

## Perioperative Blood Management in Total Hip Arthroplasty

\*Charles R. Clark, MD

### Abstract

*Blood management during total hip arthroplasty is a critical component of successful patient care, and an overall strategy is necessary. Multiple options for blood management are available, including the use of predeposited autologous blood, perioperative blood salvage, hemodilution techniques, erythropoietic agents, hemostatic agents, and allogeneic blood. Rather than relying on automatic so-called transfusion triggers, the surgeon should identify patient-specific risk factors such as the anticipated difficulty of the procedure, preoperative hemoglobin level, comorbidities, and a plan for blood management.*

**Instr Course Lect 2009;58:167-172.**

Blood management is an important consideration in total hip arthroplasty (THA) that is critical to the successful management of patients undergoing total joint arthroplasty. Important considerations include the safety of blood or blood products, the efficacy of oxygen delivery to the tissues, cost, and convenience. Patient-specific factors are integral to the decision process. The ultimate objective is to minimize the use of allogeneic blood transfusion and its associated risks.

Bierbaum and associates<sup>1</sup> described current blood usage in their review of 9,482 patients, 5,741 (61%) of whom had predeposited autologous blood before total joint arthro-

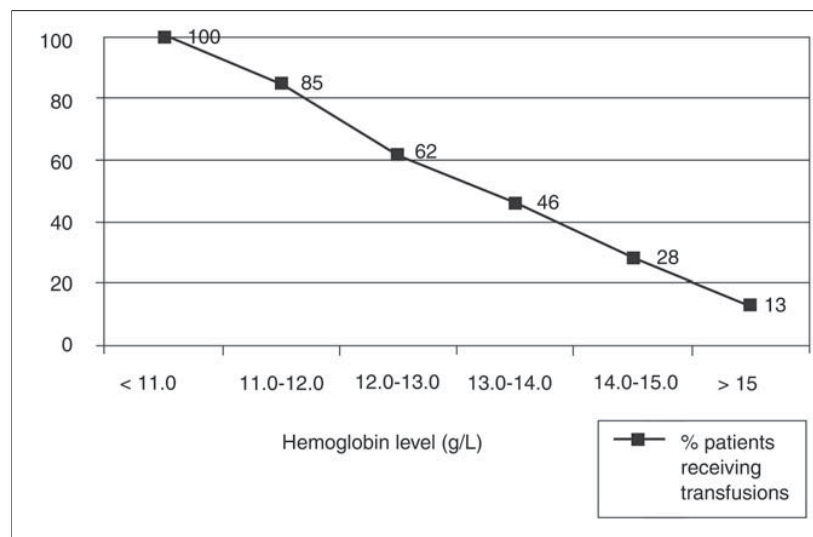
plasty. Interestingly enough, 4,464 of 9,920 units (45%) were not used. Patients undergoing primary total hip or knee arthroplasty and revision total knee arthroplasty had the greatest number of so-called wasted units. In addition, 9% of patients (503 of 5,741) who had predeposited blood needed to have an allogeneic blood transfusion. The frequency of allogeneic transfusion was highest in patients undergoing revision THA, bilateral total knee arthroplasty, and patients with a baseline hemoglobin level of 13 g/dL or less.

With respect to clinical factors, Pola and associates<sup>2</sup> analyzed the factors associated with the risk of requiring an allogeneic blood transfu-

sion and evaluated clinical variables such as age, gender, the presence of hypertension, and body mass index. The authors performed a simultaneous analysis of parameters and stratified patients with different risks. The goal was to increase the efficacy of, as well as reduce the cost associated with, blood management. The authors found that these various parameters may be synergistic. There was a significantly increased risk of blood transfusion when two or more of these clinical parameters were present ( $P = 0.02$ ).

Salido and associates<sup>3</sup> also evaluated clinical factors associated with the need for allogeneic blood transfusion after hip and knee arthroplasty and found that the preoperative hemoglobin and weight of the patient significantly predicted the need for transfusion. As shown in Figure 1, all patients with a preoperative hemoglobin level less than 11 g/dL required a blood transfusion, whereas the percentage of patients receiving transfusions with a hemoglobin level greater than 15 g/dL was 13%. Furthermore, these authors found that with a hemoglobin level less than 13 g/dL, there was a four times greater risk of requiring a

\*Charles R. Clark, MD or the department with which he is affiliated has received research or institutional support from Zimmer and is a consultant for or an employee of Zimmer.



