Impact of Reinfusion Drains on Hemoglobin Level in Total Knee Arthroplasty

Palaniappan Lakshmanan, MS (Orth), FRCS (Orth), Balaji Purushothaman, MRCS, and Ajay Sharma, MS (Orth), MCh (Orth)

Abstract

We conducted this study to determine the effect of reinfusion drains on the difference in hemoglobin (Hb) levels before and after total knee arthroplasty. Of the 158 patients who underwent total knee arthroplasty on one side, 74 had autologous blood transfusion through reinfusion drains (group 1); the other 84 did not have autologous blood transfusion, but ordinary suction drains were used to drain the wound during the immediate postoperative period (group 2).

Mean preoperative Hb levels were 13.6 g/dL for group 1 (SD, 1.4 g/dL; range, 10.4-18.1 g/dL) and 13.6 g/dL for group 2 (SD, 1.3 g/dL; range, 10.0-16.7 g/dL). Mean postoperative Hb levels were 10.7 g/dL for group 1 (SD, 1.5 g/dL; range, 7.9-16.5 g/dL) and 10.7 g/dL for group 2 (SD, 1.6 g/dL; range, 5.4-13.6 g/dL). The difference in Hb levels between the groups before and after the surgery was analyzed with *t* test and found to be not significant (*P* = .76). The reinfusion drain cost £36.43 (≈US$ 58.87) more than the suction drain.

Autologous blood from reinfusion drains did not significantly improve postoperative Hb levels. Further use of reinfusion drain is not cost-beneficial.

Total knee arthroplasty (TKA) is associated with significant blood loss.[1] Over the years, postoperative blood loss has been managed with different methods, including allogenic transfusion, autologous predonation, and autologous reinfusion of salvaged blood.

Although allogenic transfusion is still the most common method of compensating for blood loss, it may have deleterious effects, including transfusion-related infection, incompatibility-related transfusion reaction, and immunomodulatory effects.[2] These risks led to use of autologous predonation, which itself has drawbacks in terms of difficulty organizing patients for predonation, adherence to iron/erythropoietin therapy, and unexpected surgery delays requiring drawing of new units. Bierbaum and colleagues[3] reported that 48% of autologous blood donated by patients for surgery is discarded. Hence autologous transfusion may prove to be wasteful and costly.[4]

More recently, blood loss has been corrected with postoperative blood salvage and reinfusion. Woolson and colleagues[5] found this method easier to perform and more cost-effective than predonated autologous blood, and it also helps avoid the risks associated with post-TKA use of allogenic blood. In addition, studies around the world have found autologous reinfusion to significantly reduce the need for allogenic transfusion.[2,6-8] The criteria for allogenic retransfusion in these studies were hemoglobin (Hb) level <9 g/dL and hematocrit <34%. Recent studies have found no difference in mortality in healthy individuals between using a lower Hb threshold (8 g/dL) and using a higher threshold (10 g/dL).[9-12] In a randomized study of low-risk coronary artery bypass surgery patients, Bracey and colleagues[9] found no difference in mortality, postoperative myocardial infarction, or ventricular complications between patients with restrictive (Hb <8 g/dL) and liberal (Hb >9 g/dL) transfusion policies.[9] Hence, the Scottish Intercollegiate guidelines for blood transfusion in elective surgery suggest lowering the threshold for allogenic transfusion and con-

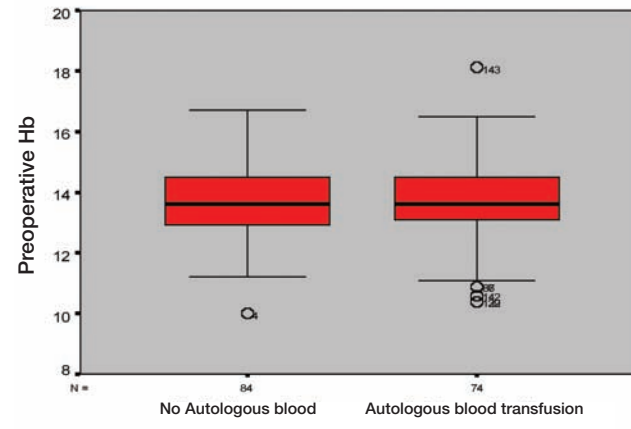

Figure 1. Preoperative hemoglobin levels in groups 1 and 2.

