Original Article

A COMPARATIVE STUDY OF DILUENTS (CRYSTALLOID VS COLLOID) IN ACUTE NORMOVOLAEMIC HAEMODILUTION (ANH)

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ABSTRACT

Background: Acute normovolaemic haemodilution (ANH) is one of the types of autotransfusion which can be used as an alternative method of replacing lost blood during surgery. Normovolaemia has to be maintained during ANH by administering sufficient volume of haemodiluents either crystalloids or colloids. Aim: To compare prospectively the effects of two haemodiluents, Crystalloid (Ringer lactate) and Colloid (Polygeline) in moderate Acute Normovolaemic haemodilution (ANH). Methodology: 50 patients(ASA physical status I or II) undergoing elective gynaecological surgeries with an estimated prediction of blood loss from 500-750ml in each patient were divided into two groups of 25 each. In Group R – Ringer lactate in the ratio of 3:1 and in Group H –Polygeline (Haemaccel) in the ratio of 1.5:1 were used during haemodilution. Heart rate, systolic BP, diastolic BP, SPO2 and Haematocrit were observed before and after haemodilution, before and after retransfusion of the blood. All the data were analyzed using Student's 't' test and P values < 0.05 were taken to be significant. Results: During all the stages there were no statistical differences in heart rate, systolic BP, Diastolic BP, SPO2, Haematocrit and surgical blood loss between the two groups. Conclusion: We conclude that during moderate acute normovolaemic haemodilution(ANH) either Ringer's lactate or Polygeline(Haemaccel) can be used as replacement fluid as both are comparable in terms of haemodynamic stability, oximetric and haematological profiles.

INTRODUCTION

Blood for blood is an ancient dictum surprisingly still being followed perioperatively by many doctors. But blood is a tissue and its transplant is not without risks. Blood is often scarce, needs screening and blood should be considered only if the need is thoroughy established. This led to the search for alternative methods of replacing lost blood during surgery. Among these the most valid alternative is auto transfusion, where donor and recipient are the same person. The most widely used methods of autotransfusion are a) predeposit, b) intraoperative salvage, c) Acute Normovolaemic Haemodilution (**ANH**). ANH involves taking a specific quantity of blood from the patient immediately before the operation and replacing it with a sufficient volume of crystalloids and/or colloids to maintain a state of normovolaemia. Limited (moderate) normovolaemic hemodilution refers to the technique that does not allow haemotocrit level to drop below 25%. Extreme normovolaemic hemodilution refers to the technique that allows the haematocrit level to fall below 20%.

Two major reasons for employing autologous transfusions are avoidance of complications associated with allogenic transfusion and conservation of blood resources. Other advantages are (i) avoidance of immunosuppressive effects of allogenic transfusion (ii) Elimination of allo-immunisation, allergic and febrile reactions, acute and delayed haemolytic reactions (iii) Patients with rare blood phenotypes can benefit from autologous blood transfusion because compatible allogenic blood may not be available (iv) preoperative phlebotomy with acute normovolamic haemodilution is the only practical source of fresh whole blood for transfusion during surgery.

AIM

To compare prospectively the effects of two haemodiluents, Crystalloid (Ringer lactate) and Colloid (Polygeline) in moderate Acute Normovolaemic haemodilution(ANH). The parameters observed and compared in the study were (a) haemodynamic (heart rate, systolic blood pressure, diastolic blood pressure), oximetric (oxygen saturation of Haemoglobin), Haematological (haematocrit).

MATERIALS AND METHODS

This study was conducted at the Government Rajaji Hospital, Madurai which is attached to Madurai Medical College, Madurai. The study was conducted during the year 1996. The Institutional Ethics committee approval was obtained. The sample size was 50 patients undergoing elective gynaecological surgeries with an estimated prediction of blood loss from 500-750ml in each patient. The aim of the study is to compare the effects of two diluents namely crystalloid (Ringer's lactate) and colloid (Polygeline) during moderate haemodilution. The patients admitted to the study were candidates for elective gynaecological surgery in which the transfusion of even a single unit of blood was envisaged. The inclusion criteria for the study were a) females who came for surgery for DUB, Uterine fibroid, Ovarian tumours, Carcinoma of Cervix, b) Haematocrit 30% or higher with effective normohydration, c) Haemoglobin level equal to or more than 10 gms%. The exclusion critieria for the study were a) reduced cardiac function reserve, b) reduced respiratory function reserve, c) blood coagulation disorders, d) renal insufficiency, e) hypoalbuminaemia, f) haemoglobinopathies, g) treatment with beta-blockers.

