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Comparison of therapeutic effects between drainage blood reinfusion and temporary clamping drainage after total knee arthroplasty in patients with rheumatoid arthritis

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OBJECTIVE: To compare the therapeutic effects between drainage blood reinfusion and temporary clamping drainage after total knee arthroplasty in patients with rheumatoid arthritis to provide a basis for clinical practice.

METHODS: Data from 83 patients with rheumatoid arthritis undergoing total knee arthroplasty were retrospectively analyzed. The 83 patients were divided into a drainage blood reinfusion group (DR group, n = 45) and a temporary clamping drainage group (CD group, n = 38). In the DR group, postoperative drainage blood was used for autotransfusion. In the CD group, closed drainage was adopted, and the drainage tube was clamped for 2 h postoperatively followed by patency. The postoperative drainage amount, hemoglobin level, rate and average volume of allogeneic blood transfusion, swelling and ecchymosis of the affected knee joint, time to straight-leg raising and range of active knee flexion were compared between the two groups.

RESULTS: The total drainage volume was higher in the DR group than in the CD group ($P = 0.000$). The average volume of postoperative allogeneic blood transfusion ($P = 0.000$) and the decrease in the hemoglobin level 24 h after total knee arthroplasty ($P = 0.012$) were lower in the DR group than in the CD group. Swelling and ecchymosis of the affected knee joint, time to straight-leg raising and the range of active knee flexion were improved in the DR group compared with the CD group (all $P < 0.05$).

CONCLUSION: Compared with temporary clamping drainage, drainage blood reinfusion after total knee arthroplasty can reduce the allogeneic blood transfusion volume and is conducive to early rehabilitation in patients with rheumatoid arthritis.

KEYWORDS: Arthroplasty; Rheumatoid arthritis; Knee joint; Blood reinfusion device; Blood loss.

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INTRODUCTION

In total knee arthroplasty (TKA), perioperative massive blood loss caused by the separation of soft tissues and the osteotomy of a larger area is an important factor that affects postoperative recovery and the allogeneic blood transfusion rate (1). Reducing blood loss during the perioperative period of TKA is an important problem. Blood loss after TKA is mainly due to the application of a pneumatic tourniquet in TKA, and controlling this problem is essential. Two methods, drainage blood reinfusion and temporary clamping drainage, have been developed to protect against postoperative bleeding after TKA, but there has been considerable debate regarding their therapeutic effects (2-19). Moreover, most of the studies evaluating the effects of the two methods on the volumes of blood loss and allogeneic blood transfusion were performed in patients with osteoarthritis (OA). TKA is also commonly used in the treatment of RA, and the pathological changes in RA are different from those in OA. Joint deformity is more severe in RA than in OA because the long-term use of immunosuppressive agents and non-steroidal anti-inflammatory drugs leads to the extensive loss of bone mass and marked synovitis (20). The characteristics of blood loss after TKA in RA are different from those in OA (21,22). Therefore, it is necessary to observe the effects of various methods on blood

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loss after TKA in patients with RA. Matsuda et al (23) retrospectively analyzed data from 200 patients with RA who received either drainage blood reinfusion or conventional closed drainage after TKA and found that drainage blood reinfusion decreased the rate of allogeneic blood transfusion but increased the drainage volume. They did not report the volume of allogeneic blood transfusion or the hemoglobin level. Thus far, no studies have compared the effects of drainage blood reinfusion and temporary clamping drainage on blood loss after TKA in patients with RA. In this study, data from 83 patients with RA receiving either drainage blood reinfusion or temporary clamping drainage after TKA were retrospectively analyzed to observe the effects of the two methods on the drainage volume, allogeneic blood transfusion and postoperative rehabilitation.

MATERIALS AND METHODS

All study methods were approved by the ethics committee of our medical university. All of the subjects enrolled into the study provided written informed consent to participate.

Subjects

Patients with RA undergoing TKA for the first time between August 2008 and May 2014 were included. Exclusion criteria included bilateral TKA performed simultaneously or within less than 3 months, diabetes mellitus, hemorrhagic blood disease, hemoglobin level <100 g/L, peripheral neurovascular disease, malignant tumor, a history of vascular embolism or a history of infection in the affected lower limb. In this study, 83 patients with RA met the inclusion criteria. Of the 83 patients, 45 received drainage blood reinfusion as the DR group, and 38 received clamping drainage for 2 h postoperatively followed by patency as the CD group. The preoperative body height, body weight, circumference of the affected knee joint through the superior patellar pole, motion of the knee joint and hemoglobin level were measured (Table 1). No significant differences were found in the parameters listed above (all $P>0.05$).