Dr. Lakshmanan is Spinal Fellow, Centre for Spinal Studies and Surgery, Queen's Medical Centre, Nottingham, and Dr. Purushothaman is Specialty Trainee in Trauma and Orthopaedics, Newcastle General Hospital, Newcastle-upon-Tyne, United Kingdom.

Dr. Sharma is Locum Consultant, Trauma and Orthopaedics, University Hospital of Wales and Llandough Hospital, Cardiff, United Kingdom.

Address correspondence to: Palaniappan Lakshmanan, MS (Orth), FRCS (Orth), 36 Greenhills, Killingworth, Newcastle-upon-Tyne, NE12 5BB, United Kingdom (tel, 0044-191-216-0109; fax, 0044-709-287-3857; e-mail, lakunns@gmail.com).

Am J Orthop. 2010;39(2):70-74.

Table I. Hemoglobin Level Differences Between Men and Women in Each Blood Transfusion Group (No–Yes)

Sex	Autologous Blood Transfusion Given		Hemoglobin Level (g/dL)			
			Minimum	Maximum	Mean	SD
M	No	Preoperative	11.8	16.7	14.48	1.30
		Postoperative	8.9	13.6	11.73	1.27
		Difference	0.8	5.7	2.75	0.94
	Yes	Preoperative	10.4	18.1	14.20	1.70
		Postoperative	8.1	16.5	11.28	1.77
		Difference	1.4	5.6	2.92	1.16
F	No	Preoperative	10.0	15.5	13.21	1.06
		Postoperative	5.4	13.0	10.11	1.47
		Difference	1.2	7.2	3.10	1.20
	Yes	Preoperative	10.4	15.6	13.31	1.16
		Postoperative	7.9	13.2	10.39	1.23
		Difference	1.0	4.7	2.92	0.92

Table II. Differences Between Patients With Preoperative Hemoglobin (Hb) Levels of <13 g/dL and >13 g/dL

Autologous Blood Transfusion Given	Preoperative Hb Group		Hb Level (g/dL)			
			Minimum	Maximum	Mean	SD
No	<13 g/dL	Preoperative	10.0	13.0	12.03	0.68
		Postoperative	5.4	10.8	9.06	1.34
		Difference	1.2	7.2	2.97	1.45
	>13 g/dL	Preoperative	13.1	16.7	14.24	0.91
		Postoperative	8.5	13.6	11.27	1.25
		Difference	0.8	5.7	2.97	0.99
Yes	<13 g/dL	Preoperative	10.4	13.0	11.74	0.84
		Postoperative	7.9	10.1	9.24	0.62
		Difference	1.0	4.4	2.51	0.93
	>13 g/dL	Preoperative	13.1	18.1	14.24	0.99
		Postoperative	8.1	16.5	11.18	1.39
		Difference	1.4	5.6	3.05	1.00

sidering transfusion when the Hb level falls below 7 g/dL in healthy individuals.[13] In light of this change in Hb threshold for allogenic blood transfusion, we conducted a study to review the benefits of autologous reinfusion drains.

Our study aims were to determine if there was real improvement in the difference in Hb levels before and after surgery with use of reinfusion drains and to analyze the cost-effectiveness of using these drains.

