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The Efficacy and Safety of Autologous Transfusion in Unilateral Total Knee Arthroplasty

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Purpose: Although allogeneic blood transfusion is the most common method of transfusion in total knee arthroplasty (TKA), there are reports showing significant decrease in the amount of allogeneic transfusion and incidence of side effects after combined use of autologous transfusion. The purpose of this study is to investigate the efficacy of using an autologous transfusion device in TKA.
Materials and Methods: Patients who underwent TKA at our institution from January 2003 to January 2014 were divided into two groups: group A (n=127) who received allogeneic transfusion only in TKA and group B (n=118) who received autologous transfusion via an autologous transfusion device and allogeneic transfusion. In both groups, the patients were transfused when the hemoglobin level was below 9 g/dL. In group B, blood collected by the autologous transfusion device was transfused only once after surgery. The total blood loss volume, total transfusion volume, and the presence of side effects were assessed based on medical records.
Results: Group A received 294.6 mL more allogeneic transfusion than group B ($p<0.001$). There were no significant differences with regard to the development of side effects between groups.
Conclusions: Application of an autologous transfusion device during TKA can be effective in reducing the allogeneic transfusion volume. Moreover, allogeneic transfusion was not necessary after autologous transfusion in some patients.

Keywords: **Knee, Degenerative arthritis, Arthroplasty, Autologous transfusion**

Introduction

The incidence of osteoarthritis is increasing as the world's population is rapidly aging, and total knee arthroplasty (TKA) has become a common surgery in the orthopedic field. It has been known that perioperative blood loss is estimated to be between 1,000 mL and 1,500 mL, and transfusion is required in 18%–95% of the patients[1]. In the meantime, there are increasing doubts about the efficacy of allogeneic transfusion due to the risk of transfusion-transmitted infectious diseases and the absence of management measures during transfusion[2-4]. Curran et al.[5] reported on the growing incidence of transfusion-transmitted infectious diseases such as AIDS following allogeneic transfusion. Alter[6] indicated that hepatitis B virus could be transmitted by transfusion.

There have been numerous attempts in the search for an alternative to allogeneic transfusion; autologous transfusion is considered as one of the options, including the use of preoperative autologous blood deposit, salvation of bleeding during surgery, postoperative reinfusion of drained blood after sterilization, and the use of hematopoietic agents such as erythropoietin[7-9]. A lot of studies have suggested that allogeneic transfusion can be reduced by autologous transfusion[3,10-12].

However, existing reports are based on insufficient study population sizes to elucidate whether autologous transfusion can reduce the necessity of allogeneic transfusion.

In this study, we investigated whether allogeneic blood transfusion combined with autologous transfusion using an autologous transfusion device can reduce the use of allogenic transfusion compared with allogenic transfusion alone in a substantial num-

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ber of unilateral TKAs. Further, we assessed whether the use of an autologous transfusion device has an influence on the complication rate (e.g., infection, embolism, etc.).

Materials and Methods

Of the patients who underwent unilateral TKA at our institution with a diagnosis of degenerative arthritis of the knee, 245 patients in whom the surgery was performed by the same surgeon were enrolled in this study. The exclusion criteria were liver disease or preoperative findings of prolonged coagulation battery. The mean age of the included patients was 72 years. There were 54 males and 191 females. The patients were divided into group A and group B according to the use of an autologous transfusion device which was introduced in May 2009 at our institution. Group A consisted of 127 patients who underwent TKA and allogeneic transfusion between January 2003 and April 2009 without the use of an autologous transfusion device. Group B was composed of 118 patients who underwent allogeneic transfusion and autologous transfusion using an autologous transfusion device after TKA between May 2009 and January 2014.

In group B, CBC II (Consta-Vac; Stryker, Kalamazoo, MI, USA), an autologous transfusion device, was applied after surgery. It was designed to drain blood after surgery from the operation site under 50–100 mmHg of negative pressure and reinfuse it 6 hours later to the patient via venous access through a filter that removes impurities without any other washing process. We inserted the drainage line into the joint space immediately prior to wound closure through an aseptic procedure and performed autologous transfusion once 6 hours later. We could hardly find machine malfunctioning cases.

Three surgical instruments—Scorpio NRG (Stryker Orthopaedics, Mahwah, NJ, USA), NexGen LPS (Zimmer Inc., Warsaw, IN, USA), and Vanguard (Biomet, Warsaw, IN, USA)—were randomly applied during surgery. In all surgery, pneumatic tourniquet was applied on the proximal femoral region at 300 mmHg of pressure. Criteria for allogeneic transfusion were below 9.0 g/dL postoperative hemoglobin level and unstable vital signs irrespective of hemoglobin level.

In each patient, the hemoglobin level was measured before operation, immediately after operation, and 1 day after operation, and the amount of drainage was aggregated at 24 hours and 48 hours after surgery. The presence of side effects (pulmonary embolism, deep vein thrombosis, acute infection, etc.) was examined based on medical records including vital signs, collaboration/consults with other departments, etc.

