

# Postoperative blood salvage in hip and knee arthroplasty

## A prospective study on cost effectiveness in 161 patients

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We conducted a prospective controlled study on 161 patients who underwent primary or revision total hip or knee arthroplasty to assess the efficacy and limitations of postoperative blood salvage. The actual quantity of blood salvaged after washing, the theoretical increase in hemoglobin concentration caused by its reinfusion and the cost of this procedure were studied.

The mean amount of packed red cells after washing was 117 g. The average increase in hemoglobin concentration, which theoretically would have been

achieved by retransfusion, was 0.47 g/dL. One third of the devices used were discarded as not effective enough and, in order to obtain an increase of 1 g/dL in the hemoglobin concentration, an average of 3.4 postoperative Solcotrans Plus Orthopaedic devices were used. To obtain the same increase in hemoglobin concentration as that given by an allogeneic blood transfusion, the overall cost of materials alone was more than five times the price of a single blood unit transfusion

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The blood losses in patients undergoing hip or knee arthroplasty often must be replaced by blood transfusions. The risk of adverse reactions to transfusions, HIV and hepatitis-virus transmission have led to the introduction of salvage of the patient's own blood.

Various studies have shown that preoperative deposition to reduce the need of allogeneic blood transfusions is a safe, effective and economical procedure (Thomson et al. 1987, Woolson et al. 1987), while intraoperative salvage is only advantageous in those cases where major blood loss is expected (Wilson 1989, Turner et al. 1990, Guerra and Cuckler 1995).

Regarding the use of postoperative salvage, opinions still vary. Kristensen et al. (1992) and Semkiw et al. (1989) claim that it drastically reduces the need for allogeneic blood, whereas other authors (Hedde et al. 1992, Umlas et al. 1994) have concluded that postoperative salvage should be used only in patients with a high risk of substantial blood loss.

We studied the efficacy of postoperative blood salvage in hip and knee arthroplasty.

## Patients and methods

161 (113 women) consecutive patients underwent total hip and knee arthroplasty during March 1994–February 1995. Patients who had infections or malignant lesions in the vicinity of the operative site were not included.

The average age of the patients was 65 (39–83) years. 133 patients underwent total hip arthroplasty, 23 of whom had revision surgery. In 77 cases, a cementless prosthesis was used, in 36 only the femoral component was cemented and 20 patients had both components cemented. 28 patients underwent unilateral total knee arthroplasty: in all cases, the tibial component was cemented. The total knee replacements were performed with a tourniquet for hemostasis, and the tourniquet was not released until the wound had been closed. 68 patients had hip arthrosis, 28 knee arthrosis, 23 aseptic loosening of total hip arthroplasty, 20 congenital dysplasia of the hip, 11 avascular necrosis of the femoral head, 4 fracture of the femoral neck, 4 rheumatoid arthritis and 3 had posttraumatic arthrosis of the hip. Preoperative autologous blood donation was performed in 156 patients (97%). Antibiotic prophylaxis was administered to all patients. Low molecular weight heparin (enoxaparin

4000 units once a day) was given as thrombosis prophylaxis to all patients until discharge. Epidural anesthesia was performed in 46 patients, spinal anesthesia in 41, psoas compartment block in 38, general anesthesia in 29 and sciatic nerve block with "3 in 1" block in 7. No hypotensive technique was used.

Reinfusion of the salvaged blood was only carried out if the quantity drained in the first four hours was at least 250 mL, otherwise it was discarded. We used the Solcotrans Plus Orthopaedic (Solco Basle Inc. (UK) Ltd.) postoperative drainage and reinfusion devices. Before reinfusion, the blood was washed with saline solution and centrifuged, with removal of the overflow material, and the sediment of red cells was weighed and subjected to a hematocrit count. Finally, 100 mL of saline solution was added for hemodilution and to facilitate the transfusion.

To assess the efficacy of this method, the theoretical increase in hemoglobin concentration obtained by the infusion of salvaged blood in each patient was determined for each salvage system. The data were calculated, considering that 2.74 g of packed red cells with a hematocrit of 100 transfused per kg of body weight should produce a hemoglobin rise of 1 g/dL. Since the salvaged packed red cells, after washing, had a hematocrit below 100, the quantity of packed red cells/kg of weight needed to increase the hemoglobin concentration by 1 g/dL was calculated using the following formula:

$$2.74 \times 100 / (\text{Hematocrit of the salvaged packed red cells})$$

The theoretical increase in hemoglobin concentration produced by each drainage and reinfusion device was then calculated as a ratio of the quantity of packed red cells salvaged after washing and the result of the previous formula multiplied by the weight of the patient.

The patient population analysis took into account age, sex, main and associated pathologies, type of surgery, pre- and postoperative blood tests, with emphasis on the hematocrit level and hemoglobin concentration, quantity of autologous and allogeneic transfusions and the amount of blood loss during hip surgery and drained in the first 48 hours following surgery. The indication for reinfusion of preoperative autologous donation or transfusion of allogeneic blood during surgery was given by the surgeon or the anesthesiologist on the basis of the age and cardiovascular and pulmonary condition of the patient, on his preoperative hematocrit and hemoglobin values and on the estimated blood losses. In postoperative recovery, it was up to the surgeon, considering the same criteria, to decide whether to transfuse; the critical value for hemoglobin being 8.5 g/dL.

**Table 1.** Mean quantity (range) of packed red cells salvaged after washing, g

Total cemented hip	93 (10–190)
Partially cemented hip	106 (15–210)
Uncemented hip	122 (50–220)
Primary total hip arthroplasty	119 (20–220)
Revision of total hip arthroplasty	92 (10–190)
Primary total knee arthroplasty	149 (90–220)
All	117 (10–220)

Statistical analysis was performed with the Student's t-test using the Bonferroni method of correction, the F-test for variance analysis and linear correlation.