Materials and Methods

We retrospectively studied 158 consecutive patients who had undergone unilateral TKA for osteoarthritis in a university teaching hospital. Excluded were patients who had undergone unicompartmental knee arthroplasty or revision TKA. All procedures were performed under pneumatic tourniquet, which was released after surgery and application of compression bandage. Patients were divided into 2 groups. Group 1 consisted of 74 patients who had autologous transfusion of blood through autologous reinfusion drains (Bellovac; Astra Tech, Mölndal, Sweden). Group 2 consisted of 84 patients who had undergone TKA before the advent of the autologous transfusion system. In group 2, conventional drains were used: Exudrains (Astra Tech) in 74 patients and reinfusion drains in the other 10 (these 10 had inadequate drainage, <200 mL, so autologous reinfusion was not performed). We obtained the case notes for all 158 patients and collected the relevant data. Demographic details, including age, sex, and preoperative Hb levels, were noted for all patients. Postoperative Hb levels were recorded for patients in both groups. In all cases, aspirin and mechanical foot pumps were used, as per the hospital's thromboprophylaxis protocol.

In addition, the amount of autologous blood reinfused was noted for group 1 patients. The maximum amount of blood that could be reinfused with these bags was 500 mL. Group 2 patients (allogenic transfusion) had Hb levels checked before transfusion. All patients had Hb levels checked between 24 and 48 hours after surgery. In both groups, allogenic transfusion was performed for patients with an Hb level of <8 g/dL or with an Hb level of <9 g/dL plus symptoms. Also, to determine if there was any difference between men and women, and whether use of reinfusion drains benefited men, women, or both, we conducted statistical analyses between men and women separately in each group. Further, to determine whether reinfusion drains benefited patients with preoperative Hb levels of <13 g/dL over patients with preoperative Hb levels of >13 g/dL, we conducted statistical analyses separately for the different Hb levels in each group and compared them to see whether the starting preoperative Hb levels can be of any guidance in deciding to use reinfusion drains.

Table III. Differences Between Men and Women With Preoperative Hemoglobin (Hb) Levels of <13 g/dL and >13 g/dL

Autologous Blood Transfusion Given	Preoperative Hb Group	Sex		Hb Level (g/dL)			
				Minimum	Maximum	Mean	SD
No	<13 g/dL	M	Preoperative	11.8	12.9	12.10	0.54
			Postoperative	8.9	10.4	9.90	0.69
			Difference	1.4	2.9	2.20	0.68
		F	Preoperative	10.0	13.0	12.02	0.72
			Postoperative	5.4	10.8	8.88	1.39
			Difference	1.2	7.2	3.14	1.53
	>13 g/dL	M	Preoperative	13.5	16.7	14.85	0.94
			Postoperative	9.7	13.6	12.02	1.09
			Difference	0.8	5.7	2.83	0.95
		F	Preoperative	13.1	15.5	13.80	0.60
			Postoperative	8.5	13.0	10.73	1.08
			Difference	1.5	5.5	3.08	1.02
Yes	<13 g/dL	M	Preoperative	10.4	12.4	11.20	0.91
			Postoperative	8.7	9.7	9.00	0.48
			Difference	1.7	2.7	2.20	0.58
		F	Preoperative	10.4	13.0	11.90	0.78
			Postoperative	7.9	10.1	9.31	0.66
			Difference	1.0	4.4	2.59	1.01
	>13 g/dL	M	Preoperative	13.2	18.1	14.72	1.17
			Postoperative	8.1	16.5	11.67	1.60
			Difference	1.4	5.6	3.04	1.19
		F	Preoperative	13.1	15.6	13.90	0.68
			Postoperative	8.9	13.2	10.84	1.13
			Difference	1.4	4.7	3.06	0.86

SPSS software (Windows version 11.5) was used to analyze results. Value distributions were tested with Kolmogorov-Smirnov tests of normality and Q-Q plot. Appropriate comparative tests were used, and $P<.05$ was considered significant.

Results

Mean age was 72.1 years in group 1 (SD, 8.5 years; range, 49-89 years) and 69.3 years in group 2 (SD, 9.1 years; range, 49-89 years) ($P<.001$). The ratio of men to women was 1.77, with no difference between the 2 groups.