Surgical technique

The surgical procedures were all performed by the same group of surgeons. All patients received the cemented posterior cruciate sacrifice prosthesis (GENES II, Smith and Nephew, Memphis, Tennessee, USA). The midvastus approach was adopted through an anterior midline skin incision (2). The joint capsule was opened up from the patellar tendon insertion on the tibial tubercle to the medial patellar pole along the medial border of the patellar tendon and the patella, followed by blunt dissection along the oblique fiber of the vastus medialis within 4 cm. Soft tissue balancing and osteophyte removal were performed before cutting the bone. The tibia was cut first, followed by the femur. Patellar resurfacing was performed instead of patella replacement. The partial lateral patella (1-1.5 cm) was cut, patellar osteophytes were removed, the patella was reshaped to match the trochlea of the femoral prosthesis, and the soft tissue around the patella was cauterized with an electro-scalpel to destroy the patellar innervation. All of the prostheses were fixed with bone cement. The tourniquet was removed after successful placement of the prosthesis. The joint cavity was washed by flushing with physiological saline after exact hemostasis was reached. In the DR group, an autologous drainage blood reinfusion device (ConstaVac CBC II Blood Conservation System, Stryker, Mahwah, NJ, USA) was placed. In the CD group, a drainage tube was placed. None of the patients received a blood transfusion during the operation. Postoperative blood transfusions were administered according to the hemoglobin level.

Postoperative treatment

All patients were provided intravenous prophylactic antibiotics from the time of anesthesia induction to 2 days after the operation, and 2500-3000 ml of intravenous physiological saline was administered within 24 h of the operation. In the DR group, vacuum aspiration was used in the blood storage tank. Blood reinfusion was performed when the drainage blood reached 200 ml or 6 h after the operation. The drainage tube of the blood reinfusion device was removed 24 h after the operation. In the CD group, the drainage tube was clamped for 2 h postoperatively followed by patency, and the drainage tube was then removed 24 h after the operation. Postoperative blood transfusions were performed when the hemoglobin level was less than 80 g/L. All patients routinely received low-molecular-weight heparin (Fraxiparine) and venous foot pumps to prevent deep vein thrombosis. The wound dressings were changed when they were soaked with exudate or when they affected the blood supply to the distal limb. The affected limb was positioned above the cardiac plane, and ice bags were placed around the knee joint. Isometric training of the quadriceps femoris muscle was initiated, but continuous passive motion (CPM) passive exercise was not adopted immediately after the operation. Patients were encouraged to perform straight leg raising and flexion and extension training of the knee joint. Walking with partial weight-bearing began 24 h after the operation.

The observational parameters included the drainage volume 24 h postoperatively, hemoglobin level, rate and average volume of allogeneic blood transfusion, swelling and ecchymosis of the affected knee joint 3 days after the operation, and straight-leg raising and range of active knee flexion 3 and 5 days after the operation. Swelling of the knee joint was evaluated by the ratio of knee circumference 3

Table 1 - Preoperative Parameters in Both Groups (mean ± SD or number).

Grouping	Sex: Male	Sex: Female	Age (year)	BMI (kg/m^2)	Circumference (cm)	Hemoglobin (g/L)	Motion of joint (°)
DR group	5	40	64.1 ± 9.5 (43-79)	26.1 ± 5.7	36.3 ± 3.5	11.3 ± 2.1 (8.7-14.2)	85 ± 19
CD group	4	34	63.5 ± 8.6 (40-78)	25.9 ± 5.5	36.7 ± 4.2	11.6 ± 1.9 (8.9-14.4)	88 ± 23
t (x^2) values	$x^2=0.007$		$t=0.302$	$t=0.162$	$t=0.466$	$t=0.683$	$t=0.640$
P values	$P=1.000$		$P=0.735$	$P=0.133$	$P=0.715$	$P=0.477$	$P=0.509$

Notes: DR: drainage blood reinfusion; CD: temporary clamping drainage; BMI: body mass index.

days postoperatively to that recorded preoperatively. The area of ecchymosis was calculated by the palm method. Ecchymosis of the knee joint was assessed by the ratio of the ecchymosis area 3 days postoperatively to the corresponding preoperative area.

Statistical analysis

Statistical treatment was performed with SPSS 16.0 software (SPSS Inc., Chicago, Illinois). A chi-square test was used for the numerical data. Student's t test was used for the measurement data that had a normal distribution; these data were expressed as $\bar{x}\pm s$. The Log-rank test was used for the measurement data that had a non-normal distribution; these data were expressed as the median or range. Statistical significance was established at $P<0.05$.

