The Use of Reinfusion Drains after Total Knee Arthroplasty in Patients Treated with Low Molecular Weight Heparin for Thromboembolic Prophylaxis

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Abstract The effect of closed-suction drainage with red-cell reinfusion on patients receiving low molecular weight heparin (LMWH) prophylaxis after total knee arthroplasty (TKA) has not been previously studied. Therefore, our goals were to determine the effect of reinfusion drains and LMWH on allogeneic transfusions and wound complications after TKA by comparing patients treated with and without drains. Overall, transfusion rates were lower in the drain group (40% vs 15%, $P=.04$). Patients with reinfusion drains had a significantly higher rate of allogeneic transfusion (15.8%) than those predonating autologous blood and no drain (5.4%, $P=.0003$). The drain group had lower rates of wound complications (P =not significant). We were unable to demonstrate the efficacy of red-cell reinfusion as a substitute for autologous donation in TKA.

Key words knee arthroplasty • drains • autologous blood • allogeneic transfusion • wound complications

Introduction

Total knee arthroplasty (TKA) has proven to be an effective surgical treatment for degenerative conditions of the knee.

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Despite its success, TKA may be complicated by problems related to the surgical site and may necessitate perioperative transfusion of allogeneic blood products. Closed-suction drainage after TKA has been used in an effort to diminish the incidence of clinically significant hematomas and wound problems. Several studies to date have demonstrated little or no benefit with the use of drains [3, 8, 9, 14]. Despite these data, many surgeons continue to use drains after TKA because they may feel that the risk is small and that the wounds remain more benign. Closed-suction drainage can be combined with a device that acts as a collection and reinfusion system for postoperative blood salvage. Published studies have demonstrated the efficacy of these systems in reducing the need for allogeneic transfusion in total joint arthroplasty [6, 7, 11, 12, 15].

None of the above-mentioned studies involved patients who received low molecular weight heparin (LMWH) for venous thromboembolism (VTE) prophylaxis. Numerous well-designed trials have shown that LMWH is effective in the prevention of postoperative VTE [2, 4, 13]. Concerns exist over potential bleeding complications, systemically and at the surgical site, although studies comparing LMWH with warfarin and unfractionated heparin have not demonstrated that statistical bleeding rate differences exist. However, a large retrospective review [1] determined that patients receiving LMWH prophylaxis after primary TKA were 28% more likely to require a transfusion when compared with patients treated with mechanical prophylaxis and aspirin.

We began using reinfusion drains in an effort to reduce the need for autologous blood donation and wound problems. Our hypothesis was that the use of closed-suction drainage after TKA in patients receiving LMWH prophylaxis would result in less clinically significant hematomas and wound problems. In addition, we hypothesized that the rates of allogeneic red-cell transfusion between patients treated with a reinfusion drain and patients donating autologous blood would be the same.

Materials and methods

The study cohort consisted of 368 patients who underwent unilateral, primary, cemented TKA performed by 1 of 4 surgeons at our institution from January 2001 to December 2003. A tourniquet, as well as prophylactic preoperative and postoperative antibiotics, was used in all patients. One hundred ninety-four knees in 180 patients with the tourniquet deflated after wound closure and dressing application did not have a drain (ND group). One hundred ninety-five knees in 188 patients had the tourniquet deflated after cement curing, with hemostasis obtained and a red-cell reinfusion drain (Constavac CBCII, Stryker Instruments, Kalamazoo, MI, USA) placed intra-articularly before closure (WD group). The reinfusion drain is a closed system, with the drainage fluid transfused through a peripheral intravenous line after filtering. No anticoagulant was used in the drainage and reinfusion system. Drainage greater than 150 mL was reinfused up to 6 hours postoperatively. After 6 hours, the device functioned solely as a closed-suction drain and was removed 24 hours postoperatively. All patients received LMWH (enoxaparin) 20 mg starting 6 hours after surgery and continuing at 40 mg daily for 10 days. Blood use and the surgical site were analyzed separately. Minimum follow up was 3 months.

Surgical-site problems

All the patients in the study cohort were used for this analysis. A retrospective review was performed to determine the rates of major and minor surgical-site complications of our cohort. Major complications were defined as those requiring surgical intervention, such as the evacuation of a hematoma or irrigation and debridement of an early infection. Minor complications that did not require repeat surgery included hematomas not requiring evacuation, prolonged serous wound drainage with the administration of antibiotics, and blistering or excessive ecchymosis at the surgical site.