Mean preoperative Hb levels were 13.6 g/dL in group 1 (SD, 1.4 g/dL; range, 10.4-18.1 g/dL) and 13.6 g/dL in group 2 (SD, 1.3 g/dL; range, 10.0-16.7 g/dL) ($P<.001$) (Figure 1). Mean postoperative Hb levels were 10.7 g/dL in group 1 (SD, 1.5 g/dL; range, 7.9-16.5 g/dL) and 10.7 g/dL in group 2 (SD, 1.6 g/dL; range, 5.4-13.6 g/dL) ($P<.001$) (Figure 2). The difference in Hb levels between the 2 groups before and after the surgery was analyzed with t test and found to be not significant ($P = .76$; mean difference, 0.05; 95% confidence interval [CI], –0.28 to + 0.38) (Figure 3). The graphical plot of individual values also did not reveal any significant change between the 2 groups (Figure 4).

Mean amount of autologous blood transfused was 333.2 mL (SD, 82.8 mL; range, 200-500 mL). The difference in Hb levels before and after surgery was plotted against the amount of autologous blood transfused, and it was observed that there was no significant improvement with increased amount of autologous blood transfusion (Figure 5). Ten patients in group 1 received a total of 26 units of allogenic blood transfusion after surgery (range, 2-4 units), and 6 patients in group 2 received a total of 20 units (range, 2-4 units).

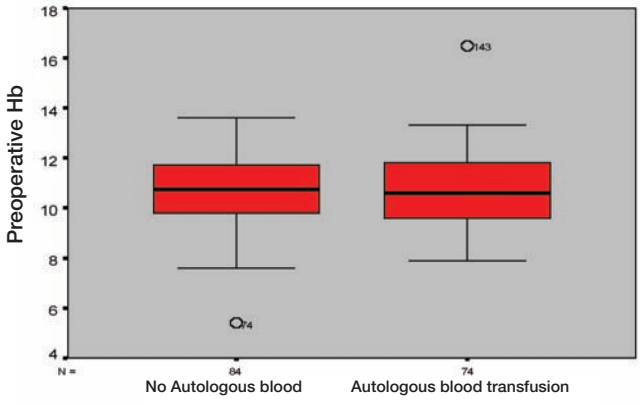

Figure 2. Postoperative hemoglobin levels in groups 1 and 2.

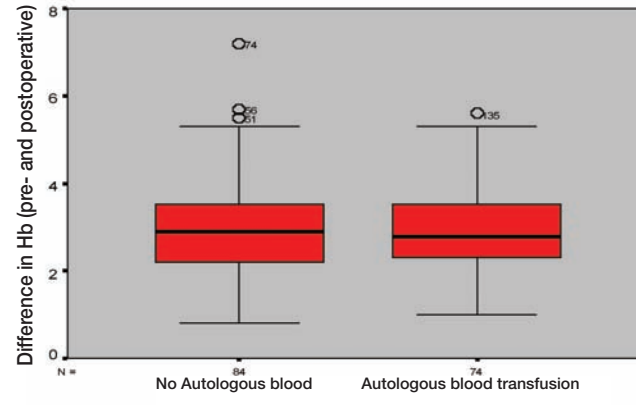

Figure 3. Difference in hemoglobin levels before and after surgery in groups 1 and 2.