Statistical analysis was done using SPSS ver. 21.0 (IBM Corp., Armonk, NY, USA). A t-test was conducted to determine the significance of differences in the average volume of drainage and transfusion between the groups. Fisher's exact test was done to identify if there is difference in the complication rate between the groups.

Results

There was no statically significant difference in demographics between group A and group B. In group A, the mean age was 74.7 years (range, 73.4 to 76.0 years), and there were 99 female and 28 male patients. In group B, the mean age was 69.1 years (range, 67.6 to 70.6 years), and there were 92 females and 26 males (Table 1).

Each patient was checked for blood drainage via Hemovac every 24 hours. The total drainage for 24 hours after operation was a mean of 718.5 mL (standard deviation [SD], 505.0 mL) in group A and a mean of 906.6 mL (SD, 410.2 mL) in group B. The mean value between 24 and 48 hours after surgery was 129.2 mL (SD, 112.3 mL) in group A and 112.7 mL (SD, 103.1 mL) in

Table 1. Demographic Data

Variable	Group A			Group B			Total	
	No. of patients (%)	Mean (SD)	95% CI	No. of patients (%)	Mean (SD)	95% CI	No. of patients (%)	Mean (SD)
Age (yr)	127	74.7 (7.6)	73.4–76.0	118	69.1 (8.1)	67.6–70.6		72.0 (8.3)
Sex								
Male	28 (22)			26 (22)			54 (22)	
Female	99 (78)			92 (78)			191 (78)	
Disease								
HTN	62	48.81		75	63.56			137 (55.92)
DM	25	19.69		31	26.27			56 (22.85)

SD: standard deviation, CI: confidence interval, HTN: hypertension, DM: diabetes mellitus.

Table 2. Postoperative Drainage

Variable	All	Group A	Group B	p-value[a)]
No. of patients (%)	245 (100)	127 (51.8)	118 (48.2)	-
Drainage (mL)				
0–24 hr	809.0 (470.4)	718.5 (505.0)	906.6 (410.2)	0.002
24–48 hr	126.1 (107.8)	129.2 (112.3)	112.7 (103.1)	0.635
48–72 hr	43.1 (57.6)	65.0 (60.0)	19.6 (44.3)	<0.001
Total	993.6 (543.5)	942.4 (611.2)	1,048.8 (455.9)	0.122

Values are presented as mean (standard deviation).
[a)]p-value calculated using t-test.

Table 3. Autologous Transfusion Volume in Group B

	No. of patients	Mean	SD	95% CI
Group B	118	625.237	119.306	603.486–646.989

SD: standard deviation, CI: confidence interval.

Table 4. Allogeneic Blood Transfusion Volume at Three Intervals

Variable	Group A	Group B	p-value[a)]
No. of patients (%)	127 (51.8)	118 (48.2)	
Allogenic blood transfusion (mL)			
0–24 hr	415.7 (471.1)	200.0 (317.0)	<0.001
24–48 hr	157.5 (334.9)	88.1 (228.8)	0.062
48–72 hr	97.6 (240.2)	88.1 (240.4)	0.757
Total	670.9 (585.3)	376.3 (456.8)	<0.001

Values are presented as mean (standard deviation).
[a)]p-value calculated using t-test.

group B. At more than 48 hours after surgery, the total amount of drainage was measured as a mean of 65.0 mL (SD, 60.0 mL) in group A and a mean of 19.6 mL (SD, 44.3 mL) in group B. The total drainage amount was a mean of 942.4 mL (SD, 611.2 mL) in group A and a mean of 1,048.8 mL (SD, 455.9 mL) in group B. There was no statistically significant difference in the total drainage amount between the two groups (p>0.05) (Table 2).

In group B, after 6 hours of application of the autologous transfusion device, a mean of 625.2 mL (SD, 119.3 mL) autologous transfusion was done. And allogenic transfusion (packed red blood cells) was done if the patient still needed blood transfusion after autologous transfusion (Table 3).

The amount of allogeneic transfusion was a mean of 415.7 mL (SD, 471.1 mL) in group A and a mean of 200.0 mL (SD, 317.0 mL) in group B during 24 hours after operation; the value was a mean of 157.5 mL (SD, 334.9 mL) in group A and a mean of 88.1 mL (SD, 228.8 mL) in group B between 24 and 48 hours after surgery. It was a mean of 97.6 mL (SD, 240.2 mL) in group A and a mean of 88.1 mL (SD, 240.4 mL) in group B at 48 hours after surgery. The total amount of allogeneic transfusion showed statistically significant difference between groups: the mean value was 670.9 mL (SD, 585.3 mL) in group A and 376.3 mL (SD, 456.8 mL) in group B, thus it was 294.6 mL less in group B than group A (p<0.05) (Table 4).

Table 5. Comparison of Complications

	Group A	Group B	Pearson's chi-square	p-value[a)]
Infection	3	2	0.136	0.712
Skin rash	3	0	2.822	0.093

[a)]Fisher's exact t-test.