**Figure 1** Relationship between the preoperative hemoglobin levels and the percentage of patients who received a blood transfusion. (Reproduced with permission from Salido JA, Marin LA, Gomez LA, Zorrilla P, Martinez C: Perioperative hemoglobin levels and the need for transfusion after prosthetic hip and knee surgery. *J Bone Joint Surg Am* 2002;84:216-220.)

blood transfusion compared with a hemoglobin level from 13 to 15 g/dL; when the hemoglobin level was less than 13 g/dL, there was a 15.3-fold greater risk of requiring a blood transfusion than in patients with a hemoglobin level greater than 15 g/dL.

The risks associated with blood transfusion are a major consideration. Many patients fear receiving an allogeneic blood transfusion because of the risk of virally transmitted diseases, such as hepatitis C and human immunodeficiency virus (HIV). The risk of acquiring hepatitis C, however, is approximately 1 in 100,000 blood transfusions, and the risk of acquiring HIV is approximately 1 in 500,000 transfusions. Fatal hemolytic reactions caused by ABO blood-type incompatibility occur in approximately 1 in 600,000 patients. One way of putting this information in perspective is to consider that a patient has a 1 in 200

chance of dying related to smoking if the patient smokes one pack of cigarettes per day.

The use of allogeneic blood transfusion has declined; however, the safety of the blood supply has improved. Other important factors to consider relate to the cost and inventory of blood supply on hand; consequently, so-called transfusion triggers can be reconsidered in view of patient-specific factors.

### **Blood Management Strategies** **Preoperative Autologous Donation**

Preoperative autologous blood was rarely used before the recognition of HIV. The patient donates blood, typically two units within 42 days of surgery. Such donation decreases a patient's hemoglobin level by approximately 1.2 to 1.5 g/dL per donated unit. Hatzidakis and associates<sup>4</sup> analyzed the risk factors for allogeneic transfusions in patients

who had donated autologous blood before total joint arthroplasty. The authors reviewed 489 consecutive patients, 271 of whom underwent THA and 247 underwent total knee arthroplasty. The authors found that preoperative autologous donation significantly reduced the need for banked blood. They recommend identifying patients who are at low risk for transfusion and found that patients with a preoperative hemoglobin level greater than 15 g/dL and patients with a hemoglobin level from 13 to 15 g/dL who were younger than 65 years were at low risk for requiring a banked blood transfusion. Billote and associates<sup>5</sup> performed a prospective randomized study of preoperative autologous donation in patients undergoing THA and found that autologous donation was of no benefit for nonanemic patients (Hgb > 12 g/dL in this study) undergoing primary THA.

Furthermore, cost is a consideration. At the University of Iowa Hospitals and Clinics, the patient charge for a unit of autologous blood in 1999 was approximately \$500; in 2008, the charge for a unit of banked blood was \$730 and a unit of autologous blood cost \$760.

### **Perioperative Blood Salvage**

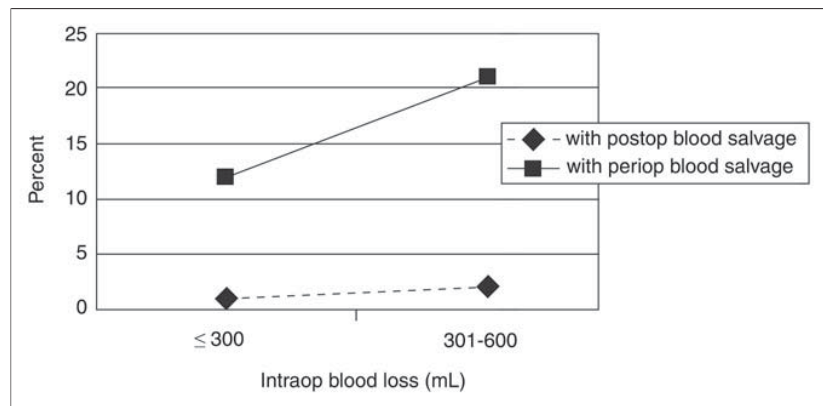
The options for perioperative blood salvage include the use of an intraoperative cell saver, postoperative blood salvage, and a technique that includes combined intraoperative and postoperative cell salvage. The principle is to collect lost blood and return it to the patient. Perioperative salvage has the advantage of returning the patient's own blood. Zarin and associates<sup>6</sup> analyzed the efficacy of intraoperative blood collection and reinfusion in patients undergoing THA. The authors reviewed

126 patients who underwent revision THA. They found that intraoperative collection and reinfusion significantly reduced the net perioperative blood loss in two groups of patients—patients who had revision of both the acetabular and femoral components and patients who had revision of the acetabular component alone.

