolytes - Na, K

Serum Proteins

Bleeding time

Clotting time

Chest X-ray PA view

ECG

Estimation of blood volume to be collected during Acute Normovolemic Hemodilution by using **GROSS FORMULA**

Volume of blood to be collected = EBV * Hct I-Hct f /Hct av

EBV = Estimated Blood Volume

Hct I = Initial hematocrit( preoperative)

Hct f = Final hematocrit desired after hemodilution.

Hctav = Average hematocrit.

Estimated blood volume is about 7% of the patients body weight.

**On the day of Surgery :**

Patients were brought to the theatre by around 8.30 am.

**Premedication :**

Patients were premedicated with Tab.Diazepam 5mg, Tab.Perinorm 10 mg and Tab.Ranitidine 10mg, the night before surgery.

**PREPARATION :**

The following baseline parameters were recorded

1. Pulse rate
2. Systolic blood pressure
3. Diastolic blood pressure
4. Pulse Oximeter –O2 saturation
5. ECG
6. Urine output –After bladder catheterization

Patients received oxygen 5 litres /min through ventimask during the preinduction phase.

Two 16 G venflon cannula were started aseptically, one on a big forearm vein to infuse crystalloid (NS,RL) and colloid (Haemaccel).The other cannula was used as the port to withdraw blood by connecting it to the blood bags. Withdrawal of blood was facilitated in some patients via automated blood pressure cuff.

**Collection of blood :**

1. Blood was collected from the antecubital vein opposite to the upperlimb, in which the intravenous fluids were on flow.

2. Blood volume to be collected was based on the calculation using the Gross Formula to perform moderate hemodilution to achieve a target PCV of 28%.

3. Blood bags used were sterile disposable bags each of 350 ml volume containing 45ml of Citrate Phosphate Dextrose as an anticoagulant.

4. For each ml of blood removed 3ml of crystalloid or 1ml of colloid (haemaccel) were replaced simultaneously through the cannula placed in the opposite forearm vein.

5. For the calculated total volume of blood, the first half volume was replaced with crystalloids and the second half with colloids.

6. Blood bags were weighed using a scale graduated to show reading in increments of every 25 gms. The volume of blood collected was calculated using the conversion: 1ml of blood is 1.06gms approximately.

7. During the period of blood withdrawal frequent manual rocking of blood bags were done to allow the blood to mix uniformly with the anticoagulant.

8. After collection of appropriate volume of blood each blood bag was labelled in the sequential order of collection. Patients details – Name, Age, IP NO, Date and time of collection were written. Bags were kept inside the theatre itself by the side of operation site.

9. All the vital signs were monitored during the process of blood withdrawal.

10. Blood samples were drawn for estimation of Hb,PCV,BT,CT,RBC count after each unit of blood withdrawal.

11. Anaesthetic technique was General anaesthesia with controlled ventilation standardized for all patients.

12. Patients were induced with 2.5% Inj.Thiopentone sodium 5mg /kg IV and intubated with Inj suxamethonium 2mg/kg IV. They were intubated orotracheally with appropriate size endotracheal tube.Maintainence of anaesthesia was with Nitrous Oxide/Oxygen and Halothane 0.5% .Inj.Vecuronium 4mcg/kg was used

to facilitate intermittent positive pressure ventilation.At the end of surgery patients were reversed with Inj.Neostigmine 50mcg/kg and Inj. Atropine 20mcg/ kg slow IV and extubated after full recovery.

13. Intraoperative fluids used were RL,NS & Haemaccel depending on the surgical blood loss with the aim of maintaining stable hemodynamics.

14. Blood that was withdrawn was administered after achieving near complete hemostasis at the end of surgery i.e. after major blood loss has ceased or if intraoperative hemoglobin was less than 8gm/dl

15. Blood was transfused in the reverse order of collection.

16. Vital parameters were monitored throughout the intraoperative period.

17. Blood samples were withdrawn for estimating Hb,PCV,RBC count,Bleeding time ,clotting time both before transfusion and after transfusion of collected blood.

18. After complete recovery patients were observed in the post operative Intensive Care Unit for 24 hours and then shifted to postoperative wards.

19. Patients were followed up till discharge.

# OBSERVATION AND RESULTS

A group of 30 patients undergoing elective gynaecological surgery were selected for the study and they underwent acute moderate normovolemic hemodilution.

## DEMOGRAPHIC PROFILE

**TABLE 1**

**AGE DISTRIBUTION**

| AGE in years | ANH n=30 |
|---|---|
| 25-29 | 3 (10%) |
| 30-34 | 8 (26.6%) |
| 35-39 | 10 (33.3%) |
| 40-44 | 5 (16.6%) |
| 45-49 | 2 (6.6%) |
| 50-54 | 2 (6.6%) |

In our study majority of patients belonged to 35-39 year age group about 33.3%.26.6% patients were in 30-34 year age group. About 16.6% patients belonged to 40-44 year age group.10% patients were in 25-29 year age group .6.6% of patients were there in 45-49 year age group and another 6.6% were in 50-54 year age group .

**TABLE 2**

**WEIGHT DISTRIBUTION**

| Weight in kg | ANH n=30 |
|---|---|
| 50-54 | 6 (20%) |
| 55-59 | 11(36.6%) |
| 60-64 | 8 (26.6%) |
| 65-69 | 4 (13.3%) |
| 70-74 | 1 (3.3%) |

In our study majority of patients were in the weight distribution group 55-59 kg (36.6%). 8 (26.6%) patients weighed between 60-64 kg.6 (20%) patients weighed between 50-54kg. 4 (13.3%) patients weighed between 65-69kg. 1 (3.3%) patient weighed between 70-74 kg.

