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Blood loss during primary total hip arthroplasty: use of preoperative measurements to predict the need for transfusion

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The blood loss resulting from total hip arthroplasty was studied in 53 patients. Calculated blood loss exceeded measured blood loss in all cases. The most significant predictor of postoperative packed-cell volume (PCV) was the preoperative PCV. In a further 37 patients the preoperative PCV was used successfully to predict the postoperative PCV and the need for transfusion.

Preoperative cross-matching of blood in patients undergoing major lower limb arthroplasty is routine in many centres, regardless of a patient's blood volume or preoperative packed-cell volume (PCV). Homologous blood transfusion is still associated with significant risks, including viral and non-viral infections, immunological reactions and immunosuppression. Previous studies have suggested that a PCV of 0.30 in men and 0.27 in women is compatible with adequate tissue oxygenation *(1)*. Unless a patient's PCV is likely to fall below this level, homologous blood transfusion should probably be avoided.

Blood loss may be measured directly, or calculated using formulae such as those described by Bourke and Smith *(2)* and modified by Gross *(3)*. The calculation is based on the patient's estimated blood volume, and the pre- and postoperative PCV. Previous studies have shown that the calculated blood loss exceeds the measured loss and provides a more realistic measure of the total blood loss *(4)*.

In this study the variation in blood loss as a result of primary total hip arthroplasty performed by one surgical and anaesthetic team was studied. The relationships between blood volume and blood loss, postoperative PCV and preoperative PCV, and postoperative PCV and blood volume, were examined. We also assessed whether it was possible to predict the postoperative PCV from knowledge of the preoperative PCV and blood volume.

Patients and methods

The blood loss resulting from 53 consecutive total hip arthroplasties performed by the same surgical team in 14 males and 39 females was studied. Forty-three arthroplasties were cemented, nine were hybrid and one was uncemented. A lateral approach was used in all cases, and 46 patients had a lumbar epidural. Blood was cross-matched for all patients, but was withheld for 48 h, at which stage the PCV was measured, unless transfusion was indicated on clinical grounds during this period.

The measured blood loss was obtained by combining the intraoperative loss and the volume collected in the drains. The estimated total blood loss was calculated

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using the equation described by Gross *(3)*:

$$V_l = EB_v\,(H_0 - H_f)/2$$

where V_l = estimated blood loss, EB_v = estimated blood volume, H_0 = preoperative PCV, H_f = postoperative PCV, $H_{av} = H_0 + H_f/2$

The estimated total blood volume was derived using the method described by Moore *(5)*:

	Males (ml/kg)	*Females (ml/kg)*
Obese	60	55
Thin	65	60
Normal	70	65
Muscular	75	70

Thus, each patient's weight, preoperative and 48 h postoperative PCV and body build were recorded. Three patients were transfused during the first two postoperative days. The blood loss could not be calculated in these patients and they were therefore excluded from the study. The relationship between the measured loss and the estimated total loss was determined using linear regression analysis. Similarly, the relationships between the estimated blood loss, the estimated blood volume, the preoperative and the postoperative PCV were assessed using correlation and linear regression analysis.

Results

Estimated blood volume ranged from 2568 to 6279 ml, with a mean of 4348 ml. Measured blood loss ranged from 300 to 1750 ml, with a mean of 760 ml, and estimated total blood loss ranged from 630 to 2292 ml, with a mean of 1236 ml (SD 346 ml). A significant relationship was seen between measured and estimated blood loss ($r = 0.53$, $P = 0.0002$). Estimated blood volume showed a positive correlation with both estimated blood loss ($r = 0.46$, $P = 0.0009$), and preoperative PCV ($r = 0.52$, $P = 0.0001$). The latter was expected as men generally had both larger blood volumes and higher PCVs. A positive correlation was also shown between postoperative PCV and both preoperative PCV ($r = 0.78$, $P < 0.0001$) and estimated blood volume ($r = 0.56$, $P < 0.0001$) (Figs 1 and 2). Regression of postoperative PCV on preoperative PCV showed a highly significant relationship ($P < 0.0001$); 64% of the variability being explained. Adding estimated blood volume to the regression analysis did not significantly improve the prediction ($P = 0.49$) and did not increase the proportion of variability explained.

The data in Fig. 1 was then separated into males and females. There was no significant difference in the slope or intersect of the separate regression lines and therefore a single regression line for both sexes was drawn (Fig. 3). Using this regression line, it was possible to determine what preoperative PCV level was required to predict postoperative PCVs above 0.3 and 0.27. A preoperative PCV of 0.4 or above was needed to predict a postoperative PCV of 0.3 or above, and a preoperative PCV of 0.36 or above was needed to predict a postoperative PCV of 0.27 or above.