All the 50 patients belonged to ASA physical status I or II. The 50 patients were divided into two groups of 25 each. Group 1 (**Group R**) – Ringer lactate was used during hameodilution. In group II (**Group H**) –Polygeline (haemacel) was used during haemodilution. Written informed consent was obtained from all the patients. All the patients were premedicated with inj. Pentazocine lactate i.m and inj Atropine sulphate i.m in appropriate doses 45 minutes prior to induction. Patients were brought inside the theatre in a properly premedicated state. Under aseptic conditions a wide bore cannula (16G) inserted into one of the peripheral veins. The patient was catheterized with an indwelling urinary catheter. Pulseoximeter was connected to the patient. It was decided to monitor the blood pressure non-invasively from mercury manometer. It was decided to take blood after induction of anaesthesia. Balanced anaesthesia technique (Oxygen – Nitrous oxide - Narcotic – muscle relaxant technique) was used in all cases. Baseline blood pressure, heart rate, SPO 2,Haematocrit were noted.

After induction of anaesthesia, under stable haemodynamic conditions, blood was drained from antecubital vein of the limb which has not been cannulated for infusion of fluids. Blood was drained into sterile collapsible Citrate – Phosphate – Dextrose – Adenine (CPD-A) anticoagulated bags. Each bag contains 49ml of Anticoagulant for collection of 350 ml of blood. It was decided to draw 350ml of blood from all the patients. In Group H, blood drained was simultaneously replaced with 3.5 % polygeline (haemacael) in the ratio of 1:1.5. In Group R, blood drained was simultaneously replaced with Ringer's lactate in the ratio of 1:3.

Heart rate, systolic blood pressure, diastolic blood pressure, SPO2 were recorded during and immediately after the process of haemodilution. Haemotocrit was estimated after haemodilution. The blood taken was kept at the room temperature. After stable haemodynamic condition was achieved, the surgery was allowed to proceed. Intraoperative fluid management incuded Ringer's lactate. Dextrose saline and polygeline depending on the surgical blood loss with an aim of achieving stable haemodynamic status. Intraoperative monitoring included heart rate, systolic blood pressure, diastolic blood pressure, SPO2, Haematocrit, urine output, blood loss. Blood loss was measured from swabs, drapes and suction bottles. After major surgical loss was over, blood pressure, heart rate, SPO2, and haematocrit were recorded. The autologous blood was reinfused after surgical haemostasis was attained or if necessary when the loss exceeds 400 – 500 ml. If the surgical blood loss exceeded 800 – 1000ml bank blood was ordered. After transfusion of blood the vital parameters were recorded. At the end of surgery, the patient was adequately reversed and after patient fully recovered, shifted to postoperative ward. In the postoperative ward the vital parameters were

monitored. Patients were followed up till discharge. Patients were examined for the presence of lung infection, delayed wound healing or any other complication. They were recorded if any of them were present. All the data were analysed using **Student's 't' test** and P values < 0.05 were taken to be significant. The mean and standard deviation for all parameters were calculated in both the groups.

RESULTS

	GROUP H	GROUP R	INFERENCE BY 't' TEST
AGE (YEARS)	37.2 ± 9.84	40.84 ± 7.13	NOT SIGNIFICANT (NS)
WEIGHT (KGs)	46.88 ± 6.27	48.68 ± 4.3	NOT SIGNIFICANT (NS)

Demographic data : Table 1

As the P value is more than 0.1, there were no significant difference in age and weight between the two groups. In other words, both the groups were comparable with respect to age and weight.

PARAMETERS	GROUP H	GROUP R	INFERENCE
HEART RATE	94.64 ± 7.43	95.12 ± 3.83	NS (P>0.1)
SYSTOLIC B.P	131.2 ± 7.81	133.2 ± 8.52	NS (P>0.1)
DIASTOLIC B.P	87.2 ± 6.24	87.6 ± 4.04	NS (P>0.1)
SPO2	98.64 ± 0.57	98.56 ± 0.5	NS (P>0.1)
HAEMATOCRIT	35.44 ± 2.2	34.96 ± 2.2	NS (P>0.1)

PRE-HAEMODILUTION : Table 2

As the P values were more than 0.1, there were no statistical differences in heart rate, systolic BP, diastolic BP, SPO2, and Haematocrit between the two groups.