## Table 3

## BLOOD COLLECTION AND STATISTICAL DATA

| ANH N=30 | Initial Hb gm/dl | Initial Hematocrit % | Target Hematocrit % | Maximum volume of blood that can be withdrawn (ml) | Volume of blood collected (ml) | Colloid replaced (ml) | Crystalloid replaced (ml) |
|---|---|---|---|---|---|---|---|
| **Average** | **12.16** | **36.25** | **28%** | **803** | **780** | **508** | **1207** |

The average Hb level of patients who entered our study was 12.16 gm/dl, the average Hematocrit was 36.25%. The target hematocrit aimed to be achieved after hemodilution was 28%. The maximum volume of blood that could be withdrawn was 803 ml. The average volume of blood collected was 780ml. Average volume of colloid replaced was 508ml and crystalloid replaced was 1207 ml on an average.

## Table 4

### TIME DURATION FOR HEMODILUTION

| ANH N=30 | Average volume of blood collected (ml) | Start time of ANH (a.m.) | Finish time of ANH (a.m.) | Total duration of ANH (minutes) |
|---|---|---|---|---|
| **Average** | **780** | **9.05** | **9.50** | **45** |

The average time taken for withdrawal of 780ml of blood was 45 minutes.

Therefore to withdraw one bag of 350ml of blood time taken was 20.1 minutes.

## HEMODYNAMIC PARAMETERS AT VARIOUS STAGES OF ACUTE NORMOVOLEMIC HEMODILUTION

### TABLE 5

### HEART RATE CHANGES DURING ANH

| Stage of ANH | Pre Hemodilution | Post Hemodilution | Pre Transfusion | Post Transfusion |
|---|---|---|---|---|
| **Heart Rate** | **77.4 ± -5** | **78 ± 5** | **79.2± 5** | **79.6 ± 4** |

**Heart rate changes were as follows :**

Heart rate during the pre hemodilution period was 77.4 ± 5 beats/ min , in the post hemodilution phase it was 78 ± 5/min. In pretransfusion phase heart rate was 79.2 ±5 / min and 79.6 ± 4/min in post transfusion phase.

## TABLE 6

## HEART RATE CHANGES DURING ANH

| Parameter | Stages of ANH compared | Mean change | P value |
|---|---|---|---|
| HEART RATE | Pre hemodilution vs post hemodilution | 1 | 0.60 NS |
| | Prehemodilution vs pretransfusion | 2 | 0.16 NS |
| | Prehemodilution vs post transfusion | 2 | 0.09 NS |

NS:Non Significant

The mean change in heart rate during various stages of ANH was 1 or 2 beats/min .Statistical analysis have shown that the changes in heart rate during various stages of ANH was insignificant with p value >0.05.

## TABLE 7

## BLOOD PRESSURE CHANGES IN ANH

| Parameter | Pre | Post | Pre | Post |
|---|---|---|---|---|

| | Hemodilution | Hemodilution | Transfusion | Transfusion |
|---|---|---|---|---|
| SBP | 123.67±6 | 124±0.8 | 121.87±4 | 123.87±6 |
| DBP | 77.93±3 | 78±0.6 | 77±5 | 78.3±4 |
| MAP | 94.7±6 | 93.3±5 | 92.57±0.8 | 94.2±5 |

The blood pressure parameters during various phases of ANH are: Prehemodilution systolic BP 123.67±6mm Hg,in posthemodilution period it was 124 ±0.8 mm Hg , pretransfusion value was 121.8 ± 4 mm Hg, during posttransfusion period it was 123.87 ± 6 mm Hg.

Diastolic BP variations during ANH were 77.93 ± 3mmHg in prehemodilution phase, 78 ± 0.6mmHg in posthemodilution phase, During pretransfusion period it was 77±5 mm Hg ; post transfusion diastolic BP was 78.3 ± 4.

The changes in Mean Arterial pressure were 94.7 ±6 mm Hg in pre hemodilution phase, 93..3±5 mm Hg in posthemodilution period , 92.57 ±0.8 mm Hg in the pre transfusion period, 94.2±5 mm Hg in the post transfusion period.

**TABLE 8**

**CHANGES IN SYSTOLIC BLOOD PRESSURE**

| Parameter | Stages of ANH compared | Mean | P-value |
|---|---|---|---|

| | | change | |
|---|---|---|---|
| | Prehemodilution vs posthemodilution | 0.33 | 0.12 NS |
| Systolic Blood Pressure | Prehemodilution vs pretransfusion | 1.8 | 0.41 NS |
| | Prehemodilution vs post transfusion | 0.2 | 0.62 NS |

NS:Non Significant

Table 8 shows the mean change and test of significance of systolic blood pressure between various stages of ANH. The changes in systolic blood pressure during different phases of the ANH procedure were statistically insignificant with P value >0.05

**TABLE 9**

**CHANGES IN DIASTOLIC BLOOD PRESSURE**

| **Parameter** | **Stages of ANH compared** | **Mean change** | **P-value** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| | Prehemodilution vs posthemodilution | -0.07 | 0.25 NS |
| Diastolic blood pressure | Prehemodilution vs pretransfusion | 0.93 | 0.43NS |
| | Prehemodilution vs posttransfusion | 0.37 | 0.12NS |

NS:Non Significant

Statistical analysis of the Diastolic blood pressure variations observed during various phases of ANH showed insignificant changes with P value >0.05.

## TABLE 10

## CHANGES IN MEAN ARTERIAL PRESSURE

| Parameter | Stages of ANH compared | Mean Change | P value |
|---|---|---|---|
| Mean arterial pressure | Prehemodilution vs posthemodilution | 1.4 | 0.16 NS |
| | Prehemodilution vs pretransfusion | 2.13 | 0.09 NS |
| | Prehemodilution vs posttransfusion | 0.5 | 0.52 NS |

NS:Non Significant

Table 10 has listed the mean change and test of significance of mean arterial pressure at various phases of Acute Normovolemic Hemodilution.