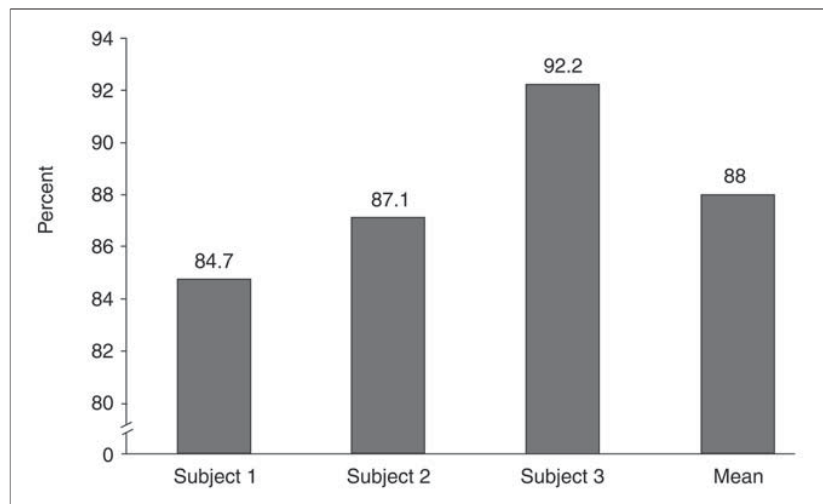
Grosvenor and associates<sup>7</sup> analyzed the efficacy of postoperative blood salvage following primary THA in patients with or without predeposited autologous units. They found that postoperative salvage significantly reduced the risk of allogeneic transfusion among patients undergoing primary THA, whether or not the patients had predeposited autologous blood ( $P = 0.001$ ). As shown in Figure 2, patients without postoperative salvage were approximately 10 times more likely to require allogeneic transfusion than were patients who had the reinfusion drain.

Colwell and associates<sup>8</sup> analyzed erythrocyte viability in blood salvage during intraoperative (from a cell saver) cemented total joint arthroplasty. They used a double isotope-labeling technique and found that the mean erythrocyte viability was 88%, which is well above the American Association of Blood Banks standards for banked and preoperative autologous-donated blood of 70%. The values for three subjects are shown in Figure 3.

A combined technique of intra- and postoperative salvage can be performed with a device known as OrthoPAT (Haemonetics, Braintree, MA). Clark and associates<sup>9</sup> reviewed their experience with this perioperative autotransfusion device in 398 patients undergoing total hip and total knee arthroplasty. They used a decision-tree analysis; in-



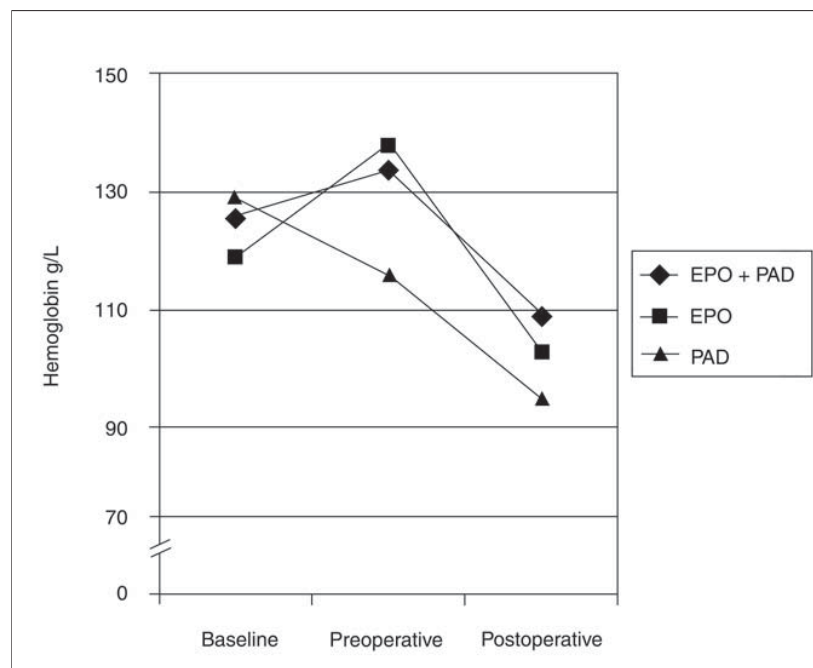
**Figure 2** Graph illustrating the likelihood of allogeneic transfusion in a 60-year-old man with one unit of deposited autologous blood, a preoperative hematocrit of 0.35, and a cementless prosthesis. Postop = postoperative; periop = perioperative; intraop = intraoperative. (Reproduced with permission from Grosvenor D, Goyal V, Goodman S: Efficacy of postoperative blood salvage following total hip arthroplasty in patients with and without deposited autologous units. *J Bone Joint Surg Am* 2000;82:951-954.)



