Patients undergoing primary total hip arthroplasty (THA) have historically been over-transfused. In a district general hospital setting, the authors observed a significant downward trend in blood transfusion requirements in these patients over 6 years after a change in transfusion policy. The purpose of this study was to retrospectively analyze the change in transfusion practice and present the results of the restrictive transfusion policy.

All patients undergoing primary THA between January 2003 and December 2008 were identified from hospital records. Pre- and postoperative hemoglobin levels, transfusion trigger hemoglobin, blood transfusion requirements, patient age and sex, 30-day mortality, and length of stay data were analyzed for all patients. A total of 1169 primary THAs were performed. Annual allogeneic blood transfusion requirements reduced progressively from 151 units in 2003 to 90 units in 2008 despite an increase in the number of patients undergoing THA. During this period, the proportion of patients transfused decreased from 35% to 17%. A reduction of mean transfusion trigger hemoglobin from 79 to 73 g/L was observed over the study period. No patient experienced any significant complications as a result of undertransfusion.

The authors’ institution has steadily restricted the use of blood transfusion in patients undergoing THA to those symptomatic of anemia. Increasing confidence among medical and nursing staff that reduced postoperative hemoglobin levels can be safely tolerated has resulted in a 55% reduction in blood transfusion in patients undergoing THA with no other change of practice.
Orthopedic surgery is the third largest user of red blood cells in the National Health Service (NHS) in England and Wales. Blood transfusion is frequently prescribed following elective total hip arthroplasty (THA), which is associated with an average blood loss of 1000 to 2000 mL. Transfusion of allogeneic blood is associated with serious complications at a rate of 1 in every 67,000 cases. Concerns regarding reduced red blood cell availability and cost issues have been responsible for a change in transfusion practice. Between 2009 and 2010, one unit of red blood cells cost the NHS £130, and the total NHS cost for an adult transfusion of red blood cells has been estimated at £635.

Various strategies have previously been used in THA to reduce the requirements for blood transfusion, including preoperative hemoglobin optimization using erythropoietic supplements, preoperative autologous blood donation, perioperative hemodilution, antifibrinolytic agents, and red cell salvage. The majority of these techniques are not in common practice because they have not proven cost effective in uncomplicated primary THA.

The current authors’ institution adopted a policy to restrict allogeneic blood transfusion to patients symptomatic of anemia (ie, dizziness or presyncopal symptoms) or with signs of anemia (ie, hypotension or postural hypotension despite intravenous fluid resuscitation). Previously, transfusions had often been prescribed on the basis of a postoperative hemoglobin level less than 80 g/L alone or prior to checking the hemoglobin level using a laboratory assay. The practice of transfusing blood before checking the postoperative hemoglobin level was also discouraged. This change of practice was promoted by the senior author (J.J.), who chaired the hospital transfusion committee during the study period.

The purposes of this study were to present the authors’ institution’s policy of restrictive transfusion practice, to demonstrate how a reduction in transfusion rates was achieved, and to demonstrate the safety of this protocol in terms of 30-day mortality rates.

**Materials and Methods**

**Patients**

All patients who had undergone primary THA between January 2003 and December 2008 were identified retrospectively from hospital records. Data regarding patient age at operation, patient sex, hemoglobin levels pre- and postoperatively, transfusion trigger hemoglobin, posttransfusion hemoglobin, allogeneic blood transfusion requirements, 30-day mortality, and length of stay were gathered from electronic records. Transfusion trigger hemoglobin refers to the hemoglobin level on postoperative day 1 in patients who were transfused.

No alternative blood-conserving measures (eg, intra- or postoperative cell salvage, pharmacological agents, or autologous blood transfusion) were used during the study period. Surgical and anesthetic techniques did not change throughout the study period.

**Transfusion Protocol**

Full blood count assay was performed on the morning of postoperative day 1. Full blood count was only performed on subsequent days if it was clinically indicated (ie, if the patient had signs or symptoms of anemia). Transfusion was performed with the aim of restoring the hemoglobin to a level at which the patient’s symptoms of anemia were relieved (eg, relieving hypotension, presyncopal symptoms, or postural hypotension). If the hemoglobin level was approximately 70 g/L and the patient was symptomatic of anemia or had signs of anemia, 1 or 2 units of red blood cells were prescribed. If the hemoglobin level was less than 80 g/L and the patient had vials in the normal acceptable limits (eg, pulse, blood pressure, and urine output) and no serious or concerning symptoms of anemia, he or she was not transfused.

