Comparison Of Autologous Vs Homologous Blood Transfusion Combined With Acute Normovolemic Hemodilution And Hypotensive Anaesthesia In Spine Surgeries

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Abstract

Background : Major spine surgeries are almost always associated with significant blood loss and associated hemodynamic instability. It is the responsibility of the anaesthesiologist to ensure that stable hemodynamics are maintained throughout the surgery, at the same time minimizing the risks associated with blood transfusion, using blood conservation strategies during the surgery.
Methods : Acute normovolemic hemodilution and hypotensive anaesthesia are proven methods of blood conservation. They can safely reduce the amount of blood loss and thereby reduce the requirement for subsequent blood transfusion. This study compares the safety and efficacy of autologous versus homologus blood transfusion in spine surgery patients, using the above blood conservation strategies.
Results: This study proves that Acute normovolemic hemodilution combined with hypotensive anaesthesia significantly reduced the amount of blood loss, and the subsequent transfusion requirements in patients undergoing spinal surgeries.
Conclusions : Acute normovolemic hemodilution (PCV>27 %) and hypotensive anaesthesia (systolic BP of 80 mm Hg) can be safely combined. These techniques preclude the use of homologous transfusions in most of the spinal surgeries. Autologous blood transfusion is more superior than homologous transfusion.

INTRODUCTION

Major spine surgeries are associated with clinically significant blood losses and hemodynamic instability. This would necessitate multiple homologous blood and plasma transfusions of large volume, which are associated with significant risks to the patient, such as transmission of infections , acute lung injury, autoimmune reactions, sensitization reactions and hemolysis.

Blood collected from a patient for re transfusion at a later time into that same individual is “autologous blood transfusion”. It is a safer method, eliminating the risks of infections and alloimmunization. There is decreased demand on the blood bank and cancellations of elective surgeries due to non availability of blood are avoided.

Acute normovolemic hemodilution refers to the removal of blood from the surgical patient immediately before or just after induction of anaesthesia, replacement with asanguinuous fluid and later re infusion of the withdrawn blood into the same patient. Thus reducing the hematocrit. This is simpler and reduces the need for transfusion, without compromising the oxygen delivery to the patient. However, there are certain limitations which curtail its use in all patients.

Hypotensive anaesthesia is a method in which the systolic blood pressure of the patient is iatrogenically, thereby reducing the amount of intra operative blood loss. This also reduces transfusion requirements in the patient.

AIMS AND OBJECTIVES

1. To study the efficacy and safety of Acute normovolemic hemodilution along with hypotensive anaesthesia in spine surgery patients.
2. To compare the efficacy and safety of autologous

Vs homologous blood transfusion in spine surgery patients.

3. To study the hemodynamic effects on the patient with the above techniques
4. To study the oxygen delivery to the tissues
5. To study the extent of reduction in transfusion requirements.

INCLUSION CRITERIA

1. Patients with a Hemoglobin value more than 10 gm/dl.
2. Patients with a hematocrit value of more than 30 %.
3. ASA Grade I and II patients, without any severe obstructive or restrictive respiratory or any major cardiac disease.
4. Patients in whom the anticipated blood loss in the spine surgical procedure was large , due to
    a. Anticipated prolonged surgery
    b. Involvement of multiple levels of fracture or surgery
    c. Type of surgery e.g. scoliosis correction
    d. Type of disease e.g. Koch's spine
    e. Use of instrumentation
6. Patients without any evidence of coagulopathy.
7. Age more than 12 years.

EXCLUSION CRITERIA

1. Patients with impaired renal function, which may prolong excretion of colloids or diluents fluids.
2. Patients with pre existing coagulopathy.
3. Significant restrictive or obstructive pulmonary disease with inadequate tissue oxygenation
4. Significantly impaired cardiac reserve status
5. Patients with hemoglobin of less than 10 gm/dl
6. Patients with hematocrit value of less than 30 %

A valid, written and informed consent was taken after explaining to the patient, the risks and benefits of autologous blood transfusion, giving them the opportunity to consent to, or refuse the procedure. This was done in the language and manner best suited for patient comprehension. Institution ethics committee approval was obtained prior to the conduct of the study.