**Figure 3** Erythrocyte viability for three patients at 24 hours after surgery. (Reproduced with permission from Colwell CW Jr, Beutler E, West C, Hardwick ME, Morris BA: Erythrocyte viability and blood salvage during total joint arthroplasty with cement. *J Bone Joint Surg Am* 2002;84:23-25.)

cluded in the study group were patients who underwent primary and revision total knee and total hip arthroplasties as well as bilateral simultaneous total knee arthroplasties. Some patients underwent preoperative autologous donations and others used the OrthoPAT de-

vice. Overall, the authors found that all patients undergoing total hip and total knee arthroplasty with the reinfusion device had a significant relative risk reduction with regard to the use of banked blood. There is a cost involved with this device, however, and it is helpful to have a dedicated



**Figure 4** Graphic representation of the changes in hematologic parameters (from baseline to immediately preoperative to the lowest postoperative level) in each group. EPO = erythropoietin, PAD = preoperative autologous donation. (Reproduced with permission from Bezwada HP, Nazarian DG, Henry DH, Booth RE Jr: Preoperative use of recombinant human erythropoietin before total joint arthroplasty. *J Bone Joint Surg Am* 2003;85:1795-1800.)

team of nurses and/or technicians to troubleshoot technical problems with the device that may arise.

### Hemodilution

A technique for diluting the patient's blood is known as acute normovolemic hemodilution. Blood is collected immediately preoperatively for immediate postoperative reinfusion. The volume removed is replaced with crystallite and colloid, with the rationale that intraoperative blood loss will have a lower hematocrit level and transfused cells will be healthier. Carless and associates<sup>10</sup> performed a meta-analysis of nine randomized controlled trials and found no reduction in the requirement for allogeneic blood transfusion with the use of acute normo-

volemic hemodilution. They did, however, recommend its use in conjunction with other blood conservation techniques.

### Hematopoiesis

There are two basic techniques for hematopoiesis: the use of iron and erythropoietin  $\alpha$ . Although in use for many years, iron is slow acting and is less effective than erythropoietin  $\alpha$ . Oral iron preparations are relatively inexpensive; however, some patients do not tolerate their use over the long term. Recombinant human erythropoietin is more effective than iron for stimulating the differentiation of progenitor cells to become a dedicated red blood cell line, but it is much more expensive than oral iron. Sparling

and associates<sup>11</sup> reviewed the use of erythropoietin in five Jehovah's Witness patients who underwent revision THA. Each received 100 IU/week of erythropoietin preoperatively over an average of 26 days. Hematocrit level was monitored and was held at greater than 45%. The authors found no complications due to blood loss, and no patient underwent a blood transfusion. Bezwada and associates<sup>12</sup> analyzed the preoperative use of recombinant human erythropoietin before total joint arthroplasty. They concluded that the preoperative use of erythropoietin in conjunction with preoperative autologous donation reduced the need for allogeneic blood transfusion associated with total joint arthroplasty and was more effective than either erythropoietin or preoperative autologous donation alone (Figure 4).

Indications for the use of erythropoietin include a hemoglobin level less than 13 g/dL and greater than 10 g/dL. Further, it may be considered for patients unable or unwilling to predeposit autologous blood and for patients undergoing simultaneous bilateral total hip or total knee arthroplasty. The strategy may also be useful in revision cases and patients with religious concerns regarding the receipt of blood.

