COMPARATIVE EFFECTS OF INDUCED HYPOTENSION AND NORMOVOLAEMIC HAEMODILUTION ON BLOOD LOSS IN TOTAL HIP ARTHROPLASTY

G. BARBIER-BÖHM, J. M. DESMONTS, E. COUDERC, D. MOULIN, P. PROKOCIMER AND H. OLIVIER

SUMMARY

The effects of deliberate hypotension and normovolaemic haemodilution on operative blood loss were studied in patients undergoing hip arthroplasty. Thirty patients were anaesthetized with halothane-nitrous oxide, and assigned to one of three groups. In group I, mean arterial pressure was decreased to 55 mm Hg by sodium nitroprusside. In group II, $23 \pm 2$ ml/kg of blood was withdrawn just before the surgical procedure and replaced by twice the volume with 4% albumin and Ringer lactate solution. The shed blood was reinfused at the end of the surgical procedure. In group III, the blood replacement was equal to blood loss and this group served as control. Intraoperative blood losses were $1050 \pm 185$ ml and $900 \pm 130$ ml in the autotransfused and control groups, respectively, and $320 \pm 35$ ml in the hypotensive group. However, the total red cell loss was significantly less in the hypotensive and autotransfused groups than in the control group. No complications occurred in any of the three groups. Deliberate hypotension was the most effective means of reducing intraoperative bleeding and the time for this procedure was shorter than for normovolaemic haemodilution combined with autotransfusion.

Total hip replacement is associated with substantial blood loss. Techniques used to reduce intraoperative bleeding include hypotensive anaesthesia, deliberate hypotension and preoperative normovolaemic haemodilution combined with several variations of autologous blood transfusion. The advantages of decreased blood loss include better surgical conditions, improved attachment of methyl methacrylate cement to bone, and the need for less transfusion of bank blood. A recent review of the published reports on average blood loss for total hip arthroplasty (Thompson et al., 1978) showed that good results were obtained with extradural or spinal anaesthesia and deliberate hypotension. No data on the effects of haemodilution were reported in this review. However, Rosberg and others (1977) did not observe any difference in total blood loss between a haemodilution group and a control group undergoing hip surgery. We have evaluated two techniques for reducing blood loss: controlled hypotension, and normovolaemic haemodilution followed by postoperative transfusion of the shed blood. The results were compared with those observed in patients undergoing the same surgical procedure with normotensive anaesthesia.

METHODS

Thirty patients undergoing total hip arthroplasty gave informed consent for the study. None had previously undergone any surgical procedure on the hip. Patients with cardiovascular, pulmonary or renal disease were excluded. The patients were assigned to one of three groups: (1) Hypotension with sodium nitroprusside (group I; $n = 11$); mean arterial pressure was maintained at 55 mm Hg. The nitroprusside infusion was started before the incision and stopped before wound closure. Transfusion was started when intraoperative blood loss exceeded 300 ml. (2) Haemodilution (group II; $n = 9$) in which $23 \pm 2$ ml/kg body weight of blood was withdrawn after induction of anaesthesia but before the start of the surgical procedure. Simultaneously, the volume of shed blood was replaced with an equal volume of 4% albumin in saline, and a similar volume of lactated Ringer's solution. Intraoperative blood loss was replaced with the same mixture. At the end of the surgical procedure, the shed blood was reinfused over approximately 2 h. Additional donor blood was transfused when necessary. (3) Control group (group III; $n = 10$) in which operative blood loss was replaced with the same amount of homologous

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blood. In all cases, the volume of blood lost was estimated during operation by weighing sponges and by measuring suction drainage, and after operation by measuring blood collected from the wound drainage. The red cell volume lost was estimated from the haematocrit.

Mean ages were 54±5, 51±3 and 55±3 yr in groups I, II and III respectively. All patients received diazepam 10 mg and atropine 0.5 mg i.m. 1 h before induction. Anaesthesia was induced and maintained with nitrous oxide 60% in oxygen, supplemented by halothane 0.5% and small doses of phenoxyperidine. All operations were performed by one surgeon, with the patient in the lateral position. A Wagner double-cup prosthesis was used in all cases. The attachment of the double-cup was with methacrylate cement. This procedure differs from the Charnley-type total hip arthroplasty, in that resection of the femoral head is not necessary and blood loss is reduced.

Haemoglobin concentration was measured before operation and immediately and 1, 4 and 10 days after operation. The means and standard errors were calculated for group data and comparison between groups was performed with Student's t test for unpaired data. P<0.05 was regarded as statistically significant.