MATERIAL AND METHODS

The criteria for choosing autologous donors are not as stringent as those of allogeneic donors. 50 patients were chosen and divided into 2 groups :

Group A - In whom hemodilution and hypotensive anaesthesia were employed, but without collecting blood from the patient for the purpose of transfusion.

Group B - In whom acute normovolemic hemodilution with hypotensive anaesthesia were employed , after collecting autologous blood prior to induction of anaesthesia.

PROCEDURE AND CONDUCT OF THE STUDY

In the Autologous Group : After taking consent for autologous blood transfusion , the patient is taken into the operation theatre and intravenous line is secured with a 16G veinflow and intravenous crystalloid solution namely Ringer's Lactate was started. The procedure of collecting blood from the patient is explained to the patient and whole blood is collected via a venous access, using commercially available sterile autologous blood collection kits, using the antecubital vein. The Citrate – phosphate – dextrose – Adenine anticoagulant bag (CPD – A) is used, along with a weighing scale, where 1 gram is 1 cc of whole blood approximately.

Estimation of the amount of blood to be collected depended on various factors including those , which are responsible for increasing intraoperative blood loss. The various factors include :

1. Haemoglobin value of the patient
2. Haematocrit of the patient
3. Age
4. Weight
5. Males Vs Females

6. Duration of surgery
7. Posterior versus anterior approach.
8. The use of instrumentation.
9. Multiple levels fused.
10. Presence or absence of underlying disease.

Each standard whole blood unit was equal to 350 cc. Blood was collected by gravity dependent drainage. The bag was kept on the weighing machine for estimation of the amount of blood collected and a tourniquet was tied on the arm, inflating it to approximately 20-30 mm Hg above systolic blood pressure of the patient. The unit of blood was sealed, and labeled with patient identification and stored at room temperature in the operating room. In 9 patients, the duration of surgery was more than 8 hours, and so was the time elapsed prior to the reinfusion. In these cases, blood was refrigerated for 2-3 hours prior to reinfusion.

The maximum quantity of blood to be sequestered was calculated to produce a reduction in haemoglobin to a level of 9 gm/dl or higher, after haemodilution. For this , the following equation was used –

The amount of blood to be withdrawn = estimated blood volume * (pre operative Hb-desired Hb) / pre operative Hb

Volume of blood collected was replaced simultaneously with Ringer Lactate solution, at the rate of 3:1 for the first pint of blood withdrawn, and subsequent hemodilution if greater than one pint of blood was withdrawn, was done based on the vital parameters, haemoglobin and haematocrit level such that Hb does not fall below 9 gm/dl and haematocrit does not fall below 25 %.

The entire procedure was completed in the immediate preoperative period , before induction of anaesthesia , and typically required approximately 30-45 minutes.

IN THE CONTROL GROUP

These patients were also hemodiluted at the rate of 30ml/kg to achieve adequate hemodilution and hypotensive anaesthesia along with infiltration was employed.

ANAESTHESIA MANAGEMENT

All patients were premedicated with Tab Atenolol 0.3-0.5 mg/kg body weight in the morning of surgery with sips of water. Inj. Atropine 0.01 mg/kg intramuscularly was given half an hour prior to surgery as an antisialogogue.

All patients were induced with Inj. Thiopentone sodium 5-7 mg/kg and succinylcholine 2 mg/kg , and intubated with an adequate sized cuffed armour endotracheal tube and maintained on an open circuit with a non re breathing valve , with controlled ventilation with oxygen:nitrous oxide mixture on a 40:60 ratio with 0.5% halothane continuous throughout the surgery. All patients were sedated intraoperatively with Inj. Buprenorphine 3 microgm/kg body weight, and Inj. Midazolam 0.03 – 0.06 mg/kg body weight. All patients were maintained on an intravenous infusion pump of Inj. Vecuronium, a long acting non – depolarizing agent with 4 mg in 50 ml of 5 % dextrose at 40 ml/hour. All patients were positioned in the prone position for the surgery. All patients were infiltrated with epinephrine (1 in 500000) in sensorcaine (20 ml in 500 ml of normal saline) , using 30 – 50 ml of solution on an average.