PARAMETERS	GROUP H	GROUP R	INFERENCE
HEART RATE	103.44 ± 10.45	102.16 ± 4.61	NS (P>0.1)
SYSTOLIC B.P	129.2 ± 13.04	130.4 ± 9.34	NS (P>0.1)
DIASTOLIC B.P	86.32 ± 8.9	86.64 ± 3.73	NS (P>0.1)
SPO2	98.48 ± 0.65	98.56 ± 0.5	NS (P>0.1)
HAEMATOCRIT	31.6 ± 2.06	31.8 ± 2.16	NS (P>0.1)

POST-HAEMODILUTION : Table 3

As the P values were more than 0.1, there were no statistical differences in heart rate, systolic BP, Diastolic BP, SPO2 and Haematocrit between the two groups.

PARAMETERS	GROUP H	GROUP R	INFERENCE
HEART RATE	103.0 ± 11.7	105.76 ± 5.64	NS (P>0.1)
SYSTOLIC B.P	125.36 ± 11.57	123.84 ± 9.5	NS (P>0.1)
DIASTOLIC B.P	86.56 ± 7.03	86.64 ± 3.73	NS (P>0.1)
SPO2	98.8 ± 0.81	98.56 ± 0.5	NS (P>0.1)
HAEMATOCRIT	27.44 ± 2.16	31.8 ± 2.16	NS (P>0.1)

BEFORE RETRANSFUSION : Table 4

As the P values were more than 0.1, there were no statistical differences in heart rate, systolic BP, Diastolic BP, SPO2 and Haematocrit between the two groups.

PARAMETERS	GROUP H	GROUP R	INFERENCE
HEART RATE	96.0±13.09	98.88±3.11	NS (P>0.1)
SYSTOLIC B.P	128.8±9.11	130.0±7.07	NS (P>0.1)
DIASTOLIC B.P	85.76±6.79	87.28±8.22	NS (P>0.1)
SPO2	98.4±0.64	98.6±0.5	NS (P>0.1)
HAEMATOCRIT	31.04±1.92	30.28±2.4	NS (P>0.1)

AFTER RETRANSFUSION : TABLE 5

As the P values were more than 0.1, there were no statistical differences in heart rate, systolic BP, Diastolic BP, SPO2 and Haematocrit between the two groups.

PARAMETERS	GROUP H	GROUP R	INFERENCE
SURGICAL BLOOD LOSS	604 ± 183.09	564 ± 119.48	NS (P>0.1)
URINE OUTPUT	249 ± 67.11	362 ± 60	S (P< 0.1)

BLOOD LOSS AND URINE OUTPUT : TABLE 6

As the P value was more than 0.1, there was no statistical difference in surgical blood loss between the two groups. As the P value was less than 0.001, there was statistical difference in urine output between the two groups.

In group H one patient developed hypotension immediately after transfusion of haemaccel during haemodilution. Rashes were noted in this patient. It was treated with vasopressors, steroids and antihistaminics. In group R none of them developed such reaction. In Group H and Group R taken together, only 5 patients needed homologous blood transfusion as the surgical blood loss exceeded 800 - 1000 ml and Haematocrit fell below 25%. None of the 50 patients in the study developed any complications in the postoperative period.