Analysis of MAP variation during various stages of ANH showed that the changes were statistically insignificant , P value was >0.05.

## TABLE 11
## CHANGES IN OXYGEN SATURATION DURING ANH

| Parameter | Pre Hemodilution | Post Hemodilution | Pre Transfusion | Post Transfusion |
|---|---|---|---|---|
| Oxygen saturation % | 99.5 ± 0.08 | 99.6 ± 0.4 | 99.43 ± 6 | 99.5 ± 0.09 |

Oxygen saturation during prehemodilution was 99.5 ± 0.08, during posthemodilution it was 99.6 ± 0.4 ,in pretransfusion period it was 99.43 ± 6 and post transfusion period it was 99.5 ± 0.09.

**TABLE 12**
**CHANGES IN OXYGEN SATURATION**

| Parameter | Stages of ANH compared | Mean change | P value |
|---|---|---|---|
| | Prehemodilution vs posthemodilution | 0.1 | 0.18 NS |
| $O_2$ saturation | Prehemodilution vs Pretransfusion | 0.07 | 0.32 NS |
| | Prehemodilution vs posttransfusion | 0 | 0.21 NS |

NS:Non Significant

The above table gives the mean change and test of significance of oxygen saturation at various stages of Acute Normovolemic Hemodilution.

Statistical analysis of changes in $O_2$ saturation have shown insignificant variation during various stages of ANH P value $> 0.05$.

**TABLE 13**

**CHANGES IN BLEEDING TIME AND CLOTTING TIME**

**DURING ANH**

| Parameter | Pre Hemodilution | Post Hemodilution | Pre Transfusion | Post Transfusion |
|---|---|---|---|---|
| Bleeding time (min) | 1.06 ± 0.56 | 1.74 ± 0.64 | 1.92 ± 0.46 | 1.68 ±0.56 |
| Clotting time (min) | 4.12 ± 0.69 | 4.74 ± 0.86 | 5.06 ± 0.04 | 4.90 ± 0.06 |

The bleeding time during different stages of ANH was prehemodilution 1.06 ± 0.16min, posthemodilution 1.74 ± 0.04 min, pretransfusion it was 1.92 ± 0.16min and post transfusion 1.68 ± 0.06 min.

Clotting time values were prehemodilution 4.12 ± 0.69min, posthemodilution 4.7 ± 0.86 min; pretransfusion 5.06 ± 0.04 min and post transfusion 4.90 ± 0.06 min.

## TABLE 14

## CHANGES IN BLEEDING TIME

| Parameter | Stages of ANH compared | Mean change | P value |
|---|---|---|---|
| Bleeding Time | Prehemodilution vs postHemodilution | 0.68 | <0.05 S |
| | Prehemodilution vs pretransfusion | 0.86 | <0.05 S |
| | Prehemodilution vs posttransfusion | 0.62 | <0.001 S |

S:Significant

Table 14 gives the mean change and test of significance of bleeding time at various stages of ANH. Statistical analysis of difference between bleeding time during different stages of ANH has shown to be statistically significant with P value < 0.05 and < 0.001. But the values during different stages were within normal clinical range.

## TABLE 15

## CHANGES IN CLOTTING TIME

| Parameter | Stages of ANH compared | Mean change | P value |
|---|---|---|---|
| | Prehemodilution vs posthemodilution | 0.62 | <0.001 S |
| CLOTTING TIME | Prehemodilution vs pretransfusion | 0.94 | <0.0001 S |
| | Prehemodilution vs posttransfusion | 0.78 | <0.0001 S |

S- Significant

Table 15 has given the mean change and test of significance of clotting time during various stages of ANH.

The changes in clotting time during different stages of ANH was statistically significant with $P<0.001$ . But values were within normal physiological limits .

## TABLE 16

## CHANGES IN HEMOGLOBIN AND HAEMATOCRIT

**DURING ANH**

| Parameter | Pre Hemodilution | Post Hemodilution | Pre Transfusion | Post Transfusion |
|---|---|---|---|---|
| HB GMS% | 12.16 ± 0.34 | 9.4 ± 0.5 | 8.20 ± 0.6 | 10.5 ± 0.8 |
| HCT % | 36.25 ± 2.6 | 28.0 ± 1.4 | 24.2 ± 1.9 | 32.8 ± 2.2 |

Hemoglobin in the prehemodilution period was 12.16 ±0.34 gm/dl, posthemodilution it was 9.4 ± 0.5 gm/dl, pretransfusion it was 8.2 ± 0.6 gm/dl and posttransfusion value was 10.5 ± 0.8 gm/dl.

Hematocrit values during different stages of acute normovolemic hemodilution was prehemodilution 36.25 ± 2.6% ; posthemodilution 27.8 ± 1.4%; pretransfusion 24.2 ± 1.9% & posttransfusion 32.8 ± 2.2%.

## TABLE 17

## CHANGES IN HB gms% DURING ANH

| Parameter | Stages of ANH compared | Mean change | P value |
|---|---|---|---|
| | Prehemodilution vs posthemodilution | 2.76 | <0.0001 S |
| HB gms % | Prehemodilution vs pretransfusion | 3.96 | <0.0001 S |
| | Prehemodilution vs posttransfusion | 1.66 | <0.0001 S |

S:Significant

Table 17 gives the mean changes and test of significance of Hemoglobin at various stages of acute normovolemic hemodilution. The changes were found to be statistically significant.