For hypotensive anaesthesia, a nitroglycerin infusion using 5 mg in 50 cc of 5% dextrose was used. The nitroglycerin was combined with vecuronium in the same infusion drip, and giving at the same rate. Systolic blood pressure was maintained in such a way that it does not fall below 80mmHg .The desired level of hypotension was obtained before incision and maintained upto the completion of surgery. Halothane 0.5 % was administered continuously during the surgery in order to maintain the adequate depth of anaesthesia and the desired level of hypotension. Tab. Atenolol , a potent hypotensive drug used as a premedication also served to maintain the level of hypotension.

Intraoperative monitoring was achieved by :

1. Arterial catheter with a 20 G Jelco , which provided a site for obtaining blood for determining the oxygenation and acid – base status and for continuous blood pressure monitoring.
2. Pulse oximeter which provides continuous information regarding oxygen saturation.
3. End tidal CO2 monitoring which provides information regarding the ventilator status of the patient.
4. Insertion of a urinary catheter is imperative because urine output serves as a guide to intravascular volume status. Use of a catheter is especially important when crystalloids are infused,

because of the large volumes administered and excreted.

5. Pulse monitoring , which provides information of hypovolemia , lighter planes of anaesthesia and other complications of surgery and anaesthesia.
6. ECG monitoring to ensure normal cardiac function
7. Haemoglobin and Hematocrit monitoring – at intraoperative , pre transfusion and post transfusion periods.

Blood loss was estimated by

1. Estimating the amount of blood in suction bottle – as ml
2. Weighing the mops , before being soaked with blood , and after being soaked with blood and taking the difference in grams to be its equivalent as 1 gm = 1 cc.
3. Estimating the amount of blood lost on the drapes and sheets.

TIME OF TRANSFUSION

In the autologous group , all patients were administered blood after haemostasis was achieved and closure started , before reversal of the patient , irrespective of the requirement. In the control group , homologous blood was only transfused when the blood loss far exceeded the tolerable blood loss so much so that the Hb levels fell to 9 gm/dl and below , and the haematocrit fell to 26.8 % and below , the oxygen saturation was not being maintained and the patient had acidosis.

All patients were reversed with Inj. Neostigmine 0.05 mg/kg and Inj. Atropine 0.02 mg/kg and extubated after confirming adequate tone, power and reflexes as per the case's pre operative condition.No patient required ventilator support after surgery. Arterial lines were discontinued post operatively.

Post transfusion , all the vital parameters including pulse, BP, ECG, oxygen saturation, Hb, Haematocrit were monitored and recorded in all the patients.

Post operative monitoring continued as an extension of post transfusion monitoring and as per the Hb and Haematocrit values, post operative blood transfusion – homologous blood , or haematinics were advised.

OBSERVATIONS , GRAPHS AND RESULTS

The present study was carried out to preclude the use of homologous blood in spinal surgeries, by employing various techniques. Fifty patients were studied, which included a random study of patients above 13 years of age, with an average weight of 50 kg. They compromised of two groups :

Group A – patients in whom haemodilution with hypotensive anaesthesia was done without autologous blood withdrawal prior to induction of anaesthesia.

Group B – patients in whom acute normovolemic hemodilution combined with hypotensive anaesthesia was employed i.e. in these patients, autologous blood was removed prior to induction of anaesthesia.

Fourteen patients belonging to Group B were transfused autologous blood irrespective of the indication to do so. In case of Group A, patients were transfused blood as per hemodynamic status and tolerable blood loss. Thirteen patients out of 25 patients had to be transfused more than 1 pint of blood.