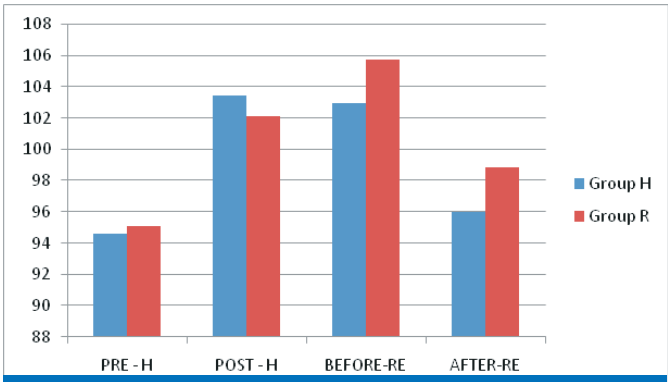

Figure 1 : HEART RATE

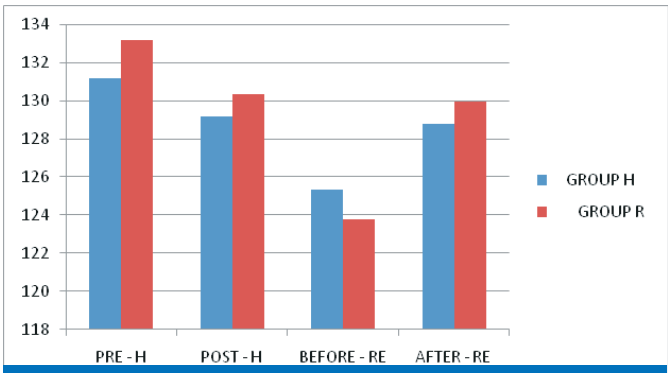

Figure 2 : SYSTOLIC BP mmHg

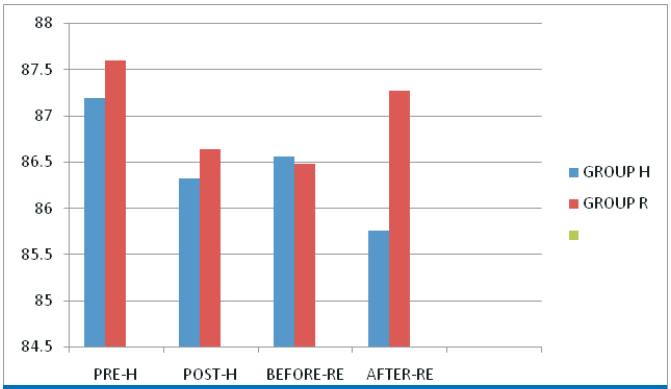

Figure 3 : DIASTOLIC BP mmHg

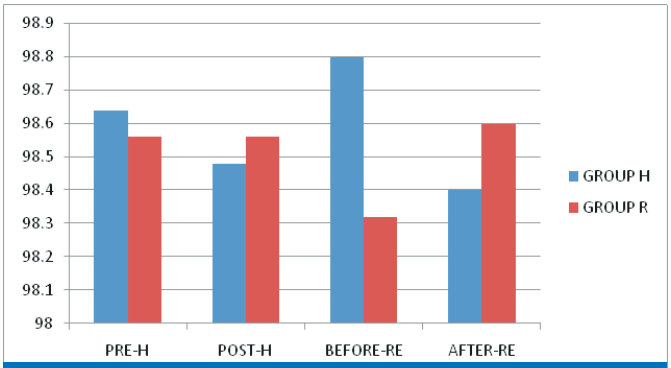

Figure 4 : SPO2

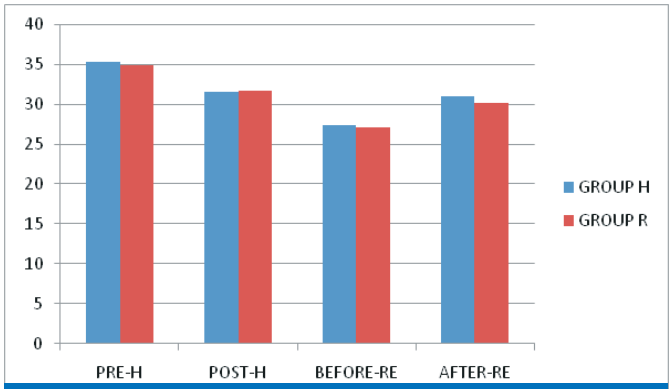

Figure 5 : HAEMATOCRIT

DISCUSSION

Since in ANH, cardiac output compensatorily rises as blood viscosity and peripheral vascular resistance fall, the selection of haemodiluent is crucial. For these physiological changes to happen before surgery, one must maintain a normal circulatory volume. Attempting to determine the best diluent, we have compared the haemodynamic effects of using either a colloid or a crystalloid as replacement of blood removed during moderate ANH. All the 50 patients were to undergo abdominal hysterectomy or laparotomy and removal of ovarian tumours. This was done as there would be standardization with respect to type of surgeries, type of surgeons, type of blood loss and blood requirements. The amount of blood to be withdrawn depends on the patients baseline haematocrit, body weight, surgical blood loss, patient's condition and availability of invasive monitors. As most of the proposed surgeries in the study need ony one unit of blood, it was decided to draw one unit of blood (350 ml) from each patient, thereby making the technique as moderate ANH. Patients in both the groups were comparable with respect to age and weight. Balanced anaesthesia technique was used in all the patients. The aim of anaesthetic technique was to use agents which would be least likely to prevent increase in cardiac output which must occur when the patient is being haemodiluted. Therefore regional anaesthesia (spinal or epidural) was not tried for fear of any hypotension. As withdrawal of blood in an awake patient would

cause hyperdynamic state due to emotional distress, it was decided to withdraw blood after induction of anaesthesia. But according to M.M.Atallah et al, ANH itself is not a stress producing technique. In order to maintain a stable haemodynamic state during haemodilution, replacement fluids were infused simultaneously while withdrawing blood. The debate on the choice of replacement fluid is not yet fully resolved. Several authorities agree that the plasma substitute of choice should have an intravascular half-life of between 3 and 6 hrs and be isotonic with plasma. Various crystalloid and colloid solutions have been employed to achieve normovolaemic haemodilution. These have included Ringer's lactate, 5% albumin, Dextran, Hydroxyethyl starch, gelatin or combination of these agents.