### Hemostasis Agents

Hemostasis agents are pharmacologic agents and include topically active agents (such as thrombin, collagen, and fibrin glue) as well as antifibrinolytics. Levy and associates<sup>13</sup> analyzed their use of fibrin tissue adhesive following total knee arthroplasty and found that it was associated with a significant reduction in blood loss following total knee arthroplasty. Antifibrinolytic agents are controversial, however,

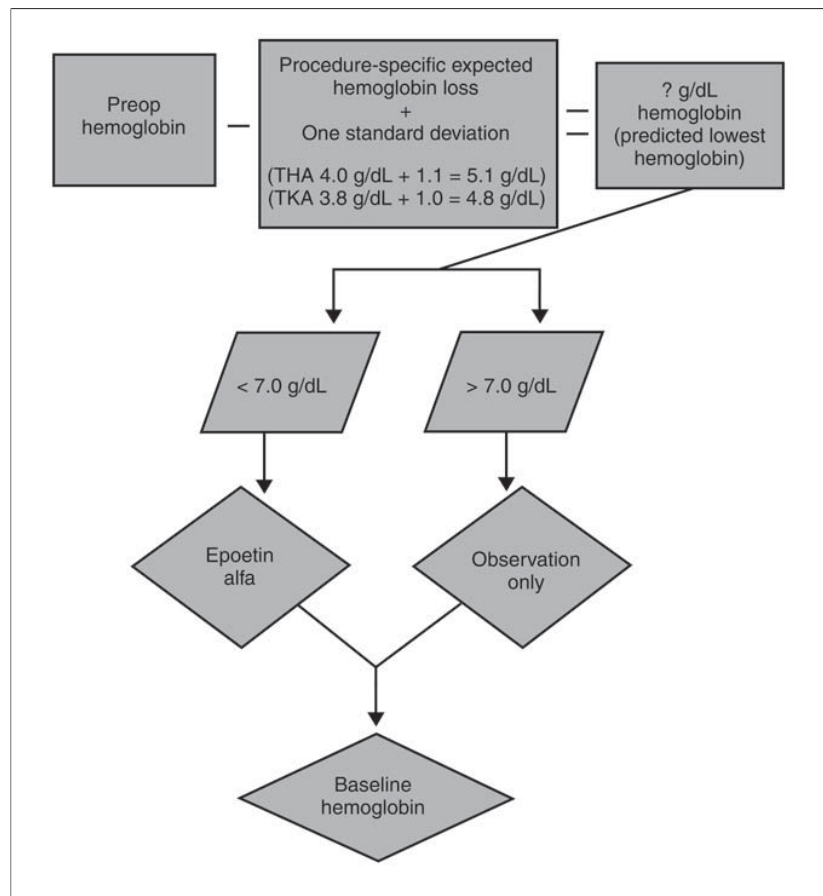
because of their high cost and associated thromboembolic complications.

**Allogeneic Blood Transfusion**

It is important to note the increased safety of the allogeneic blood supply now that blood banks are able to screen for various viruses. Further, the surgeon should not have so-called automatic triggers, based on a specific hemoglobin or hematocrit level, for blood transfusion. Rather, patient-specific factors need to be considered, including the patient's comorbidities and age as well as procedure-specific factors such as an anticipated difficult revision arthroplasty or bilateral simultaneous arthroplasties.

Along with an increased risk of infection, allogeneic blood is associated with immunomodulation, and the T cells and macrophages are suppressed by its presence. Patients may inquire about having a designated donor with regard to allogeneic blood. However, there has been an increased risk of hepatitis B and C as well as HIV in comparison with the transfusion of standard banked blood. Furthermore, waste of the blood product remains an issue because it is expensive; designator donor blood is wasted if not given to the designated patient.

Pierson and associates<sup>14</sup> used a blood conservation algorithm in patients undergoing total hip and total knee arthroplasty. These authors found a reduced need for allogeneic blood transfusion in patients in whom the algorithm was used. They studied a consecutive series of 500 patients undergoing total hip and total knee arthroplasty, 433 of whom followed the algorithm and 67 did not. When the algorithm was followed (Figure 5), there was a 2.1% rate of banked blood transfu-



**Figure 5** Flowchart illustrating patient-specific recommendations. TKA = total knee arthroplasty. (Reproduced with permission from Pierson JL, Hannon TJ, Earles DR: A blood-conservation algorithm to reduce blood transfusion after total hip and knee arthroplasty. *J Bone Joint Surg Am* 2004;86:1512-1518.)

sion. When the algorithm was not followed, the banked blood transfusion rate rose to 16.4% ( $P = 0.001$ ).