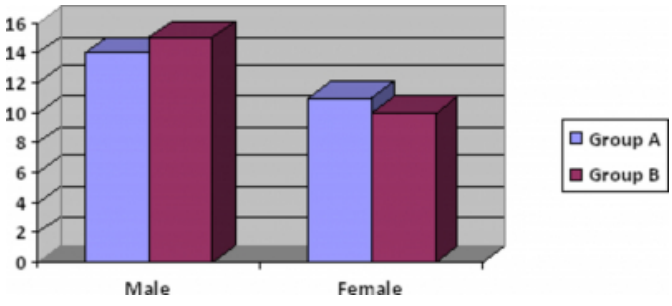
Figure 1

Table 1 : Sex distribution

Sex	Male	Female
Group A	14	11
Group B	15	10

Figure 2

Graph 1



In the randomized study , almost equal number of males and females participated in the study.

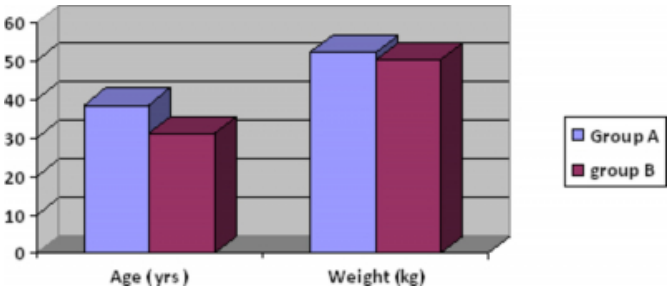
Figure 3

Table 2 : Age distribution

	Age (years) Mean +/- SD	Weight (kg) Mean +/- SD
Group A	38.6 +/- 18.7	52.28 +/- 11.81
Group B	31.4 +/- 15.27	50.12 +/- 11.52

Figure 4

Graph 2



There was no significant difference in the age and the weight of the patients in both the groups who participated in the study.

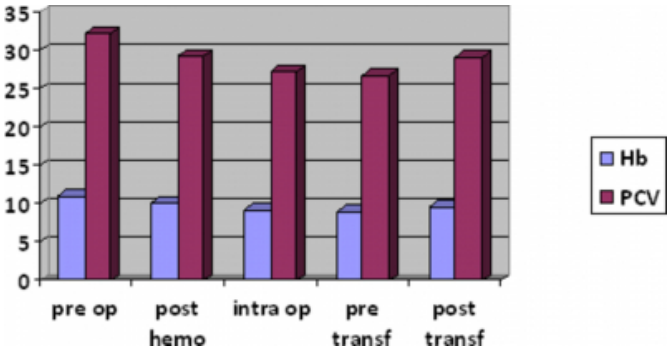
Figure 5

Table 3 a : Hemoglobin (Hb) and Hematocrit (PCV) values in Group A

Stage	Pre operative	Post hemodilution	Intra operative	Pre transfusion	Post transfusion
Hb (mean +/- SD)	11.048+/- 0.96	10.14 +/- 0.941	9.18 +/- 0.69	8.98 +/- 0.728	9.68 +/- 0.59
PCV (mean +/- SD)	32.16 +/- 4.836	29.24 +/- 1.96	27.28 +/- 2.3	26.8 +/- 2.243	29.2 +/- 1.87

Figure 6

Graph 3 a



Intraoperatively, Hb was maintained at 9.18 +/- 0.69 gm% and the PCV was maintained at 27.28 +/- 2.301%. The post transfusion values of Hb and PCV were much lower than the pre operative values.