## TABLE 18

## HEMATOCRIT CHANGES DURING ANH

| Parameter | Stages of ANH compared | Mean change | P value |
|---|---|---|---|
| | Prehemodilution vs posthemodilution | 8.45 | <0.0001 S |
| HEMATOCRIT % | Prehemodilution vs pretransfusion | 12.05 | <0.0001 S |
| | Prehemodilution vs posttransfusion | 3.45 | <0.0001 S |

S:Significant

Table 18 gives the mean change and test of significance of Haematocrit at various stages of acute normovolemic hemodilution.

The changes as anticipated were statistically significant.

## TABLE 19

## CHANGES IN RBC COUNT DURING ANH

| Parameter | Pre Hemodilution | Post Hemodilution | Pre Transfusion | Post Transfusion |
|---|---|---|---|---|
| RBC COUNT (millions/ cumm) | 4.65 ± 0.6 | 3.75 ± 0.3 | 3.3 ± 0.6 | 4.1 ± 0.3 |

The red blood cell count during different stages of ANH was 4.65 ± 0.6 million/cu.mm in pre hemodilution period ; 3.75± 0.3 million/ cumm during posthemodilution; 3.3 ± 0.6 million/cumm during pretransfusion and 4.1 ±0.3 million / cu.mm in the posttransfusion stage.

## TABLE 20

## RBC COUNT CHANGES DURING ANH

| Parameter | Stages of ANH compared | Mean change | P value |
|---|---|---|---|
| | Prehemodilution vs posthemodilution | 0.9 | <0.0001 S |
| RBC Count | Prehemodilution vs pretransfusion | 1.35 | <0.0001 S |
| | Prehemodilution vs posttransfusion | 0.55 | <0.0001 S |

S :Significant

Table 20 gives the mean change and test of significance of RBC count at various stages of Acute normovolemic hemodilution.

Following hemodilution the RBC count decreased to 3.75 ± 0.3 millions / cumm, during pre transfusion period the values further decreased to 3.3 ± 0.6 million /cu.mm, following transfusion the increase in RBC count was observed to reach values of 4.1 ± 0.3 million / cu.mm. The changes were statistically significant as anticipated.

**Table 21**

## SURGICAL BLOOD LOSS

| BLOOD LOSS | ANH n=30 |
|---|---|
| 400-499 | 1 (3.3%) |
| 500-599 | 2 (6.6%) |
| 600-699 | 8 (26.6%) |
| 700-799 | 11(36.6%) |
| 800-899 | 6 (20%) |
| 900-999 | 2 (6.6%) |

36.6% patients had blood loss between 700 - 799 ml

26.6% patients had blood loss between 600 - 699 ml

20% had blood loss between 800 - 899 ml

6.6% had blood loss between 500 - 599 ml

Another 6.6% had blood loss between 900 - 999 ml

About 3.3% patients had blood loss between 400 - 499ml

**Table 22**

## COST ANALYSIS OF STUDY REQUIREMENTS

| ANH n=30 | Blood volume collected (ml) | Colloid replaced (ml) | Cost Rs | Crystalloid replaced (ml) | Cost Rs |
|---|---|---|---|---|---|
| Sum | 23400 | 15250 | 4713.6 | 36210 | 1975 |

| | | | | | |
|---|---|---|---|---|---|
| Average | 780 | 508.3 | 157.1 | 1207 | 65.8 |

| Venflon | Blood bags used | Cost ( Rs) | Total Cost (Rs) |
|---|---|---|---|
| 1650 | 80 | 6000 | 14338.6 |
| 55 | 2.6 | 195 | 472.9 |

Total volume of blood collected was 23400ml

Average volume of blood collected was 780ml.

Total colloid replaced was 15250ml

Average volume of colloid replaced was : 508.3 ml

508ml of colloid costed about : **Rs.157**

Total volume of crystalloid replaced was : : 36210ml

Average volume of crystalloid replaced was 1207ml

To replace 1207ml of crystalloid it costed : **Rs.65.8**

One 16G venflon used to withdraw blood costed **:Rs.55**.

***The total no.of blood bags used was 80 on an average the no.of blood bag used per patient was 2.6***

***The blood bags used for blood withdrawal for each patient Costed:Rs165***

The cost involved in withdrawing 780ml of blood was **Rs.472.9**

Therefore to withdraw one bag of 350ml of blood it costs :

**Rs.212.10**

**Table 23**

**Complications of ANH**

| Complications | Pre Hemodilution | Post Hemodilution | Pre Transfusion | Post Transfusions | Post Operative |
|---|---|---|---|---|---|
| Hypotension | - | - | 1 | - | - |
| Oliguria | - | - | - | - | - |
| Allergic reaction | - | 1 | - | - | - |
| ST segment changes | - | - | - | - | - |
| Pulmonary Odema | - | - | - | - | - |
| Wound Infection | - | - | - | - | 1 |
| Urinary tract infection | - | - | - | - | 1 |

In our study 1 patient experienced hypotension during the pretransfusion period .

Allergic reaction to colloid transfused was noticed in 1 patient. During the postoperative period 1 patient had wound infection and one of the patient had urinary tract infection

# DISCUSSION

ANH is a safe ,easy to handle and effective blood conservation technique. A number of studies conducted by comparing ANH with other blood conservation modalities in various surgical fields have confirmed this.

This study was conducted on 30 patients undergoing gynaecological surgeries .Patients were monitored intraoperatively, postoperatively for the various hemodynamic ,hematological parameters and for occurrence of complications.

**Age distribution :**

In our study the age group of patients selected for the study were between 25-55 years with 33% of patients in the age group 35-39 years and 26%between 40-44 years and 10% belonged to 25-29 years with 6.6% of patients in both 45-49 and 50-54 year age group.

**KUMAR et al**[28] conducted a study of ANH on patients undergoing general,ENT and orthopedic surgeries.The mean age of the patients entering the study was 39+15 years i.e.24-54 years.It was a comparative study between Acute normovolemic hemodilution and

Hypervolemic hemodilution.55% patients belonged to 35-45 year age group. 35% belonged to 24-35 year age group.5% belonged to45-50 years and 5% were >50 years.