## Results

220 drainage and transfusion devices were used in postoperative recovery, but only 139 (63%) were reinfused, while the other 81 (37%) were too few for use. We needed an average of 3.4 Solcotrans Plus Orthopaedic devices to obtain a 1 g/dL increase in hemoglobin concentration.

The quantity of packed red cells salvaged in uncemented prostheses was higher than in cemented ( $p = 0.007$ ) or partially cemented ( $p = 0.02$ ) ones. There were differences in average quantities of packed red cells between primary total hip and knee arthroplasty and revision procedure of total hip arthroplasty ( $p = 0.003$  and  $p = 0.0004$ ), as also between primary total hip arthroplasty and total knee arthroplasty ( $p = 0.01$ ) (Table 1).

The average theoretical increase in hemoglobin concentration, which would have been obtained by use of the salvaged blood, was 0.47 g/dL (0.04–0.88). In total cemented hip arthroplasty, it was 0.37 g/dL (0.04–0.76), in partially cemented prostheses 0.42 g/dL (0.06–0.84) ( $p = 0.03$ , compared to uncemented arthroplasty) and in uncemented prostheses 0.49 g/dL (0.2–0.88) ( $p = 0.02$ , compared to cemented arthroplasty).

The theoretical increase in hemoglobin concentration in patients who underwent primary total hip arthroplasty was average 0.47 g/dL (0.08–0.88), in revisions it was 0.36 g/dL (0.04–0.78) and in primary total knee arthroplasty 0.59 g/dL (0.36–0.88). The increases differed between patients with a revision procedure and those who underwent a primary total hip and unilateral knee arthroplasty ( $p = 0.005$ ) and between those with primary total hip arthroplasty versus total knee arthroplasty ( $p = 0.02$ ), but they were significant.

39 patients (24%) needed an allogeneic transfusion

**Table 2. Mean quantity (SD) of blood loss during hip surgery, mL**

Epidural anesthesia	392 (200-1000)
Spinal anesthesia	479 (200-700)
Psoas compartment block	360 (200-700)
General anesthesia	398 (200-700)
All	406 (200-1400)

and, of these, 24 underwent primary total hip arthroplasty, 13 a revision procedure and 2 unilateral knee arthroplasty.

Psoas compartment block resulted in lower operative blood loss than spinal anesthesia ( $p = 0.01$ ) (Table 2).

The amount of packed red cells salvaged and the increase in hemoglobin concentration did not correlate to age, the preoperative hematocrit values or hemoglobin concentration.

## Discussion

Postoperative blood drainage and transfusion devices are used in total hip and knee replacement because reduction of the need for allogeneic transfusion is anticipated. Kristensen et al. (1992) claimed that the Solcotrans Orthopaedic drainage and reinfusion system reduced the use of allogeneic blood by 72% in total hip arthroplasty and by 91% in total knee arthroplasty. In a controlled and randomized trial on total knee arthroplasty patients, Heddle et al. (1992) demonstrated that the use of the drainage and reinfusion device was able to reduce significantly the number of patients who needed allogeneic transfusions and to increase by 42% the number of those who did not require allogeneic transfusions. Other authors (Clements et al. 1992, Ayers et al. 1995) claim, on the other hand, that these devices are useful only in patients who do not have preoperative blood donations available.

Our findings demonstrate that reinfusion of the actual quantity of salvaged blood, after washing, would increase the hemoglobin concentration on an average by 0.47 g/dL. This corresponds to less than transfusion of one blood unit (Goodnough et al. 1989) and is therefore not efficacious in reducing the need for blood transfusion during postoperative recovery which, apart from autologous blood, in our experience required allogeneic blood in 25% of the patients. Umlas et al. (1994) believe that the postoperative loss of blood is only a limited percentage of the total loss during this kind of surgery (about 8% in total hip arthroplasty and 16% in total knee arthroplasty). They also claimed that in postoperative drainage and rein-

fusion systems the concentration of red cells, even in large salvaged volumes, is low in the collection bags, because of hemolysis and the fact that most of the fluid that accumulates in the joint space comes from hemorrhagic effusion rather than from bleeding.

The largest quantities of packed red cells were obtained during total knee arthroplasty and in cementless total hip arthroplasty, as shown by other authors (Semkiw et al. 1989, Heddle et al. 1992, Kristensen et al. 1992). On the other hand, in revision surgery of the hip we found a significantly lower quantity of salvaged packed red cells. Apart from the use of cement, this result depends on the fact that, as already pointed out by Umlas et al. (1994), large volumes in the postoperative drainage are not strictly correlated to large quantities of salvaged red cells. This observation leads us to the conclusion that the amount of blood salvaged during the postoperative period cannot be foreseen, as the quantity of packed red cells and the increase in hemoglobin concentration are not related to age, preoperative hematocrit values or hemoglobin concentration.

According to Kristensen et al. (1992), the price of one Solcotrans equals the price of one allogeneic blood unit, while Slagis et al. (1991) claim that the price is lower. On the other hand, Heddle et al. (1992) observed that the number of devices discarded because so little is salvaged (22% in their data) must also be taken into account. In our study, 37% of them were discarded and we needed an average of 3.4 Solcotrans Plus Orthopaedic devices to obtain an increase of 1g/dL in the hemoglobin concentration, equal to the average increase obtained using one unit of blood.

In our hospital, the price of one device is USD 177 and therefore, to obtain an increase in hemoglobin concentration equal to that produced by one blood unit, the overall cost of devices alone would be USD 596, whereas one allogeneic blood unit costs USD 108.

Our conclusion is that in hip and knee arthroplasty, postoperative collection is an expensive and laborious method. It is also difficult to predict where large quantities of blood can be salvaged.

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