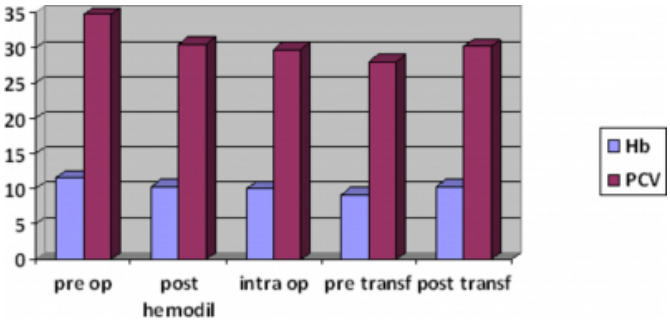
Figure 7

Table 3 b : Hemoglobin (Hb) and Haematocrit (PCV) values in Group B

Stage	Preoperative	Post Haemodilution	Intra operative	Pre transfusion	Post transfusion
Hb (Mean +/- SD)	11.6 +/- 1.4	10.34 +/- 1.382	10 +/- 1.35	9.16 +/- 1.273	10.34 +/- 1.31
PCV (Mean +/- SD)	34.8 +/- 4.22	30.62 +/- 3.96	29.88 +/- 3.87	28.08 +/- 3.87	30.2 +/- 3.41

Figure 8

Graph 3 b



The intraoperative values of Hb were maintained at 10 +/- 1.35 gm% and a PCV of 28.08 +/- 3.87 gm%. The post transfusion values of Hb and PCV were not much lower than the pre operative values , signifying a lesser amount of blood loss which could be easily corrected.

Figure 9

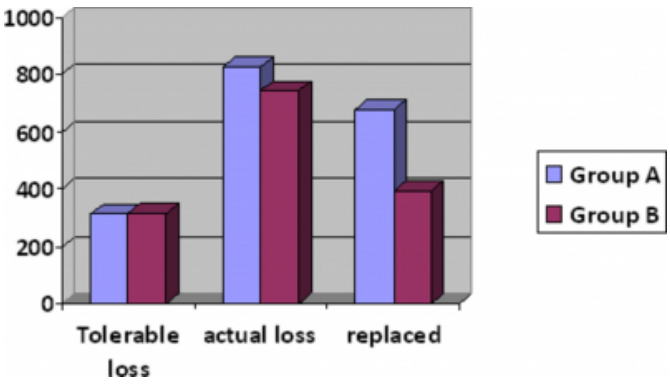
Table 4 : Blood loss (ml) and blood transfusion (ml)

	Group A (mean +/- SD)	Group B (mean +/- SD)
Tolerable blood loss (ml)	312.2 +/- 95.35	316.54 +/- 91.29
Actual blood loss (ml)	826 +/- 490.7	744 +/- 409.85
Blood replaced (ml)	676.92 +/- 433.3	396 +/- 159.37

(1 unit = 350 ml)

Figure 10

Graph 4



The amount of homologous blood replaced was significantly

higher ($p < 0.005$) as compared to the autologous blood transfusion as per the unpaired t – test.

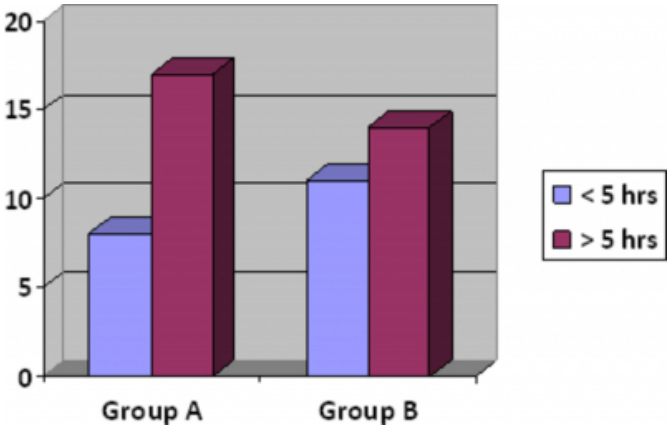
Figure 11

Table 5 : Duration of the surgery

Duration of surgery	Group A (no. of patients)	Group B (no. of patients)
< 5 hours	8	11
>5 hours	17	14

Figure 12

Graph 5



The maximum duration of surgery was 12 hours and the minimum duration of surgery was 2 hours.