RESULTS

The results obtained with the different methods are in table I. The smallest intraoperative blood loss occurred with controlled hypotension: 320±35 ml v. 1050±180 ml and 900±130 ml in the autotransfused and control groups respectively. Blood loss after operation was similar in the three groups. However, total red cell loss including losses during and after operation was not different in the hypotensive and autotransfused groups, because the intraoperative haematocrit in the latter group (23%) was less than in the hypotensive group (36%). Red cell loss in both of these groups was significantly less than in the control group (table II). However, total measured blood loss was significantly less in the hypotensive patients compared with the other groups. The criteria for blood transfusions were different in

| TABLE I. Operative blood losses (mean± SEM) | Group I | Group II | Group III |
| Volume of loss (ml) | During operation | 320±35 | 1050±180 | 900±130 |
| | After operation | 460±75 | 400±50 | 530±100 |
| | Total | 780±80 | 1450±220 | 1430±150 |

| TABLE II. Red cell volume loss (mean± SEM). | Group I v. group II; | Group II v. group III; | Group III v. groups I and II |
| Red cell volume (ml) | During operation | 130±20 | 240±40 | 350±60 |
| | After operation | 150±20 | 110±23 | 180±40 |
| | Total | 280±30 | 350±50 | 530±60 |

| TABLE III. Blood loss and replacement in the three groups |
| Total measured blood loss (ml) | Transfused blood (ml) | Patients transfused |
| Hypotensive group | 780±80 | 500±170 | 8/11 |
| Autotransfused group | 1450±220 | 135±100 | 2/9 |
| Control group | 1430±150 | 1485±190 | 10/10 |

![Fig. 1. Changes in haemoglobin concentration after surgery:](image-url)
BLOOD LOSS DURING HIP SURGERY

Each group, so that comparison of the amount of transfused blood is only of incidental interest. Excessive bleeding after operation in two of the autotransfused patients necessitated banked blood transfusion (table III). Comparison of haemoglobin concentrations in the three groups revealed significantly smaller values in the autotransfused group early after operation (fig. 1). However, by the 4th day, no difference was observed in the three groups. Moderate anaemia was present in all patients on the 10th day after operation.

DISCUSSION

Our study demonstrates that deliberate hypotension to a mean arterial pressure of 55 mm Hg during hip arthroplasty was the most effective means of reducing bleeding during surgery. Similar results have been reported with nitroprusside (Lawson et al., 1976) or with deliberate hypotension induced by halothane (Thompson et al., 1978) despite the fact that different mechanisms are involved in the hypotension. Halothane produces hypotension by myocardial depression (Prys-Roberts et al., 1974) and nitroprusside by arteriolar vasodilatation (Adams et al., 1974). Comparison with other studies is difficult because of differences in the management of deliberate hypotension. Amanarath and others (1975) reported blood loss of 800 ml during surgery with nitroprusside and trimetaphan, but the intraoperative arterial pressure was reduced by only 20-30% from the value before operation. Furthermore, in this study, a correlation between blood loss and arterial pressure during operation was noted. Controversy regarding the use of deliberate hypotension stems from the possible increased risk of tissue damage from hypotension-induced hypoperfusion. In evaluating previous reports dealing with the complications of induced hypotension, it is important to consider the recent improvement in management of these patients. Hypotensive anaesthesia has been made safer and more reliable by the use of modern monitoring techniques. Thompson and others (1978) have shown that the use of deliberate hypotension for hip surgery did not affect the results of tests of cerebral, hepatic or renal function and myocardial status after operation.

Regional anaesthetic techniques also decrease blood loss during operation (Stanton-Hicks, 1971; Davis, Jennings and Harris, 1974; Sculco and Ranawat, 1975), but in a previous study from this hospital, we did not observe any difference attributable to general v. extradural anaesthesia (Guyochin et al., 1973).

In the present study, there was no difference between the haemodilution and control groups with respect to the total blood loss. Thus the need for homologous blood was reduced in the haemodilution group compared with the control group, because the red cell volume was significantly reduced. Patients subjected to normovolaemic haemodilution tolerated the procedure well, but Laks and others (1974) have shown that acute haemodilution resulted in a marked increase in cardiac output and in a parallel decrease in blood viscosity and total peripheral resistance. Guyton and Richardson (1961) demonstrated that the decrease in peripheral resistance resulted in increased venous return and thus increased cardiac output. This adaptation is dependent on cardiac function, which is sometimes altered in elderly patients undergoing total hip replacement. Rao, El-Etr and Montoya (1979) have shown that haemodilution-induced anaemia is not well tolerated in patients with severe coronary artery disease.