**GOKHALE and PS ROY et al** [9] conducted a study comparing the efficacy between Preoperative autologous blood donation and acute normovolemic hemodilution, on patients undergoing general and gynaecological surgeries.

The age group of patients selected were between 21-60 years.46% of patients belonged to 41-50 year age group.32%belonged to 31-40 year age group.5% of them belonged to 51-60 year age group, remaining 17% belonged to 21-30 year age group.

The age group of patients selected for our study on ANH is similar to the age group of patients selected for the above 2 studies.

**Weight of the patients :**

In the study conducted by **Mirhasemi et al**[29] by comparing the two diluents HES and 5% Dextran used for ANH on patients undergoing major gynaecological surgeries the mean weight of the patients was 56+8kg.

In the study by **KUMAR et al**[28] who compared between Hypervolemic hemodilution and Isovolemic hemodilution on patients undergoing general ,ENT and orthopedic surgeries the mean weight of patients was 53±9 kg.

In our study the mean weight of our patients was 58±6 kg.

The weight of the patients who underwent ANH in our study is similar to those included in the above 2 studies.

**Hematocrit :**

**NESS et al** conducted a study comparing perioperative moderate hemodilution with preoperative autologous blood donation .The mean hematocrit of patients included in the ANH group was 34.8±4.7%.

In **KUMAR et al**[28] study which was done on patients undergoing general and ENT surgeries the mean hematocrit among the ANH group was 32.1±2.4%.

The average initial hematocrit of patients included in our study was 36.25%.

This value of hematocrit for our patients was similar to the hematocrit values of patients included for the above 2 studies.

**Heart rate :**

In the study conducted by **Good nough LT et al**[23] by performing moderate Acute Normovolemic Hemodilution on patients undergoing total hip replacement, baseline heart rate was 76+14 beats /min,after withdrawal of first unit of blood it was 72+11 beats /min and after collection of second unit it was 74+12 beats/min. The change in heart rate in his study was statistically insignificant..

**SUTTNER et al**[33] conducted a study comparing the blood sparing efficacy of controlled hypotension alone with combination of ANH and controlled hypotension .In the later group after hemodilution the baseline HR was 72 beats/min,Intraoperative 68/min and immediate postoperative period it was 73 beats /min.Heart rate change was not statistically significant during various phases of ANH.

In a study by **KLOEVEKORN W.**P. et al where moderate acute normovolemic hemodilution was done to a target haematocrit of 27±1 % heart rate was not changed significantly.

In our study the baseline heart rate was 77.4±5beats/min .After hemodilution 78±5/min,pretransfusion it was 79.2±5 and posttransfusion 79.6±4/min.The difference was not statistically significant during various

phases of ANH which is concurrent to the above 3 studies.

**BLOOD PRESSURE :**

In our study MeanArterial Pressure in the prehemodilution period was 94.7±6 mm Hg.Posthemodilution period it was 93.3±5 mm Hg.During the pretransfusion period mean arterial pressure was 92.57± 0.8 mm Hg and in the post transfusion period it was 94.2±5 mm Hg.Throughout the phases of ANH the blood pressure changes were statistically insignificant.

**Hillel laks et al**[17] performed normovolemic hemodilution in patients undergoing total hip replacement. Baseline BP was 122 /78 mm Hg ,post dilution it was 115/76 mmHg,intraoperative it was 115/80 mm Hg.Post transfusion was 119/76 mm Hg.The changes in Blood pressure were statistically insignificant throughout.

In **Anish Firodiya et al**[2] study of ANH on cancer patients the values of Mean Arterial Presssure were as follows Prehemodilution 98.24±4.89 mm Hg,Posthemodilution 95.68±7.1 mm Hg.This difference was statistically significant but clinical difference was only 3 mm Hg and insignificant. The mean postoperative values of MAP was 95.86±.07 mm Hg, which was statistically insignificant.(P>0.05)

The observation in our study is similar to the results of the above studies.

**OXYGEN SATURATION :**

In the study of moderate acute normovolemic hemodilution performed on patients undergoing primary total hip arthroplasty by **Goodnough LT et al**[23] the oxygen saturation was 99±2 % in the prehemodilution period and 99±1% after withdrawal of 2 units of blood .The difference in the saturation levels were statistically insignificant.

**John L Fontana et al**[21] in their study on acute profound normovolemic hemodilution during during scoliosis surgery found that $PaO_2$ during various phases was 505.9±81.7 prehemodilution.; posthemodilution it was 496±55.6 and posttransfusion 520.1±75.5. There was no statistical difference among the saturation levels of various phases.

In a study by **SUTTNER et al**[33] comparing the blood sparing efficacy of controlled hypotension with combined Acute Normovolemic Hemodilution and controlled hypotension the $paO_2$ values during various phases was baseline 169 mm Hg, Posthemodilution 155mm Hg and

posttransfusion 153mm Hg which was statistically insignificant.

In our study the oxygen saturation during prehemodilution was 99.5±0.08, Posthemodilution it was 99.6±0.4, Pretransfusion it was 99.43±6, Posttransfusion value was 99.5±0.09. There was no statistical difference between the values.

This is concurrent to the above 3 studies.

**Bleeding time and Clotting time :**

**Stephanie B Jones et al**[34] conducted acute normovolemic hemodilution on 40 patients undergoing radical prostatectomy. They used 4 different diluents RL,5% albumin, 6% Dextran, 6% Hetastarch to compare their influence on hemostatic markers.

The difference between the preoperative and postoperative values of bleeding time were statistically significant in all group of patients except when RL was used as diluent.

Prehemodilution, posthemodilution and postoperative values of clotting time was statistically significant in all patients irrespective of the diluent used.