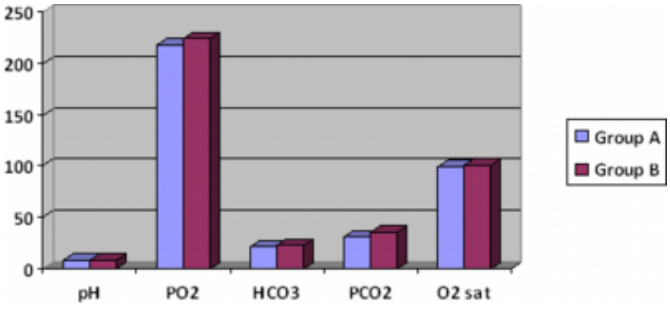
Figure 13

Table 6 : Intra operative Arterial Blood gas values

	Group A (Mean +/- SD)	Group B (Mean +/- SD)
pH	7.423 +/- 0.082	7.382 +/- 0.532
pO_2	217.24 +/- 59.4	223.8 +/- 61.33
HCO_3	20.46 +/- 3.03	22.16 +/- 2.34
pCO_2	30.15 +/- 6.06	36.312 +/- 6.308
O_2 Saturation	99.55 +/- 0.392	99.99 +/- 0.367

Figure 14

Graph 6



The intra operative ABG in both control as well as autologous groups were maintained within the normal limits without any significant difference in their values.

In our observations, mean and standard deviation and the unpaired t – test were applied as required.

In the control group :

1. Hb and PCV : Twenty five patients of the control group were hemodiluted from a pre operative Hb of 11.048 +/- 0.965 gm % to a Hb of 10.14 +/- 0.941 gm % and a pre operative PCV of 32.16 +/- 4.836 % to a PCV of 29.24 +/- 1.96 %. (Table and Graph 3a).

2. Hypotensive anaesthesia : A pre operative BP of 117 +/- 13.92 mm Hg systolic was reduced to a post hemodilution BP of 97.68 +/- 7.29 mm Hg systolic , which further increased post transfusion to a BP of 114.6 +/- 17.06 mm Hg systolic BP. Hence the post transfusion BP was almost the same as preoperative BP. The intra operative pulse rate values remained at 73.2 +/- 19.22 per minute.

3. Blood transfusion : At a Hb of 8.98 +/- 0.728 and a PCV of 26.88 +/- 2.242, homologous blood was transfused. The pre transfusion BP values were 90.84 +/- 5.65 mm Hg systolic and the pulse rate was 99.64 +/- 0.489 . (Table and Graph 3 a).

4. Blood loss : The blood loss was 826 +/- 490.7 ml as against the tolerable blood loss of 312.2 +/- 95.359 ml , hence a significant amount of homologous blood of 676.92 +/- 433.3 ml had to be replaced. (Table and Graph 4).

5. Intraoperative ABG (Table and Graph 6) : Throughout the surgery , the ABG was maintained as follows :

Figure 15

pH	7.423 +/- 0.082
pO_2	217.24 +/- 59.4
HCO_3	20.46 +/- 3.03
pCO_2	30.15 +/- 6.06
O_2 Saturation	99.55 +/- 0.392

In the Autologous group :

1. Hb and PCV : As compared to the second group of 25 patients , this group underwent Acute Normovolemic hemodilution combined with hypotensive anaesthesia from a pre operative Hb of

11.6 +/- 1.4 gm % and a PCV of 34.8 +/- 4.22 % to a post hemodilution Hb of 10.34 +/- 1.38 gm % and a PCV of 30.63 +/- 3.96 % (Table and Graph 3 b).

2. Hypotensive anaesthesia : Hypotensive anaesthesia was employed from a pre operative BP of 116.48 +/- 13.72 mm Hg systolic to a post hemodiluted BP of 101.8 +/- 15.75mm Hg systolic, and was maintained throughout the surgery, to a post transfusion BP of 115.56 +/- 15.63mmHg. The intraoperative pulse rate was maintained at 84.28 +/- 15.23 per minute.