RESULTS

The results are shown in Table 2. There were no significant differences in hemoglobin levels between the DR group and the CD group at 24 h or at 3 or 5 days after the operation (all $P>0.05$); however, the decrease in hemoglobin levels 24 h after the operation was significantly lower in the DR group compared with the CD group ($P<0.05$). Moreover, 27 patients in the DR group and 30 patients in CD group received an allogeneic blood transfusion, indicating that there was no significant difference in the rate of allogeneic blood transfusion between the DR group and the CD group ($P>0.05$). However, the average volume of allogeneic blood transfusion was significantly less in the DR group than in the CD group ($P<0.01$). The postoperative drainage volume was significantly higher in the DR group than in the CD group ($P<0.01$). In the DR group, the volume of autologous blood reinfusion accounted for approximately 70% (880 ml/1253 ml) of the total postoperative drainage.

The circumference of the affected knee joint and the area of ecchymosis around the affected knee were significantly increased in the CD group compared with the DR group (all $P<0.01$). The range of active knee flexion and the number of people able to perform straight-leg raising were significantly increased in the DR group compared with the CD group 3 and 7 days after the operation, respectively ($P<0.01$), indicating that patients in the DR group achieved better postoperative rehabilitation. One patient in the DR group and five patients in the CD group developed wound infections during the early postoperative period ($P>0.05$). These patients recovered after intravenous antibiotic administration and surgical debridement. No patients in either group developed deep vein thrombosis.

DISCUSSION

Although TKA and total hip arthroplasty (THA) can have good therapeutic outcomes, postoperative bleeding remains an issue to be resolved. In contrast to THA, blood loss in TKA mainly occurs postoperatively due to the application of a pneumatic tourniquet. As a result, two methods against postoperative bleeding, drainage blood reinfusion and temporary clamping drainage, have been developed and given widespread attention. We compared the effects between drainage blood reinfusion and temporary clamping drainage in patients with RA undergoing TKA and found that drainage blood reinfusion relieved the decrease in hemoglobin levels observed 24 h postoperatively, reduced the average volume of postoperative allogeneic blood transfusion and relieved the swelling of the knee joint, all of which promote postoperative rehabilitation; however, the postoperative drainage volume was increased.

The literature includes various reports about postoperative autologous drainage blood reinfusion in TKA (3-9). Some researchers have reported that postoperative autologous drainage blood reinfusion offered no advantage in relieving the decrease in hemoglobin levels and reducing the volume of allogeneic blood transfusion; rather, these studies reported that this procedure simply increased the cost of TKA (3,4,6). However, some researchers have drawn contradictory conclusions (5,7-9). Markar et al (2) conducted a meta-analysis of 8 prospective randomized controlled studies and found that the postoperative drainage volume was 639-1140 ml and that the average volume of allogeneic blood transfusion was 0-40 ml in the drainage blood reinfusion group; thus, autologous drainage blood reinfusion effectively decreased the postoperative blood transfusion requirement in TKA. However, most studies evaluating he therapeutic effects of autologous drainage blood reinfusion

Table 2 - Postoperative Parameters in Both Groups (mean $\pm$ SD or number).

Parameters	DR group (n = 45)	CD group (n = 38)	t (x^2) values	P values
Postoperative 24-hour Hb (mg/L)	10.1 ± 3.6	9.2 ± 2.7	t = 1.299	0.233
Postoperative 3- or 5-day Hb (mg/L)	9.3 ± 4.5	9.4 ± 3.9	t = 0.108	0.895
Decrease in postoperative 24-hour Hb (mg/L)	1.3 ± 0.5	1.7 ± 0.9	t = 2.649	0.012
Decrease in postoperative 3- or 5-day Hb (mg/L)	1.8 ± 0.8	1.9 ± 1.0	t = 0.497	0.682
Rate of allogeneic blood transfusion (%)	27/45 (60%)	30/38 (79%)	x^2 = 3.438	0.096
Average volume of allogeneic blood transfusion (ml/individual)	210 ± 246 (0-1200)	640 ± 486 (0-1700)	t = 4.780	0.000
Postoperative drainage volume (ml)	1253 ± 638 (350-2420)	687 ± 541 (200-1630)	t = 4.373	0.000
Volume of autologous blood reinfusion (ml)	880 ± 554			
Area of ecchymosis 3 days after operation (%)	0.7 ± 0.5	2.8 ± 1.6	t = 7.778	0.000
Increase in the circumference of the affected knee joint 3 days after operation (%)	3.2 ± 0.9	7.1 ± 2.3	t = 9.848	0.000
Number of people initially performing straight-leg raising				
Three days after operation	28	15	x^2 = 4.270	0.049
Seven days after operation	43	30	x^2 = 5.363	0.038
Range of active knee flexion (°)				
Three days after operation	63 ± 15	52 ± 17	t = 3.099	0.003
Seven days after operation	82 ± 21	73 ± 19	t = 2.049	0.041

Notes: DR: drainage blood reinfusion; CD: temporary clamping drainage; Hb: hemoglobin.