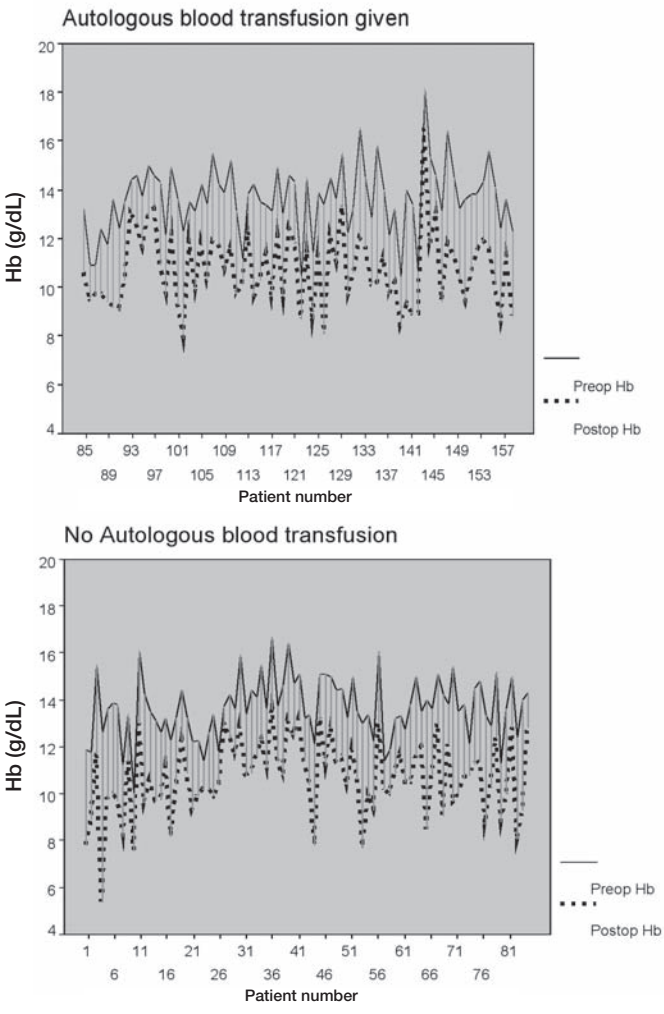

Figure 4. Difference in hemoglobin levels before and after surgery for each patient in groups 1 and 2.

To determine if there was any male–female difference between the 2 groups, we statistically analyzed the data separately for men and women in each group (Table I). The difference in Hb levels before and after surgery was found to be not significant for men and women in group 1 ($P = 0.17$, Levene equal variances assumed; 95% CI, –0.85 to + 0.15) and group 2 ($P = 0.99$, Levene equal variances assumed; 95% CI, –0.49 to + 0.48). Further, as a whole group, there was no difference in Hb levels before and after surgery between men and women ($P = .29$, Levene equal variances assumed; 95% CI, –0.53 to +0.16).

To analyze whether the autologous transfusion from reinfusion drains benefited patients with low starting preoperative Hb levels, we analyzed the data separately for patients with Hb levels of <13 g/dL and patients with Hb levels of >13 g/dL (Table II). The difference in Hb levels before and after surgery was found to be not significant, whether the preoperative Hb level was <13 g/dL or >13 g/dL ($P = .20$, Levene equal variances assumed; 95% CI, –0.67 to + 0.13). On analyzing them separately for men and women in these 2 groups, whether Hb was <13 g/dL or >13 g/dL (Table III), it was found that in women the difference in Hb levels was not at all significant ($P = .47$; 95% CI, –0.63 to + 0.29).

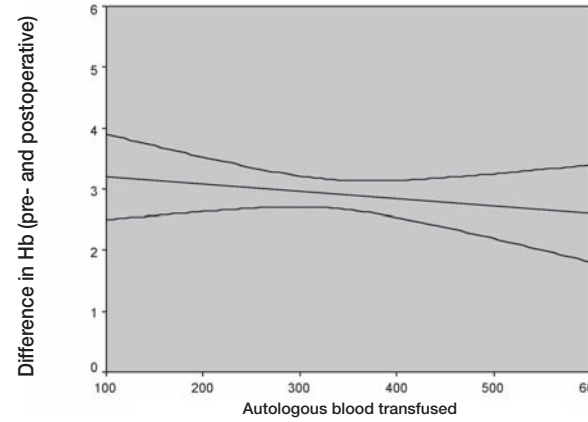

Figure 5. Amount of autologous blood transfused to difference in hemoglobin levels in group 1.

In men, even though it approached statistical significance, there was no difference in Hb levels before and after surgery, whether preoperative Hb level was <13 g/dL or >13 g/dL, as there were only 8 men with a preoperative Hb level of <13 g/dL ($P = .06$; 95% CI, –1.5 to + 0.05).