In our study the prehemodilution bleeding time was 1.06±0.16

minutes, posthemodilution 1.74±0.04 min, pretransfusion 1.92±0.16 min, posttransfusion 1.68±0.06 min which were statistically significant. But the mean values were within physiologically normal limits.

The prehemodilution clotting time was 4.12±0.69 minutes, posthemodilution was 4.74 ± 0.86 min; pretransfusion 5.06±0.04min; posttransfusion 4.9±0.04min.The difference was statistically significant. But the mean values were within the clinical normal limits. So this observation is similar to the above study.

**Messmer, Sunderplassmann et al** showed in their studies , blood coagulation was not impaired as long as the hematocrit is above 20%.

**HEMOGLOBIN :**

In their study **Stephanie B.Jones et al**[34] observed that mean Hemoglobin values were 12.5±0.8 gm/dl prehemodilution ;9.2±0.6 gm/dl posthemodilution; and 10.2±1 gm/dl in the postoperative period. This was statistically significant.

**Suttner et al**[33] in their study observed following Hb levels changes Baseline 13.7 gm/dl; posthemodilution 9.1 gm/dl; posttransfusion 9.7gm/dl.The difference was statistically significant.

In our study the Hb levels were 12.16±0.34gm/dl prehemodilution; 9.4±0.5gm/dl posthemodilution; 8.2±0.6gm/dl pretransfusion, 10.5±0.8 gm/dl posttransfusion. The difference between the values is statistically significant, which is similar to the above studies.

**HEMATOCRIT :**

In their study **Hillel Laks et al**[17] observed that baseline hematocrit was 42%, posthemodilution it was 21.3% after withdrawal of 2 units of blood; pretransfusion it was 19.7%; posttransfusion was 25.7%.

**KLOEVEKORN W.P et al** in their study of moderate acute normovolemic hemodilution observed that prehemodilution hematocrit was 38 %; post hemodilution it was 31%, pretransfusion 27% and during posttransfusion it was 29% .The differences were statistically significant.

In our study the prehemodilution Hematocrit is 36.25±2.6% posthemodilution Hematocrit is 27.8±1.4%, pretransfusion 24.2±1.9% and posttransfusion was 32.8±2.2%. The differences were statistically significant which is concurrent with the above studies.

**RED CELL COUNT :**

In our study the RBC count was 4.65±0.6 millions/mm3 in the prehemodilution period, 3.75±0.3 million/mm3 in the posthemodilution period 3.3±0.6millions/mm3 in pretransfusion period 4.1±0.3 millions/mm3 in posttransfusion period. The difference in RBC count as anticipated was statistically significant.

**COST FACTOR :**

In our study the average volume of blood collected was 780 ml per patient. .Colloid used for replacement was 508ml and costed Rs.157.10.Average volume of crystalloid used was 1207 ml and costed Rs 65.80. Average number of blood bags used was 2.6 per patient and costed Rs.195 . 16G venflon used for blood withdrawal costed Rs.55.Total cost was Rs.472.90 on an average for one patient. For withdrawal of one bag of 350 ml of blood it costs Rs.210.10.

The major proportion of the cost incurred was spent on the blood bags .Colloids constitute for the next major proportion of money spent. Crystalloids and venflon consumed a small proportion of the total cost. Among them the cost of blood bags will be incurred when the patient needs homologous blood during surgery too. Thus we find that the cost

incurred for Acute Normovolemic Hemodilution is reasonable compared with the expense involved in collection, screening, storage and crossmatching needed for homologous blood.

**TIME FACTOR :**

Average blood collected in our study was 780 ml/patient and it took 45 minutes for hemodilution.For collecting 1 unit of 350 ml of blood time taken was 20.1 minutes.

**COMPLICATIONS :**

In our study 1 patient among 30 patients who underwent ANH experienced hypotension with systolic BP< 100 mm Hg during pretransfusion period ; the blood pressure was stabilized after administration of 1 unit of RL and starting collected blood simultaneously through other port.

In a study by **DOMEN et al**[13] who evaluated the adverse effects of autologous blood in patients undergoing major general surgeries hypotension occurred in 2 patients among 68 who underwent ANH.

The results of our study is similar to the above study.

In our study one patient developed allergic reaction to colloid administered. J.RING et al has reported the incidence of adverse reaction to colloid to be 10-20/10000 patients. His observation therefore coincides with our study.

The incidence of wound infection in our study is 1 among 30 patients who underwent ANH.

In a study conducted by **SANDERS et al**[31] ANH in patients under going major GI surgeries the incidence of wound infection was 3 among 78 patients.

The incidence of urinary tract infection postoperatively was 1 among 30 patients in our study. In **SANDERS et al**[31] study the incidence of UTI was 5 among 78 patients who underwent ANH during major GI surgeries.

So the results of our study is concurrent to the findings in the above study.

# SUMMARY

In our study on Acute Moderate Normovolemic Hemodilution carried out on patients undergoing gynaecological surgeries we found that,

- Average blood collected was 780 ml per patient ,the average volume of colloid used was 508 ml and average volume of crystalloid used was 1207 ml.

- Average time taken to collect 780 ml of blood was 45 min.

- The changes in Heart rate,systolic blood pressure, diastolic blood pressure and mean arterial pressure in the prehemodilution, posthemodilution, pretransfusion, posttransfusion periods were statistically insignificant.All the parameters were well within physiological limits throught the procedure.

- Oxygen saturation changes during the prehemodilution, posthemodilution, pretransfusion, and posttransfusion period was statistically insignificant.

- Bleeding time and clotting time changes during prehemodilution, posthemodilution, pretransfusion, and posttransfusion period were

statistically significant but the changes were clinically insignificant.