in TKA were performed in patients with OA. Several reports have evaluated whether the characteristics of blood loss during the perioperative period of TKA are the same between RA and OA. Some researchers have reported that the characteristics of blood loss are similar between RA and OA (24), whereas others have found that postoperative blood loss is higher in RA than in OA (21,22). In this study, the patients with RA served as the research subjects; the average postoperative drainage volume was 1253 ml, and the average volume of allogeneic blood transfusion was 210 ml in the DR (drainage blood reinfusion) group. The average postoperative drainage volume and the average volume of allogeneic blood transfusion were higher in this study than in the reports mentioned above, supporting the conclusion that postoperative blood loss is higher in RA than in OA. This difference may occur because ① inflammatory cytokines inhibit human hematopoietic functions in patients with RA, leading to hemolysis (25,26); ② the autoimmune nature of RA and the long-term use of immunosuppressive agents and non-steroidal anti-inflammatory drugs lead to the extensive loss of bone mass, including bone cysts and secondary osteonecrosis (20), which can easily cause postoperative bleeding; ③ an important component of TKA in patients with RA is complete synovectomy, which increases the postoperative bleeding (27); and ④ in patients with RA, severe joint deformity requires extensive soft tissue separation, which increases the postoperative bleeding (28).

In TKA, the aim of temporary clamping drainage is both to form a hematoma against postoperative bleeding and to aid in drainage to protect against incision complications. There are conflicting reports about the effects of temporary clamping drainage on postoperative blood loss in TKA (11-19). Tao et al (10) performed a meta-analysis of 9 prospective randomized controlled studies and found that temporary clamping drainage decreased the postoperative drainage volume but failed to reduce the rate of allogeneic blood transfusion compared with postoperative drainage tube patency; however, they did not compare the average volume of allogeneic blood transfusion between the two methods. In fact, some patients require several allogeneic blood transfusions due to fluctuating postoperative hemoglobin levels; thus, evaluating the rate of allogeneic blood transfusion exclusively cannot truly reflect the use of allogeneic blood. The average volume of allogeneic blood transfusion should also be considered. Notably, our study indicated that although there was no significant difference in the rate of allogeneic blood transfusion, there was a significant difference in the average volume of allogeneic blood transfusion between the DR (drainage blood reinfusion) group and the CD (temporary clamping drainage) group. In addition, the clamping drainage interval is reported to range from 30 min to 24 h (10). The optimal clamping drainage interval remains a matter of debate. Closed drainage can prevent postoperative hematoma formation, which may trigger a series of complications (29,30). Although clamping drainage can form a hematoma to protect against postoperative bleeding, prolonged clamping drainage also may form a large hematoma, which affects wound healing. Postoperative blood loss only occurs within a few hours after TKA (31,32). In this study, we adopted a two-hour clamping drainage interval based on our practical experience.

Invisible blood loss, which is a main form of blood loss in TKA, may comprise 55% of the total blood loss (33). Invisible blood loss is mainly caused by blood extravasation into the tissue space and joint cavity and is usually evaluated by limb swelling and ecchymosis in clinical practice (34,35). In this study, the circumference of the affected knee joint and the area of ecchymosis around the affected knee were significantly decreased in the DR group compared with the CD group, suggesting that less invisible blood loss occurred in the DR group than in the CD group. This decrease in invisible blood loss is conducive to rehabilitation after TKA because ① edema may reduce the excitability of receptors in the joint capsule, thereby affecting muscle activity; ② swelled limbs require more strength against the increased gravity during tasks such as straight-leg raising; ③ swelling increases soft tissue tension, thereby affecting the flexion of the affected knee joint; and ④ swelling decreases the oxygen tension in the skin around the incision, thereby affecting wound healing. In this study, the range of active knee flexion and the number of people able to perform straight-leg raising were significantly increased in the DR group compared with the CD group, which may be associated with the factors listed above.

The limitations of this study include the relatively small study population size and the retrospective nature. In addition, the patients were not randomly assigned, leading to an increased risk of selection bias in the present trial. Furthermore, the lesions of the knee joint were not graded for joint deformity, loss of bone mass and synovitis, which are associated with intraoperative and postoperative blood loss. Nonetheless, there were several strengths in this study, including the matched demographic features of the patients, the use of the same surgeons, and the application of a consistent operation method. These strengths increased the power of the statistical results in the trial.

Our results suggest that drainage blood reinfusion can relieve the decrease in postoperative hemoglobin levels, can reduce the average volume of postoperative allogeneic blood transfusion and is conducive to early rehabilitation training, although the postoperative drainage volume is increased.

AUTHOR CONTRIBUTIONS

Li B designed the study, collected the data, and wrote the paper. Liu Z, Shen P, Zhou B, and Bai L collected the data.

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