Blood use

Because this was a retrospective review, the 389 knees in the cohort were not randomized to a group. This resulted in heterogeneity between groups with regard to autologous blood donation before surgery. To better compare the effect of red-cell reinfusion to autologous predonation on allogeneic transfusion, we selected from the original cohort 91 patients with 95 knees in the ND group who had donated autologous blood and 92 patients with 96 knees in the WD group who did not donate autologous blood. A review of inpatient charts for preoperative and discharge hemoglobin levels, as well as type and number of units of blood products transfused, was performed for both groups. Shed red-cell reinfusion volumes and total drain output were recorded for each patient in the WD group. Although this study reviewed the cases of 4 surgeons, the criteria for red-cell transfusion were similar. The triggers for transfusion of allogeneic or autologous blood were hemoglobin levels less than 9.0 g/dL

and/or objective evidence of symptomatic anemia such as tachycardia, hypotension, orthostasis, or dizziness with physical therapy. Patients with preexisting coronary or peripheral vascular disease were generally transfused at higher hemoglobin levels to maintain oxygen-carrying capacity. In addition, complications related to anemia, such as myocardial infarction and syncopal episodes, were noted after a review of inpatient and outpatient records.

Outcome data

Patients were evaluated routinely at 1 and 3 months postoperatively, with more frequent visits made on an as-needed basis. Range of motion was recorded and compared at the 1- and 3-month time points. The need for manipulation under anesthesia was made at the surgeon's discretion. Manipulation rates were recorded for each group. The prevalence of symptomatic VTE was recorded for each group. Symptomatic VTE was defined as a proximal deep vein thrombosis and/or pulmonary embolism (PE) requiring extended anticoagulation with heparin and warfarin. VTE was confirmed with Doppler ultrasonography for proximal or distal deep venous thrombosis (DVT) and either ventilation/perfusion (V/Q) scan or spiral computed tomography for PE.

Statistical analysis

Statistical analysis was performed with Analyse It for Excel v1.71 (Analyse It software Ltd, Leeds, England, UK). Normally distributed continuous variables were analyzed with an independent-samples *t* test. Nonparametric continuous data were tested with the Mann-Whitney *U* test. Categorical variables were compared with the χ^2 test.

Results

Surgical site

All patient records in both groups were available for review. Four major (2%) and 12 minor (6.2%) surgical-site problems occurred in the ND group and 2 major (1%) and 5 minor (2.6%) problems occurred in the WD group. No statistically significant differences between groups were found with regard to major, minor, or overall surgical-site complication rate. We also calculated the rates of clinically significant hematomas, adding the hematoma incidence from the major and minor problems for each group. No statistically significant difference was established between the groups, with hematoma rates 3.6% and 1% for the ND and WD groups, respectively (Table 1).

Blood use

Ninety-five knees in the ND group and 96 knees in the WD group were reviewed. A significant difference was found between groups regarding mean preoperative hemoglobin levels, with the mean for the ND group being 13.14 ± 1.08 g/dL and the mean for the WD group being 13.52 ± 1.4 g/dL [$P=.03$; 95% confidence interval (CI), 0.03–0.73]. A signifi-

Table 1. Surgical site complications

	ND (N=196) n(%)	WD (N=194) (n=194)	P
Minor problems*	6.2% (12)	2.6% (5)	.13
Major problems*	2.0% (4)	1.0% (2)	.68
Total problems*	8.2% (16)	3.6% (7)	.08
Hematoma*	3.6% (7)	1.0% (2)	.17

*Values expressed as percentage of knees experiencing complication. Statistical analysis performed with χ^2 test.