Regarding major postoperative side effects, wound infection occurred in 3 knees in group A and in 2 knees in group B, which healed without re-operation and uncomplicated by superficial infection, showing no statistically significant difference between groups. There were 3 patients who were medicated for skin rash in group A and none in group B (Table 5). Other postoperative complications, such as pulmonary embolism and deep vein thrombosis, did not develop in both groups.

Discussion

This study demonstrated two major findings among numerous TKA patients: first, using an autologous transfusion device can result in statistically significant reduction in the allogeneic blood transfusion volume compared to allogeneic transfusion alone; and second, there was no significant difference in complication, such as infection or embolism, in spite of the loss of blood from the operation site for autologous transfusion.

TKA may necessitate postoperative transfusion according to the degree of injury to soft tissue or bone tissue that may occur

during surgery[3,13]. There are some methods for autologous transfusion; however, we could not utilize a short-term preservation method which is performed after dilution of blood during surgery or the intraoperative blood collection method due to tourniquet application during surgery. Preoperative blood deposit method was not chosen because of inappropriateness in elderly patients according to Adalberth et al.[14]. Therefore, recollection of blood in the operated joint by an autologous transfusion device and reinfusion via venous access method was chosen.

There has been controversy regarding the efficacy of autologous transfusion in reducing the need for allogeneic transfusion. Marks et al.[15] reported that autologous transfusion through an autologous transfusion device failed to prove itself as an efficient method to decrease the amount of allogeneic transfusion. Lee et al.[16] insisted reinfusing lost blood during TKA does not guarantee beneficial outcome. Also, Abuzakuk et al.[4] reported that autologous transfusion cannot replace allogeneic transfusion. Ha et al.[10], however, insisted autologous transfusion could decrease allogeneic transfusion based on a comparative study of 71 patients who underwent minimally invasive knee arthroplasty. Simpson et al.[11] implied that autologous transfusion via an autologous transfusion device can decrease the amount of allogeneic transfusion based on a prospective study of 24 TKA patients. Our study also confirmed that autologous transfusion after TKA decreases the use of allogeneic transfusion.

Even though the total amount of drainage had no statistically significant difference between the groups, group B had significantly greater amount of drainage than group A within 24 hours after surgery. We attribute this to the greater negative pressure for the use of autologous transfusion device in group B; we applied −100 mmHg pressure for the first 6 hours when using the autologous transfusion device. After the autologous transfusion, we changed the pressure to −50 mmHg. The total amount of drainage in group B was an average of 906.6 mL for 24 hours. The average amount of drainage was 625.2 mL for the first 6 hours, which was equal to the amount of autologous transfusion. Considering that the amount of drainage for the rest 18 hours was not more than the half of the original volume, we think that bleeding was induced in early stage due to the greater negative pressure.

There are a lot of arguments about the safety of reinfusion of collected blood. According to Friedman et al.[13], there were fewer infection events in groups that received autologous transfusion alone than those with allogeneic transfusion. There was no systemic infection in the group with autologous transfusion, whereas 2 infections were observed in the group with allogeneic transfusion in our study, which also supports the study results of Friedman et al.[13]. Furthermore, according to Han et al.[8], although there was decreased antithrombin III in blood collected by an autologous transfusion device, no clinical symptoms including side effects caused by thrombosis were reported after reinfusion. Nor were there reported side effects associated with thrombosis in this study. Yim et al.[3] suggested using two blood filters can reduce the possibility of thrombosis formation by bone tissue, cement fragments, or metal powder remaining at the operation site. The device we used in this study consisted of pre-filter and fat retention valve, so there were no side effects such as embolization or thrombosis after surgery.

The major limitations of this study are that it is a retrospective design and transfusion was determined based on hemoglobin level alone. According to the transfusion guidelines proposed by American Society of Anesthesiologists, transfusion should be considered based on clinical symptoms such as hemoglobin level, blood oxygenation, and total oxygen delivery. However, in this study, hemoglobin level was the only criterion for determining transfusion; other clinical conditions that can reflect the capacity of oxygen delivery, such as peripheral capillary oxygen saturation or dyspnea, were not taken into consideration. This may have been the cause of critical difference in the amount of transfusion with other studies where transfusion was based on physiological requirements. Of the patients in whom the autologous transfusion device was used, allogeneic transfusion was not necessary for postoperative management in 24 patients. If clinical symptoms had been taken into consideration as criteria for transfusion, the amount of allogeneic transfusion could have been less, which could have enabled patient management through postoperative autotransfusion alone.

Furthermore, as three surgical instruments were randomly applied during surgery, it is difficult to rule out the influence of surgical instruments on the difference in postoperative blood loss.

Conclusions

Autologous transfusion using an autologous transfusion device following TKA could reduce the amount of allogeneic transfusion, and there were no significant differences in the incidence of side effects between the autologous transfusion group and allogeneic transfusion group. Without the risk of blood incompatibilities or unexpected events during medical treatment, autologous transfusion in TKA can be a reliable alternative to reduce the amount of allogenic transfusion.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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