- Acute Normovolemic Hemodilution was technically easy to perform.

- Hemoglobin, Hematocrit and Red blood cell count dropped after hemodilution and following surgical blood loss they further dropped down.The values rose up after transfusion of collected autologous blood.

- The complications observed during the study were hypotension 1/30,allergic reaction to colloid in1/30 wound infection 1/30 and urinary tract infection in 1/30.

- The average cost incurred per patient for withdrawal of 780 ml of blood was Rs472.9 which accounts for Rs 210.10 per 350 ml bag of blood.

# CONCLUSION

From the observation we can conclude that moderate Acute Normovolemic Hemodilution is a safe ,technically easy,relatively cheaper method to be considered for salvaging homologous blood transfusion during gynaecological surgeries.Elaborating it

- Acute Normovolemic Hemodilution can be safely performed on patients with routine monitoring of Heart rate,Blood pressure, Pulse oximetry, Urine output and ECG changes.

- It avoids the complications of transfusion reactions and transmission of infectious diseases associated with homologous blood transfusion.

- It is a cost effective method to overcome the shortage of homologous bank blood.

- The technique of Acute Normovolemic Hemodilution is relatively easy to carry out but can extend the theatre occupancy time by an average of 20.1 minutes for each 350ml of blood withdrawn.

- The complications related to the procedure are minimal when compared with the benefits.

## BIBLIOGRAPHY


1. **M.M.Atallah et al** . Does timing of Hemodilution influence the stress response and overall outcome – Anes & Anal 1993 (76)113-7

2. **Dr.Anish Firodiya et al,Dr.J.V.Divatia et al**: Autotransfusion by ANH using 6% HES in cancer patients for head and neck reconstructive surgeries - .Indian Journal of Anaesthesia 2002,(46) 1056-57

3. **G.Audibert, MD Donner M Ph D et al**: Rheological effects of plasma substitutes used for preoperative hemodilution –Anes & Anal April 1994 vol 78,No.4

4. **Brian Friedman et al**. Comparitive study of Postoperative allogenic blood sparing effect of Tranexemic acid Vs ANH after total knee replacement ; Anes&Anal 1999 (89) 138

5. **D.L.Bourke et al.** Estimating allowable hemodilution – Anaesthesiology : 1974 (41) 609-10

6. **J.L.Carlson ,D.G.Alt Man, M.P. Weistein et al** .Risk of bacterial infection associated with allogenic blood transfusion among patients undergoing hip fracture repair. Transfusion Vol 39 ,July 1999; 694-700

7. **Crossby ,Edward T Bsc MD FRCPC** . Perioperative Hemotherapy Journal of Anaesthesia Sept 1992 Vol 39; No 7

8. **Chaney, Mark A MD, Aasen MD et al**, Severe Acute

Normovolemic Hemodilution and survival .Anes &Anal June 1993 Vol 76, No.6

9. **Lt Cols Gokhale et al**. Homologous blood transfusion. Do we have alternatives?-Journal of anaesthesiology vol 56: No 2 ,2000.

10. **Doss Doss N MD Ph D Carlos M et al**. Mechanism of systemic vasodilatation during Acute Normovolemic Hemodilution ,Anes &Anal July 1995, Vol 81: No.1

11. **Dureja et al**. Evaluation of Normovolemic Hemodilution using polygeline and Hetastarch in patients undergoing major surgical procedures.Anes &Anal ,Vol 3: No. 1, 2002 April

12. **D.Rose et al** .Acute Normovolemic Hemodilution: Anaesthesiology 1979 (51)-3

13. **Domen RE et al**. Adverse reactions associated with Autologous blood transfusion. Evaluation and Incidence at large academic hospital. –Acta Anaesthesiology Scandinavia, 2002 Jan ,46(1) ; 74-8

14. **Eike Martin, MD Ernil Hansen MD et al** . Acute limited Normovolemic Hemodilution .A method of avoiding homologous transfusion –World Journal of Surgery 11,1987 ,53-57.

15. **Feldman,Jeffrey M,MD,Mse, Roth et al.** Maximum blood savings by Acute Normovolemic Hemodilution .Anes &Anal -Jan 1995, Vol 80, No.1

16. **George J. Crystal and M. Ramaz salem et al.**Acute

Normovolemic Hemodilution :Text Book of Transfusion Practice, Chapter 7,168-188

17. **Hillel Laks M.D**.**et al .**ANH and its effects on Hemodynamics and oxygen transport in Anaesthetised man. Annals of Surgery –July 1991 ,vol 180, No. 1 .

18. **Herregods L et al .**Comparative study of limited intentional normovolemic hemodilution in patients with left main coronary artery stenosis. Anaesthesiology 1995;(50). 950-3

19. **H.Hint et al .**Hemodilution possibilities and safelimits Acta-Anaes Scandinavia. 1988 ; 90;50-54

20. **C.F.Hogman, Loof et al.** Storage of whole blood before seperation. .The effect of temperature on red cell 2,3 DPG and the accumulation of lactate .Transfusion- Vol 39,May 1999

21. **John .L. Fontana M.D. Peter Sturm M.D**. **et al.** Oxygen consumption and cardiovascular function during profound intraoperative Normovolemic Hemodilution.Anes &Anal 1995 (80),219-25

22. **Konred Messmer et al .**Hemodilution –Possibilities and safety aspects .Acta-Anaes Scandinavia -1988(89) 49-53

23. **Lawrence LT Goodnough et al.** A randomized trial comparing Acute Normovolemic Hemodilution and preoperative Autologous blood donation in total hip arthroplasty.Transfusion Sep 2000 ,Vol 40, 1056-57.

24. **Mortelmans, Y J Gerry et al .**Analysis of autologous and allogenic transfusion in Hip replacement surgery.American Journal of surgery: Vol 171, March 1996.