cant difference was also seen between the groups in discharge hemoglobin levels. The levels at discharge were 9.91 ± 1.08 and 10.49 ± 1.24 g/dL for the ND and WD groups, respectively ($P=.0008$; 95% CI, 0.24–0.91). Thirty-eight cases (40%) in the ND group required transfusion of packed red blood cells, 33 (35.1%) were autologous transfusions, and 5 (5.4%) were allogeneic transfusions. Fifteen cases (15.8%) required transfusions in the WD group; all of these were allogeneic (Table 2). Significantly more patients were transfused in the WD group ($P=.04$), but allogeneic transfusions were significantly higher in the ND group ($P=.0003$). Additional analysis of each group was done in an attempt to determine preoperative risk factors associated with the need for transfusions. Our goal was to determine if preoperative hemoglobin levels related to the need for all transfusions and/or allogeneic transfusions. We also studied the effect of an arbitrary hemoglobin level cutoff of 13.0 g/dL on the need for allogeneic and all transfusions. Transfused patients had a significantly lower ($P=.0001$) preoperative hemoglobin level than those not transfused in both the ND and the WD groups. In addition, a starting hemoglobin level less than 13.0 g/dL was a significant risk factor ($P=.048$) for transfusion in both groups (Tables 3 and 4). Autologous units were wasted in 56 (59.6%) of 94 patients. Four (4.3%) patients had anemia-related complications in the ND group and 1 (1.1%) in the WD group. The complications in the ND group were 1 episode of new-onset atrial fibrillation, 1 cerebrovascular accident, 1 readmission for nose bleeding and anemia, and 1 episode of syncope. The complication in the WD group was new-onset atrial fibrillation. This difference was not significant.

Table 2. Comparison of transfusion rates

	ND predonation	WD no predonation	P
Preop hemoglobin* (g/dL)	13.14 $\pm$ 1.08	13.52 $\pm$ 1.4	.03
Discharge hemoglobin* (g/dL)	9.91 $\pm$ 1.08	10.49 $\pm$ 1.24	.0008
Total transfusions [†]	40% (38/95)	15.8% (15/96)	.04
Allogeneic transfusions [†]	5.4% (5/95)	15.8% (15/96)	.0003

*Value expressed as mean $\pm$ SD.

[†] Value expressed as percentage of cases requiring transfusion.

Table 3. Risk factors for transfusion: ND group

	Transfused	Not transfused	P
Preoperative hemoglobin (g/dL) – Patients receiving allogeneic transfusions*	12.9 $\pm$ 0.86	13.16 $\pm$ 1.1	.61
Preoperative hemoglobin (g/dL) – Patients receiving any transfusions*	12.56 $\pm$ 1.05	13.54 $\pm$ 0.92	.0001
Preoperative hemoglobin <13.0 g/dL – Patients receiving allogeneic transfusions [†]	2.1%	3.2%	.73
Preoperative hemoglobin <13.0 g/dL – Patients receiving any transfusions [†]	27.7%	12.8%	.0001

*Value expressed as mean $\pm$ SD.

[†] Value expressed as percentage of cases requiring transfusion.

Range of motion and VTE

The total arc of motion and total flexion was calculated for patients at their first and second postoperative visits. The first visit was at approximately 1 month after surgery and the second was at 3 months. No statistically significant difference between groups was seen in arc of motion or total flexion at either time point. Two (1.0%) manipulations were performed under anesthesia in the ND group and 8 (4.1%) in the WD group (Table 5). This difference was not statistically significant.

The prevalence of symptomatic proximal DVT and/or PE necessitating prolonged anticoagulation were 7 (3.1%) and 6 (3.6%) for the ND and WD groups, respectively (Table 5). This difference was not statistically significant. No fatal PE occurred in either group.

Discussion

The orthopedic literature is replete with studies about closed-suction drainage and blood salvage after primary knee arthroplasty [3, 6–9, 11, 12, 14, 15], but not with patients receiving LMWH for VTE prophylaxis.

Table 4. Risk factors for transfusion: WD group

	Transfused	Not transfused	P
Drain reinfusion volume* (mL)	275 (200–600)	300 (280–400)	.58
Preoperative hemoglobin [†] (g/dL)	12.7 $\pm$ 1.29	13.7 $\pm$ 1.31	.007
Preoperative hemoglobin [‡] <13.0 g/dL	9.5%	6.3%	.048

*Value expressed as median (95% CI).

[†] Value expressed as mean $\pm$ SD.

[‡] Value expressed as percentage of cases requiring transfusion.