In conclusion, the best surgical conditions were achieved with deliberate hypotension, which was the most effective means of reducing intraoperative bleeding. The need for donor blood transfusion was reduced in patients undergoing haemodilution and retransfusion of fresh autologous blood. However, withdrawal of blood before operation considerably lengthened the time leading to operation and the operative field was not as dry as with deliberate hypotension. The combination of moderate intraoperative haemodilution and hypotensive anaesthesia could be suggested as the best technique for patients undergoing hip surgery.

REFERENCES


Les effets d’une hypotension délibérée et d’une hémodilution normovolémique sur les pertes de sang opératoires ont été étudiés sur des patients subissant une arthroplastie de la hanche. Trente patients ont été anesthésiés à l’aide d’halothane-protoxyde d’azote et inclus dans l’un des trois groupes suivants. Dans le Groupe I, la pression artérielle moyenne a été abaissée à 55 mm Hg à l’aide de nitroprussiate de soude. Dans le Groupe II, on a retiré 23 ± 2 ml/kg de sang juste avant l’intervention chirurgicale et on l’a remplacé par deux fois ce volume d’une solution lactate de Ringer contenant 4% d’albumine. Le sang prélevé a été réintroduit par perfusion à la fin de l’intervention chirurgicale. Dans le Groupe III, le remplacement de sang a été égal au sang perdu et ce groupe a servi de groupe témoin. Les pertes de sang résultant de l’opération ont été respectivement de 1050 ± 185 ml et de 900 ± 130 ml dans le groupe “autotransfusion” et le groupe “témoin” et de 320 ± 35 ml dans le groupe “hypotension”. Cependant, la perte totale de globules rouges a été nettement moindre dans les Groupes “hypotension” et “autotransfusion” que dans le groupe témoin. Il ne s’est produit de complication dans aucun des trois groupes. L’hypotension délibérée a été le moyen le plus efficace de réduire les saignements se produisant au cours des opérations et le temps nécessaire à ce procédé a été plus court que celui qu’il a fallu pour l’hémodilution normovolémique combinée avec une autotransfusion.

**VERGLEICHENDE WIRKUNGEN VON INDUZIERTEN BLUTDRUCKERNIEDRIGUNG UND VERDÜNNUNG MIT BLUTPLASMA-ERSATZSTOFFEN AUF DEN BLUTVERLUST BEI TOTALER HÜFTGLENKPLASTIK**

**ZUSAMMENFASSUNG**


**EFFECTS COMPARATIFS DE L'HYPOTENSION PROVOQUEE ET DE L'HEMODILUTION NORMOVOLEMIQUE SUR LA PERTE DE SANG SUBIE AU COURS D'UNE ARTHROPLASTIE COMPLETE DE LA HANCHE**

**RESUMEN**

Se estudiaron los efectos de la hipotensión deliberada y de la hémodilución normovolémica relativas a la pérdida sanguínea, en pacientes sometidos a arthroplastia de la cadera. Se anestesiaron 30 pacientes con óxido nitroso–halotano y se les asignó a uno de los tres grupos. En el grupo I, la presión arterial media se disminuyó hasta un valor de 55 mm Hg por medio de nitrato prúsico de sodio. En el grupo II, se extrajeron 23 ± 2 ml/kg de sangre justo antes de llevar a cabo la operación quirúrgica y se sustituyeron mediante el doble del volumen extraído con un 4% de albúmina y una solución ‘Ringer’ de lactato. La sangre extraída se reintegró al término del proceso quirúrgico. En el grupo III, la sangre sustituida igualó a la
pérdida, y este grupo sirvió como control. Las pérdidas intraoperatorias de sangre fueron de 1050±185 ml y de 900±130 ml en los grupos de control y de autotransfusión, respectivamente, y de 320±35 ml en el grupo de hipotensión. No obstante, la pérdida total de glóbulos rojos fue significativamente inferior en los grupos de hipotensión y de autotransfusión que en el grupo de control. No tuvo lugar complicación alguna en ninguno de los tres grupos. La hipotensión provocada fue el medio más efectivo de reducir el derrame de sangre intraoperatorio y el tiempo de duración de este proceso fue más corto que para la hemodilución normovolémica combinada con autotransfusión.