25. **Mirhasemi R et al.** Impact of intraoperative autologous blood transfusion during Type 3 Radical Hysterectomy. American Journal of Obstetrics &Gynaecology 1999, dec 181(6), 1310-5.

26. **Neil Blumberg MD et al .**Cost Analysis of Autologous and Allogenic transfusion in Hip Replacement surgery.American Journal of Surgery.Vol 171, March 1996.

27. **Oberhauser M et al.** Isovolemic Hemodilution for avoiding homologous blood transfusion.Effectiveness in large gynaecological interventions .Infusions Ther Transfusion 1996 February 23(1) ,15-23.

28. **Rakesh Kumar MD et al**. Prospective randomized study comparing 2 techniques of perioperative blood conservation .Annual Conference of Indian society of Anaesthetists.Dec 1997.

29. **Robert pilon et al .**Study of Acute Normovolemic Hemodilution on hemodynamics in patients undergoing hip replacement .Acta Anaes Scandinavia 1979, (76) ,490-494.

30. **Salma zafar,Ravindra Goyal et al.** ANH in major elective surgeries and effect of hemodilution on the clinical status of the patients .Indian Journal of Anaesthesia –1997,(41) ,166.

31. **Sanders G et al.** Prospective randomized controlled trial of Acute Normovolemic Hemodilution in Major GI Surgery. British Journal of Anaesthesia -vol 93, No.6 ,Pg.775-781.

32. **Spahn, Donat R M.D. et al.** Cardiovascular and coronary physiology of Acute Isovolemic Hemodilution .Anes&Anal -May 1994, Vol 78,No.5.

33. **Suttner S.W.et al.** Cerebral effects and blood sparing efficiency of Sodium Nitroprusside induced hypotension alone and in combination with ANH .British Journal of Anaesthesia-2001,vol.87,No.5 699-705.

34. **Stephenie B.Jones et al.** Influence of crystalloids and colloid replacement solutions in Acute Normovolemic Hemodilution. Survey of hemostatic markers -Anes &Anal -2003 ,(96) ,363-8.

**PROFORMA**

**ACUTE NORMOVOLEMIC HEMODILUTION**

| | | | |
|---|---|---|---|
| Name : | Age : | Unit : | I.P. No. |
| | | Weight : | Date of Surgery: |

Diagnosis :

Surgery :

**INVESTIGATIONS**

| | | | | |
|---|---|---|---|---|
| 1. | Hb | : | BT | : |
| 2. | PCV | : | CT | : |
| 3. | T.C., DC, ESR | : | Blood group | : |
| 4. | RBC count | : | Chest X-Ray | : |
| 5. | Platelets | : | ECG | : |
| 6. | Blood - Urea | : | Urine Alb | : |
| | Sugar | : | Sugar | : |
| 7. | Sr. Creatinine | : | Microscopy | : |
| 8. | Sr.Electrolytes Na+ | : | | |
| | K+ | : | | |
| 9. | S.proteins | : | | |

FORMULA : Volume of Blood to be removed

$$= \text{EBV} \times \frac{(\text{HCT Initial} - \text{HCT Target})}{\text{HCT Average}}$$

| | | | |
|---|---|---|---|
| Volume of blood withdrawn | : | Fluids Replaced | : |
| | | Colloids | : |
| | | Crystallodis | : |
| Anesthetic Technique | : | Starting time | : |
| Monitoring | : | Completing time | : |

| | **Pre ANH** | **Post ANH** | **Pre Transfusion** | **Post Transfusion** |
|---|---|---|---|---|
| H.R. | | | | |
| S.B.P. | | | | |
| D.B.P. | | | | |
| $SPO_2$ | | | | |
| Urine Output | | | | |
| ECG changes | | | | |

| | **Pre ANH** | **Post ANH** | **Pre Transfusion** | **Post Transfusion.** |
|---|---|---|---|---|
| Hb (gm/dl) | | | | |
| HCT (%) | | | | |
| BT (minutes) | | | | |
| CT (minutes) | | | | |
| RBC Count (Millions / cumm) | | | | |

| Initial Hb % | Initial HCT % | Target HCT % | Max volume of blood that can be withdrawn | Volume of blood collected ml | Colloid Replaced ml | Crystalloid Replaced ml |
|---|---|---|---|---|---|---|
| | | | | | | |

Surgical Blood Loss : First Post Operative day. : Hb : PCV :

Date of discharge : Hb : PCV :

Intraoperative : Any complication :

Complications In postoperative

Period

# ABBREVIATION

| | | |
|---|---|---|
| ANH | - | Acute Normovolemic Hemodilution |
| BT | - | Bleeding Time |
| CT | - | Clotting Time |
| DBP | - | Diastolic Blood Pressure |
| DPG | - | DiPhospho Glycerate |
| ECG | - | Electro Cardiogram |
| EDRF | - | Endothelium Derived Relaxing Factor |
| ESR | - | Erythrocyte Sedimentation Rate |
| gms | - | Grams |
| HES | - | Hydroxy Ethyl Starch |
| Im | - | Intramuscular |
| Iv | - | Intra venous |
| Inj | - | Injection |
| IP No | - | Inpatient Number |
| min | - | Minutes |
| mcg | - | Microgram |
| MAP | - | Mean Arterial Pressure |
| NS | - | Normal Saline |
| PABD | - | Preoperative Autologous Blood Donation |
| PCV | - | Packed Cell Volume |
| RL | - | Ringer Lactate |
| RBC | - | Red Blood Corpuscle |
| Sr | - | Serum |
| SBP | - | Systolic Blood Pressure |
| $Spo_2$ | - | Saturation of oxygen |
| $Pao_2$ | - | Arterial oxygen saturation |
| Tab. | - | Tablet |
| U.O | - | Urine Output |