Table 5. Range of motion and VTE rates

	ND	WD	P
1-Month arc of motion*	95° (93–103)	100° (95–105)	.10
1-Month flexion*	98° (95–105)	105° (100–105)	.12
3-Month arc of motion*	110° (110–118)	115° (110–117)	.94
3-Month flexion*	112° (110–120)	115° (110–120)	.59
Manipulations†	1.0% (2/196)	4.1% (8/194)	.11
Symptomatic VTE†,‡	3.1% (7/196)	3.6% (6/194)	.99

*Value expressed as median (95% CI). Analysis performed with Mann-Whitney *U* test.

†Value expressed as percentage of cases experiencing VTE or manipulation. Analysis performed with χ^2 test.

‡The ND group had no PEs and 6 DVTs; the WD group had 5 PEs and 2 proximal DVTs.

Fitzgerald et al [4], in a randomized prospective trial of patients undergoing primary TKA, demonstrated a significantly lower rate of total DVT and proximal DVT in patients given enoxaparin compared with those given warfarin. Although major and operative site hemorrhagic complications occurred more frequently in the enoxaparin group, this difference was not statistically significant. Colwell et al [2] also found a significantly lower rate of total DVT in patients given enoxaparin compared with those receiving unfractionated heparin after TKA. The LMWH-treated patients had a higher rate of operative site hemorrhagic complications but a lower rate of other bleeding complications. None of these differences were significant. Another study by Warwick et al [13] comparing LMWH with mechanical prophylaxis in TKA showed no difference between groups with regard to VTE, but a higher rate of bleeding complication in the LMWH treatment group. Patients in the Warwick et al study randomized to LMWH were begun on therapy 12 hours before surgery. The American College of Chest Physicians guidelines [5] state that LMWH started postoperatively is likely a more effective treatment for the prevention of VTE after TKA than warfarin. This is qualified by the statement that based on available data, LMWH probably causes more surgical-site bleeding and wound hematomas than warfarin. The possibility of bleeding is likely a concern causing some surgeons to choose not to use LMWH after TKA. The prevalence of symptomatic proximal DVT and PE in our cohort given LMWH was comparable to that of cohorts given LMWH reported by Colwell et al [2] and Fitzgerald et al [4].

Closed-suction drainage after TKA has also been a controversial topic. Ritter et al [10] reported no difference in blood transfusion, excessive drainage, or average flexion of the knees at 7 days. Likewise, Esler et al [3] found greater blood loss and no benefit in terms of swelling, pain score, or range of motion in patients treated with a drain as compared with those without a drain. In contrast, Holt et al [8], in another comparative study, reported less need for dress-

ing reinforcements, less swelling and ecchymosis, and no increase in blood transfusions in patients treated with a drain. Willemsen et al [14] found no advantage of draining the knee for more than 24 hours, with a potential for increased bacterial colonization after that period. A recent meta-analysis by Parker et al [9] concluded that the only demonstrable benefit of a drain is reduction in the need for dressing reinforcement. They also concluded that patients treated with a drain after TKA have higher transfusion requirements than those treated without a drain.

Reinfusion of red cells after total joint arthroplasty has been used in an attempt to decrease the incidence of allogeneic transfusion and in some cases to replace autologous blood donation. Studies by Healy et al [7] and Han and Shin [6] assessed the safety and systemic responses to autologous salvaged blood in orthopedic patients. Both studies determined that transfusion of this blood product is safe. In a randomized prospective study, Woolson et al [15] compared primary TKA patients who predonated autologous blood with those who received autologous salvage blood from a reinfusion drain. The rates of allogeneic transfusion were the same and the authors concluded that postoperative blood salvage is as effective as autologous donation for the prevention of allogeneic transfusion. Slagis et al [12], in a study of hip and knee arthroplasty patients treated with or without postoperative red-cell salvage, found significantly fewer transfusions in bilateral TKA patients treated with salvage. No difference between groups was demonstrated in the unilateral TKA patients. A prospective study comparing reinfusion drains to closed-suction drains by Simpson et al [11] reported a significantly lower rate of transfusions in TKA patients treated with reinfusion. Although these results are promising, none of the patients in the above-noted studies received LMWH for VTE prophylaxis.