Discussion

One method for improving postoperative anemia—postoperative blood salvage and reinfusion—has recently become popular as a way to avoid allogenic blood transfusion. Some studies have found this method to be superior to others in compensating for perioperative blood loss, but other studies have disputed this finding.[2,6-8,14-16] There is some controversy with respect to the allogenic blood–sparing effect. Some studies have disputed even the use of drains in the first instance (compensating for perioperative blood loss) and concluded that these drains increase transfusion rates.[17,18]

Although our study was retrospective, its 2 patient groups were comparable in demographics; in mean preoperative Hb levels and in postoperative Hb levels before allogenic transfusion, despite group 1 patients' being reinfused with the postoperative salvaged blood.

In a retrospective study, Peter and colleagues[8] found that allogenic blood transfusion was needed for 72% of patients in a suction drain group compared with only 19% of patients in an autologous reinfusion group. The Hb threshold for transfusion in their study was 10 g/dL, similar to the 9 g/dL recommended by Claudio[10] and used by Cheng and colleagues.[6] Similarly, Strümper and colleagues[2] used 9.6 g/dL as the Hb threshold for allogenous transfusion. Further, they concentrated their discussion on the need for allogenic transfusion, which depends on multiple extraneous factors (both patient and physician/surgeon factors). Even in their study, there was no statistically significant difference in Hb levels before and after TKA between the 2 groups. The main aim in using a reinfusion drain is to increase Hb levels. Therefore, measuring Hb levels gives the direct benefit of using such a reinfusion drain. This is the rationale for using Hb levels in our study—to directly measure the benefit of using a reinfusion drain.

Many studies have been conducted to assess the Hb threshold for transfusion.[9-13] Carson and colleagues[19] found that nontransfused surgical patients with heart disease were at higher risk for death when Hb levels fell below 8 g/dL. In a prospective, 104-patient study by Abuzakuk and colleagues,[14] an autologous transfusion system was found to be safe but failed to reduce the need for postoperative allogenic blood transfusion after uncomplicated TKA. A study comparing 3 groups of patients—those with tourniquet and postoperative autotransfusion, those with tourniquet and regular drain, and those with tourniquet only at time of cementing and no drain—found that perioperative autotransfusion did not decrease the need for allogenic transfusion.[15]

Our results are comparable to results in the studies mentioned and question the benefit of invariably using reinfusion drains in TKA cases. A Bellovac drain (£50.23 ≈ US$ 81.17) costs £36.43 (≈ US$ 58.87) more than an Exudrain (£13.80 ≈ US$ 22.30). In addition, each Bellovac drain is changed to an Exudrain after the reinfusion system has been used, further increasing the cost. In a hospital in which 1,000 or more joint replacements are performed every year, the cost benefit would significantly improve patient care. Further, the Bellovac reinfusion drain may not be of much benefit in TKA because its maximum reinfusion amount is only 500 mL—bearing in mind that the fluid collected in the drain is not whole blood or red cell concentrate. On the other hand, the fluid collected is relatively diluted by tissue and other fluids used before surgery. In addition, if the volume is <200 mL, the blood is not reinfused, as the amount is considered too low. However, this situation is rather unusual in TKA performed under tourniquet control until the end of surgery, except in rare cases in which the suction in the drain is not working properly for various reasons, including inadvertent drain pull-out. Our study results also show that reinfusion drains do not benefit patients with preoperative Hb levels of <13 g/dL compared with >13 g/dL, and there is no difference between men and women in general.

Further research is needed to identify a subgroup of TKA patients who may benefit from autologous transfusion using reinfusion drains and to assess the amount of blood drained with use of reinfusion drains to assess the real benefit or detriment of using such drains. However, with this study and in the current situation, there is not enough evidence to support invariable use of reinfusion drains in TKAs. In conclusion, use of autologous reinfusion drains did not improve postoperative Hb levels in TKA patients, and, therefore, invariable use of this reinfusion drain is not cost-effective.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