Using these values, a protocol was then applied to a further 37 patients (13 males, 24 females) undergoing

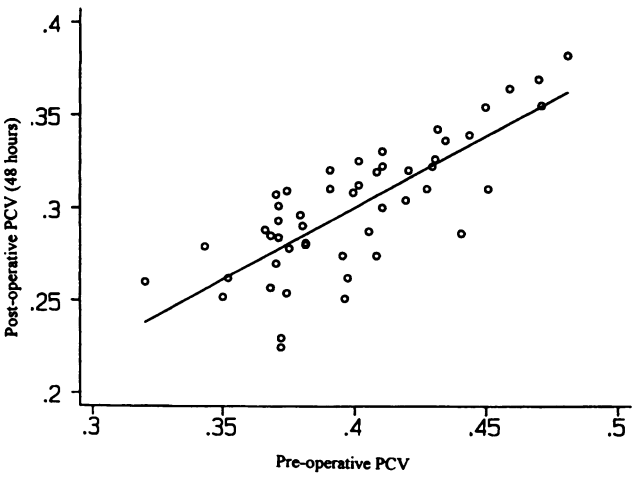

Figure 1. Postoperative PCV against preoperative PCV.

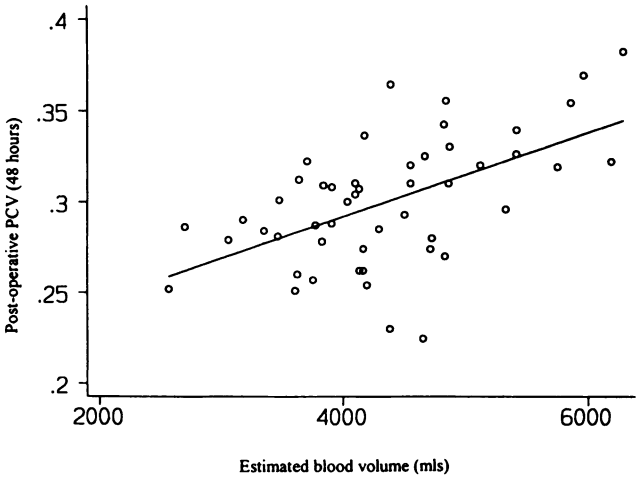

Figure 2. Postoperative PCV against estimated blood volume.

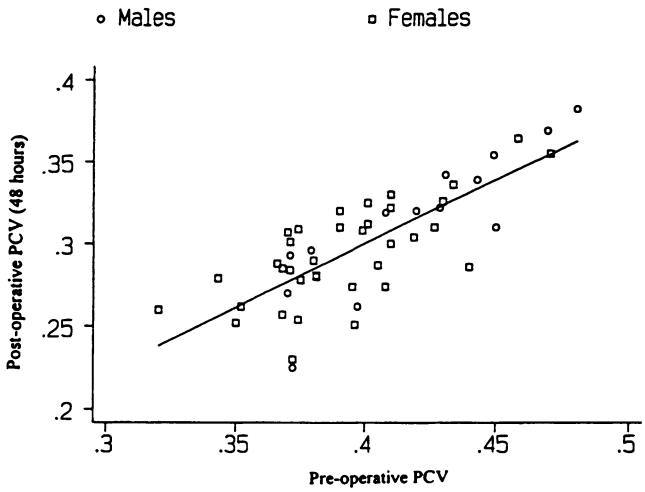

Figure 3. Postoperative PCV against preoperative PCV, indicating the sex of each patient.

primary total hip arthroplasty. Eleven patients with preoperative PCVs ranging from 0.32 to 0.36 had blood cross-matched. In all but one this was administered (2 units) immediately postoperatively. The postoperative PCVs of these patients ranged from 0.32 to 0.41. Twenty-six patients with preoperative PCVs ranging from 0.37 to 0.51 were only grouped and saved; all the males in this group had preoperative PCVs above 0.4. In only one female patient did the postoperative PCV fall below 0.27 (0.26), and in none of the males did it fall below 0.3.

Discussion

Blood loss during total hip arthroplasty is dependent on many variables including the anaesthetic technique, the operative approach, the duration of the procedure, the use of cement and previous exposure to aspirin or non-steroidal anti-inflammatory drugs *(6–11)*. This study showed that even when all the procedures are performed by one surgical and anaesthetic team, the blood loss is still variable.

The results demonstrate that while the postoperative PCV is influenced by the patient's blood volume, it is much more closely related to the preoperative PCV. This is because patients with larger blood volumes tend to lose more blood, thus counteracting the benefits of starting with a larger blood volume.

The lowest acceptable postoperative PCV is not an absolute, but should be related to the medical condition of the patient; for example, a higher level should probably be taken for a patient with ischaemic heart disease.

In this study, postoperative PCV was determined on the second day. It was assumed that the patient's blood volume had returned to normal by this stage. In 18 of the original 53 patients, the PCV was measured again at 1 week after surgery, and in 15 it had risen by between 0.01 and 0.05; in two cases it had fallen by between 0.01 and 0.02, and in one case it remained unchanged. This general rise may have been due partly to erythrocyte regeneration, but may also have been a result of haemodilution at 48 h owing to persistence of the stress response.

A regression line similar to that derived from the data in this study could be produced by any surgical team and applied to subsequent patients. The results of this study support a selective approach to preoperative cross-matching of blood for patients undergoing primary total hip arthroplasty, provided transfusion facilities are available 'on site' to cover unexpected eventualities. The data from our second group of 37 patients shows that this selective approach to cross-matching is safe, but will still result in those patients being transfused who really need to be. Clearly caution needs to be exercised in the case of patients with borderline PCVs, but we believe that this approach can be used to reduce both the exposure of patients to the risks of unnecessary blood transfusion, and the burden on the transfusion services.

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