3. Blood transfusion : At a Hb of 9.68 +/- 1.27 gm % and a PCV of 28.08 +/- 3.87 % , autologous blood was transfused. This was a significant finding at $p < 0.02$, proving that blood was transfused at a much higher Hb value compared to the control group , because the patients could maintain a higher Hb due to lesser blood loss and Acute Normovolemic Hemodilution. (Table and Graph 3b).The pre transfusion BP was 92.2 +/- 16.51 mm Hg and the pre transfusion pulse rate was 99.48 +/- 0.509 per minute. The patients in this group were transfused autologous blood irrespective of their need.

4. Blood loss : The blood loss was 744 +/- 409.85 ml comparative to the tolerable blood loss of 316.54 +/- 91.29 ml. Autologous blood of 396 +/- 159.37 ml was replaced (Table and Graph 4).

5. Intra operative ABG : Throughout the surgery , the intraoperative ABG was maintained

Figure 16

	Group B (Mean +/- SD)
pH	7.382 +/- 0.532
pO_2	223.8 +/- 61.33
HCO_3	22.16 +/- 2.34
pCO_2	36.312 +/- 6.308
O_2 Saturation	99.99 +/- 0.367

Comparative to the control group, the amount of autologous blood transfused was significantly lesser ($p < 0.005$) , proving that intraoperative acute normovolemic hemodilution reduced the amount of homologous blood required for spinal surgeries.

DISCUSSION

Blood collected from a patient for re transfusion at a later time into the same individual is “autologous blood”. Autologous blood can be obtained by pre deposit phlebotomy, intraoperative blood salvage , post operative blood salvage and peri operative normovolemic hemodilution. Predeposit autologous blood donations are scheduled weekly or at 4 day intervals with the phlebotomy performed 72 hours or more before the surgery. Most programmes require the Hemoglobin to be atleast 11 gm % or a PCV of > 34 % before each phlebotomy and oral iron supplements are administered. Diseases and conditions that otherwise preclude blood donations do not preclude autologous blood donation, eg. Cardiovascular disease. If a patient's condition is stable enough to allow elective surgery, he generally can donate several units of blood in a carefully controlled environment. Pregnant women can donate safely, especially in the second trimester. The donated blood should undergo ABO and Rh groups screening, antibody testing, and screening for Hepatitis surface antigen and HTLV type III antigen. Crossmatching is not required and is not economical. ([1,2]).

Advantages of this method are that it is safe in terms of reducing transfusion associated infectious and immunologic risks, relatively a simpler method, reduces the demand for homologous transfusion and may ensure blood availability for patients with rare phenotypes undergoing surgeries. ([3,4]).

Disadvantages of this technique are that there is no preservation of functional platelets, clotting factors and this would lead to the oxygen dissociation curve to the left , the procedure is less cost effective, time consuming and associated with side effects like anemia and hypovolemia to the patient, transient vasovagal reactions and ischemic episodes. There is a potential for administration of contaminated blood. This procedure can be used for elective surgeries only , and its use is limited in emergency surgeries. The greatest potential hazard associated with this procedure is transfusion of pre donated blood to an unintended recipient. ([5]).

Intra operative blood salvage consists of collecting blood in sterile single use reservoir units for immediate re infusion. The oxygen transport properties and survival of salvaged RBC's are equal to or superior to those of stored allogeneic RBC's. However, there are chances of air embolism while reinfusion, pulmonary dysfunction secondary to infusion of cellular debris, coagulopathy, sepsis and activation of

coagulation factors which can induce disseminated intravascular coagulopathy. ([5])

Post operative blood salvage consists of salvaging and re infusion of shed blood following open heart surgery from the mediastinum, and blood from the chest following traumatic hemothorax. Transfusion requirements can be reduces in many patients undergoing these types of surgeries, and recently this technique is also used in orthopedic surgeries. It is considered to be safe and well tolerated, but the contraindications are infected blood and exposure of blood to malignant cells ([5])