**Author's Preferred Hemogenous Management**

Factors assessed preoperatively include medical comorbidities and baseline hemoglobin and hematocrit values, as well as the anticipated difficulty of the procedure.

Typically, in a healthy patient with minor comorbidities who has a normal baseline hemoglobin level and is undergoing a primary THA,

preoperative blood salvage is the primary blood management technique; autologous blood is administered if needed.

Higher blood loss is anticipated with bilateral procedures and revision procedures, as well as difficult primary procedures. Additional blood management strategies may be necessary.

In patients who are Jehovah's Witnesses, perioperative blood salvage typically is the primary blood management technique if they agree to comply with its use. Erythropoietin is another option.

## Summary

It is important to have an overall strategy for blood management. Although allogeneic blood is safer than it has been in the past, multiple other options are available, including the use of predeposited autologous blood, perioperative blood salvage, hemodilution techniques, erythropoietic agents, hemostatic agents, and allogeneic blood.

The surgeon should not have an automatic transfusion trigger. Rather, patient-specific risk factors should be identified, such as an anticipated difficult revision or simultaneous bilateral procedures and the patient's preoperative hemoglobin level, and a patient-specific plan developed.

---

## References

1. 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;81:2-10.
2. Pola E, Papaleo P, Santoliquido A, Gasparini G, Aulisa L, De Santis E: Clinical factors associated with an increased risk of perioperative blood transfusion in nonanemic patients undergoing total hip arthroplasty. *J Bone Joint Surg Am* 2004;86:57-61.
3. Salido JA, Marin LA, Gomez LA, Zorrilla P, Martinez C: Perioperative hemoglobin levels and the need for transfusion after prosthetic hip and knee surgery. *J Bone Joint Surg Am* 2002;84:216-220.
4. Hatzidakis AM, Mendlick RM, McKillip T, Reddy RL, Garvin KL: Preoperative autologous donation for total joint arthroplasty: An analysis of risk factors for allogeneic transfusion. *J Bone Joint Surg Am* 2000;82:89-100.
5. Billote DB, Glisson SN, Green D, Wixson RL: A prospective randomized study of preoperative autologous donation for hip replacement surgery. *J Bone Joint Surg Am* 2002;84:1299-1304.
6. Zarin J, Grosvenor D, Schurman D, Goodman S: Efficacy of intraoperative blood collection and reinfusion in revision total hip arthroplasty. *J Bone Joint Surg Am* 2003;85:2147-2151.
7. Grosvenor D, Goyal V, Goodman S: Efficacy of postoperative blood salvage following total hip arthroplasty in patients with and without deposited autologous units. *J Bone Joint Surg Am* 2000;82:951-954.
8. Colwell CW Jr, Beutler E, West C, Hardwick ME, Morris BA: Erythrocyte viability and blood salvage during total joint arthroplasty with cement. *J Bone Joint Surg Am* 2002;84:23-25.
9. Clark CR, Spratt KF, Blondin M, Craig S, Fink L: Perioperative autotransfusion in total hip and knee arthroplasty. *J Arthroplasty* 2006;21:23-35.
10. Carless P, Moxey A, O'Connell D, Henry D: Autologous transfusion techniques: A systematic review of their efficacy. *Transfus Med* 2004;14:123-144.
11. Sparling EA, Nelson CL, Lavender R, Smith J: The use of erythropoietin in the management of Jehovah's Witnesses who have revision total hip arthroplasty. *J Bone Joint Surg Am* 1996;78:1548-1552.
12. Bezwada HP, Nazarian DG, Henry DH, Booth RE Jr: Preoperative use of recombinant human erythropoietin before total joint arthroplasty. *J Bone Joint Surg Am* 2003;85:1795-1800.
13. Levy O, Martinowitz U, Oran A, Tauber C, Horoszowski H: The use of fibrin tissue adhesive to reduce blood loss and need for blood transfusion after total knee arthroplasty: A prospective, randomized, multicenter study. *J Bone Joint Surg Am* 1999;81:1580-1588.
14. Pierson JL, Hannon TJ, Earles DR: A blood-conservation algorithm to reduce blood transfusion after total hip and knee arthroplasty. *J Bone Joint Surg Am* 2004;86:1512-1518.