References

1. Lotke PA, Faralli VJ, Orenstein EM, Ecker ML. Blood loss after total knee replacement. Effect of tourniquet release and continuous passive motion. *J Bone Joint Surg Am.* 2001;73(7):1037-1040.
2. Strümper D, Weber EW, Gielen-Wijffels S, et al. Clinical efficacy of postoperative autologous transfusion of filtered shed blood in hip and knee arthroplasty. *Transfusion.* 2004;44(11):1567-1571.
3. Bierbaum BE, Callaghan JJ, Galante JO, Rubash HE, Tooms RE, Welch RB. An analysis of blood management in patients having a total hip or knee arthroplasty. *J Bone Joint Surg Am.* 1999;81(1):2-10.
4. Etchason J, Petz L, Keeler E, et al. The cost effectiveness of preoperative autologous blood donations. *N Engl J Med.* 1995;332(11):719-724.
5. Woolson ST, Wall WW. Autologous blood transfusion after total knee arthroplasty: a randomized, prospective study comparing predonated and postoperative salvage blood. *J Arthroplasty.* 2003;18(3):243-249.
6. Cheng SC, Hung TSL, Tse PYT. Investigation of the use of drained blood reinfusion after total knee arthroplasty: a prospective randomised controlled study. *J Orthop Surg.* 2005;13(2):120-124.
7. Newman JH, Bowers M, Murphy J. The clinical advantages of autologous transfusion. A randomized, controlled study after knee replacement. *J Bone Joint Surg Br.* 1997;79(4):630-632.
8. Peter VK, Radford M, Matthews MG. Re-transfusion of autologous blood from wound drains: the means for reducing transfusion requirements in total knee arthroplasty. *Knee.* 2001;8(4):321-323.
9. Bracey AW, Radovancevic R, Riggs SA, et al. Lowering the haemoglobin threshold for transfusion in coronary artery bypass procedures: effect on patient outcome. *Transfusion.* 1999;39(10):1070-1077.
10. Claudio MM. Advances in understanding of tolerance of normovolemic anemia transfusion requirements in critically ill patients. Paper presented at: 28th World Congress of the International Society of Haematology; August 26-30, 2000; Toronto, Canada.
11. Hébert PC, Wells G, Blajchman MA, et al. A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care. Transfusion Requirements in Critical Care Investigators, Canadian Critical Care Trials Group. *N Engl J Med.* 1999;340(6):409-417.
12. Hébert PC, Yetisir E, Martin C, et al. Is a low transfusion threshold safe in critically ill patients with cardiovascular diseases? *Crit Care Med.* 2001;29(2):227-234.
13. Perioperative blood transfusion for elective surgery—a national clinical guideline. Scottish Intercollegiate Guidelines Network Web site. http://www.sign.ac.uk/pdf/2005bloodtransfusionreport.pdf. Published 2001. Accessed October 6, 2009.
14. Abuzakuk T, Senthil Kumar V, Shenava Y, et al. Autotransfusion drains in total knee replacement. Are they alternatives to homologous transfusion? *Int Orthop.* 2007;31(2):235-239.
15. Grimaldi NA, Sicuranza M, Eck JC. Perioperative autotransfusion systems in TKA are not necessary. *Orthopedics.* 2006;29(11):1027-1029.
16. Mauerhan DR, Nussman D, Mokris JG, Beaver WB. Effect of postoperative reinfusion systems on haemoglobin levels in primary total hip and knee arthroplasties. A prospective randomized study. *J Arthroplasty.* 1993;8(5):523-527.
17. Reilly TJ, Gradisar IA Jr, Pakan W, Reilly M. The use of postoperative suction drainage in total knee arthroplasty. *Clin Orthop.* 1986;(208):238-242.
18. Ritter MA, Keating EM, Faris PM. Closed wound drainage in total hip or total knee replacement. A prospective, randomized study. *J Bone Joint Surg Am.* 1994;76(1):35-38.
19. Carson JL, Duff A, Berlin JA, et al. Effect of anemia and cardiovascular disease on surgical mortality and morbidity. *Lancet.* 1996;348(9034):1055-1060.

This paper will be judged for the Resident Writer's Award.