Acute normovolemic hemodilution refers to the removal of blood from the surgical patient immediately before or just after induction of anaesthesia, replacement with asanguinuous fluid and reinfusion of the withdrawn blood at a later time. This is employed to reduce the need for allogeneic RBC's and to avoid the potential complication of transfusion. The chances of clinical error are limited in this technique. There is no influence over the oxygen – Hb dissociation curve and there is improvement in tissue perfusion as a result of decreased viscosity. It is simpler and less expensive than the earlier methods and it may be acceptable to patients of Jehovah's witness if the blood is maintained in a close circuit continuous system. The major contraindications include anaemia , decreased renal function , patients with significant coronary artery disease and severe carotid artery disease and inadequate vascular access and monitoring facilities. ([6],[7])

The effects of intraoperative blood salvage and induced hypotension on transfusion requirements were studied during 170 spinal surgery patients. It was found that intraoperative autologous transfusion reduced the amount of homologous blood required, by more than 50 % . ([8])

In our study involving 50 patients using preoperative autologous blood donation and acute normovolemic hemodilution , combined with hypotensive anaesthesia, only one patient out of 50 (2 %) needed to be transfused homologous blood postoperatively.

In a study involving acute normovolemic hemodilution and hypotensive anaesthesia in spinal fusion surgery , 17 % of the estimated blood volume was collected in the predonation group ([9]) In our study , the maximum amount of blood withdrawn was 700 ml and the minimum amount of blood withdrawn was 200 ml, according to the inclusion and exclusion criteria.

The average intraoperative blood loss in our study was found to be 826 ml in the control group , and 744 ml in the autologous group. Masayoshi et al in their study of the use of autologous blood in the surgical treatment of spinal disorders, observed an average blood loss of 1000-1500 ml in scoliosis patients. ([10]).

We included spine surgeries like scoliosis, PLIF and Koch's decompression surgeries in our study. These are associated with significant blood losses intraoperatively.

We maintained an intraoperative BP of mean 93mmHg systolic and diastolic of mean 65mmHg in the control group, and a systolic BP of 99mmHg and diastolic BP of 67mmHg were maintained in the autologous group. No ECG changes were observed suggestive of myocardial ischemia in both the groups. This observation is further supported by the study by Su-Ryong et al , whose study showed the mean BP of 55mmHg and there were no gross changes in the ECG suggestive of myocardial ischemia during the surgery or in the recovery period. ([11]) .

We transfused an average of 676 ml of blood in the control group and 396 ml of blood in the autologous group, which proved to be significant ($p < 0.005$) as per the unpaired t – test. This proves that Acute normovolemic hemodilution combined with hypotensive anaesthesia significantly reduced the amount of blood loss , and the subsequent transfusion requirements in patients undergoing spinal surgeries. No complications during the entire procedure of Acute normovolemic hemodilution and hypotensive anaesthesia were observed.

In conclusion , it can be implied from the above study that –

- Acute normovolemic hemodilution (PCV>27 %) and hypotensive anaesthesia (systolic BP of 80 mm Hg) can be safely combined.
- These techniques preclude the use of homologous transfusions in most of the spinal surgeries.
- The transfusion decisions should be based on clinical judgment and haemodynamic status , rather than the preset values of Hb of 10 gm % and a PCV of 30 %.
- Autologous transfusion, along with Acute normovolemic hemodilution, avoids the changes

seen in storage of blood , and proves to be the safest , most cost effective and easiest form of transfusion therapy.

- Oxygen delivery to the tissues is maintained throughout hemodilution.
- Acute normovolemic hemodilution and hypotensive anaesthesia significantly reduced the amount of blood loss and the amount of blood required to be transfused, thus precluding the use of homologous blood. Thus in comparison, autologous blood is more superior.

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