As crystalloids (ringer lactate) have extremely short intravascular half-life and extravascular steal effect the volume of Ringers lactate infused during haemodilution was three times the volume of blood withdrawn. In this study, as the volume of blood withdrawn was 350ml it was decided to infuse 2 pints of Ringer's lactate simultaneously in Group R patients. As polygeline (Haemaccel), being a colloid has a longer intravascular half-life (3-6 hours), it was decided to infuse haemaccel in the ratio of 1.5:1 to the blood withdrawn in the Group H patients. As this study of ANH belongs to moderate ANH and we did not use invasive monitoring like CVP and intra-arterial B.P. The age, body weight, blood drained, surgical blood loss were comparable in both the groups. There was insignificant change in the heart rate, systolic blood pressure and diastolic blood pressure during haemodilution and retransfusion in both the groups. This finding correlated well with the study of D.Hursh et al.and E.Martin et al in their haemodynamic studies comparing dextran, albumin and hydroxyethyl starch and had demonstrated no significant differences among diluents. The haematocrit changes were comparable in both the groups. The oximetric readings also were comparable in both the groups. None of the patients in both the groups developed any pulmonary complication or delayed wound healing in the postoperative period. This finding was in contrast to the study of Hursh et al, in which he has reported higher incidences of postoperative pulmonary complications in the patients who had been infused with Ringer's lactate during haemodilution.

In our study, one patient developed allergic reactions to polygeline (incidence 1/25). This finding correlated well with the study of J.Ring et al. who has reported an incidence of allergic reaction to polygeline as 10-20 /10,000. If the present technique of haemodilution and autotransfusion was not used to replace the blood loss in 50 patients during surgery, we would have required 55 units of blood (350 ml each). Instead, only 5 units of homologous bank blood was used. Rest of the patients were managed by haemodilution and patients own blood only. Therefore there was reduction of 90.9% of homologuous blood requirement in the present study. This correlates well with the other studies where the reduction in homologuous blood has been reported from 18 – 90%. It can be concluded that both the haemodiluents (Ringer lactate and Haemaccel) have comparable effects on haemodynamic, oximetric and haematological profiles.

CONCLUSION

The dilution of whole blood leads to a significant improvement of its rheological properties based on a decrease in haematocrit and hence blood viscosity. Under conditions of normovolaemia and an adequate response of cardiorespiratory system, the acute dilution of blood will enhance the venous return to the heart and thereby improve total and capillary blood flow significantly. In the haematocrit range of 25 -30% (moderate haemodilution) this increase in flow rate is able to compensate fully for the diminished oxygen content of the blood. Changes in the oxygen extraction and oxygen haemoglobin affinity are only encountered at haematocrit below 20% (extreme haemodilution). ANH is a part of total approach to blood conservation and can be well tolerated to a haematocrit ratio of 25% under constant circulating normovolaemic state. It helps to reduce homologous blood transfusion, improves

nutritional capillary flow and prevents thromboembolic complications.

The key for acceptance of haemodilution is appreciation of the fact that a haematocrit reading of 25-30% is adequate to prevent a tissue oxygen deficit in the operative patient. Acceptance of these principles may reduce demands for blood and protect patients from complications of homologous blood transfusion. Since normovolaemia is the condition sine qua non for the heart to increase its output compensatorily, predilutional blood volume must be maintained as the haematocrit is reduced. Even small and temporary volume losses or deficit will interfere with the effectiveness of the compensatory increase in cardiac output. For safe haemodilution the diluents has to be carefully chosen with regard to its volume effect in vivo. When the haemodilution is performed with crystalloid solution, blood should be exchanged in a 1:3 ratio for crystalloid in order to ensure normovolaemia during ANH. When colloid is used blood should be exchanged in a 1:1-1.5 ratio for colloids. In our study of moderate ANH there was no significant difference between Ringer's lactate group and Polygeline (Haemaccel) group with regard to haemodynamic stability and oximetric and haematological profiles. So we conclude that during moderate Acute Normovolaemic haemodilution (ANH) either Ringer's lactate or Polygeline (Haemaccel) can be used as replacement fluid.

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