We were unable to demonstrate the efficacy of postoperative salvaged blood to prevent allogeneic transfusion as compared with autologous predonation. In the study by Woolson and Wall [15], no patients randomized to the drain group were transfused with allogeneic blood. The 5% rate of allogeneic transfusion in the autologous donation group in that report correlated with our results. The criteria for transfusion of allogeneic blood in that study were similar to ours: a hematocrit less than 30% and symptoms of acute anemia. Our higher rate of allogeneic transfusion in the drain group as compared with Woolson and Wall is difficult to explain. Obviously, the study designs were different and we had nearly twice as many patients. The method of wound closure between our study groups possibly related to a higher transfusion rate in the drain group. Woolson and Wall's study [15] patients had the tourniquet deflated after wound closure, whereas our drain group had the tourniquet deflated before closure. The method of wound closure is a confounding variable and makes it difficult to compare the results of our study others. Bong et al [1], in a retrospective review of 1402 knee arthroplasty cases using multivariate regression analysis, concluded that the need for allogeneic transfusion was highest in patients treated with LMWH as compared with those

treated with warfarin or a combination of mechanical prophylaxis and aspirin. They reported allogeneic transfusion rates of 38% in nonautologous donors, 11% in single-unit autologous donors, and 7% in two-unit autologous donors. The rates of allogeneic transfusion in our study, 5.4% for autologous donors and 15.8% for nondonors, compare very favorably with the data of Bong et al. We did reach the same conclusions regarding the relationship of preoperative hemoglobin levels to the need for transfusions. Both studies determined that lower preoperative hemoglobin levels carried a significant risk for any transfusion in autologous donors and allogeneic transfusions in nondonors.

The meta-analysis by Parker et al [9] theorized that the primary outcome of any drain study should be the incidence of wound infection. Wound infections can stem from many sources, so determining the efficacy of a drain for prevention of this complication has proven difficult. We contend that not only frank infection, but also hematoma formation, skin blistering, and prolonged serous drainage encompass some of the surgical-site problems encountered after TKA; therefore, our study aimed to determine the effect of drains on these complications. In addition, we divided groups into major and minor complications because complications requiring surgical intervention have a greater effect on the patient. We found higher rates of major and minor complication in the ND group, but we failed to find statistical significance. With the available data, our hypothesis that drains will decrease the incidence of surgical-site complications in TKA patients receiving LMWH prophylaxis was not validated. This was a retrospective study, and thus had limitations. One limitation relevant to this portion of the study was that the method of wound closure and hemostasis as well as drain status differed between groups. If a difference had been found between groups in clinically significant hematoma formation, this variable would have been problematic. The limitation of our study design is partially compensated for by the large number of patients. Although the prospective studies mentioned above were well designed, the relatively few numbers of patients made it difficult to detect small differences between groups. We reviewed almost 400 patients in this study, more than twice as many as the largest studies referenced above. This cohort represents 3 years of clinical practice, and the incidence of surgical-site problems in this period was relatively constant, which is encouraging.

Our study results correlated with those of Esler et al [3], demonstrating no benefit of closed-suction drainage on early range of motion or the need for manipulation. Interestingly, we found an increased rate of manipulation in drained patients. This study reviewed the patients of 4 surgeons, and the difference in manipulation rate may reflect practice patterns and indications for manipulations of the individual surgeon. This uncontrolled variable may have confounded the results if the difference was significant, but, as stated in the text, we were unable to detect a difference between groups.

The rates of symptomatic VTE were essentially the same between groups. This was not a prospective study, and all patients were not screened for VTE. Only patients exhibiting

clinical symptoms or at high risk for VTE were screened with venous Doppler ultrasonography. This reflects our clinical practice, and the results of this study correlate well with controlled trials of LMWH for VTE prophylaxis.

Lower preoperative hemoglobin levels put patients at risk for blood transfusions after primary TKA with or without drains. Although autologous predonation was associated with a lower allogeneic transfusion rate than the use of a drain, the 59.6% wastage rate was disturbing. If a surgeon chooses to use a reinfusion drain without autologous predonation and tourniquet deflation before closure, our results suggest that methods to bring the preoperative hemoglobin level above 13.0 g/dL could be used to decrease the risk of allogeneic transfusion.

A higher rate of surgical-site complication was noted in the no-drain group, but this difference was not statistically significant. Based on this, the choice of whether to use closed-suction drainage after TKA in patients receiving LMWH prophylaxis is at the surgeon's discretion. A larger, prospective study with more sensitive measurements is needed to better assess the effect of closed-suction drainage in patients undergoing TKA.

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