The patients were monitored closely for signs and symptoms of anemia and kept fluid replete. Regular body temperature, heart rate, blood pressure, respiratory rate, hemoglobin oxygen saturations, and urine output were recorded. The frequency of these clinical observations depended on the clinical situation (ie, time after operation and clinical condition of the patient). Patients with a history of serious cardiovascular, respiratory, or other serious comorbidities that would be adversely affected by anemia were treated outside the protocol and were transfused at a higher trigger hemoglobin if concerns existed about anemia. For this type of patient, a hemoglobin level approximately 100 g/L was considered optimum. All patients undergoing THA were included in the analysis, regardless of their comorbidities.

The decision to prescribe either 1 or 2 units of blood was made according to the hemoglobin level and the patient’s comorbidities. The assumption was made that 1 unit of transfused blood would increase the hemoglobin level by approximately 10 g/L. The authors aimed to restore the hemoglobin level to approximately 80 g/L in patients with no comorbidities or to approximately 100 g/L in those with cardiovascular, respiratory or other serious comorbidities.

When a transfusion had been given, hemoglobin levels were checked the following morning. If the patient remained asymptomatic, the hemoglobin level was assessed and further transfusion was considered, taking into account the preoperative hemoglobin level and the patient’s comorbidities.

**Statistical Analysis**

Statistical analysis was performed by the first author (P.M.R.) using Graphpad Instat (Graphpad Software, Inc, LaJolla, California). An unpaired Student’s t test was used to compare means for continuous normally distributed variables. One-
way analysis of variance (ANOVA) and the Tukey-Kramer multiple comparisons test were used to compare multiple means. An unpaired Mann-Whitney U test was used to compare medians for continuous nonnormally distributed data. The Kruskal-Wallis test and Dunn’s multiple comparisons test were used to compare multiple medians. A P value less than .05 was considered statistically significant.

RESULTS

Over a 6-year period, 1169 patients underwent primary THA. Patient demographics were similar throughout the study period (Table 1). The proportion of women undergoing THA increased over the 6-year period. No statistical differences were found in relation to patient age (ANOVA, P = .34) or preoperative hemoglobin level (ANOVA, P = .53) during the study period. Preoperative hemoglobin levels were available for all patients.

Surgery was performed under the care of 8 consultants by various surgeons (J.J.) of differing seniority (middle and consultant grade). A total of 864 units of blood were transfused. The number of units of blood transfused annually reduced from 198 to 90 units during the period between 2004 and 2008 (Table 1). This equated to a reduction in allogeneic blood use of 55% despite increasing numbers of patients having surgery over the study period (Table 1).

A progressive annual reduction was observed in the proportion of patients undergoing THA who were transfused (40% to 17%) (Table 1; Figure 1). This trend was unchanged after intraoperative and day-of-surgery transfusions were removed (Table 1; Figure 1).

Mean postoperative transfusion trigger hemoglobin level was observed to fall during the study period, and this was in keeping with the evolving practice of restrictive transfusion during the study period. Although this was a clear trend (Table 1, Figure 2), only years 2003 vs 2005 reached statistical significance (Tukey-Kramer multiple comparisons test, P < .05). The percentage of patients who were transfused with a postoperative hemoglobin level between 80 and 100 g/L was reduced markedly over the study period (Table 2).

A progressive reduction from 19% to 7% was observed in the percentage of intraoperative and day-of-surgery transfusions (Figure 1). These transfusions were usually prescribed by the anesthetic team intraoperatively and generally adminis-

| Table 1  
<table>
<thead>
<tr>
<th>Data</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of THAs</td>
<td>176</td>
<td>171</td>
<td>189</td>
<td>186</td>
<td>215</td>
<td>232</td>
</tr>
<tr>
<td>Mean patient age, y</td>
<td>70.8</td>
<td>71.5</td>
<td>70.6</td>
<td>69.6</td>
<td>69.6</td>
<td>70.1</td>
</tr>
<tr>
<td>M:F ratio</td>
<td>1:1.2</td>
<td>1:1.2</td>
<td>1:1.4</td>
<td>1:1.5</td>
<td>1:1.8</td>
<td>1:1.9</td>
</tr>
<tr>
<td>No. (%) of patients transfused</td>
<td>62 (35)</td>
<td>69 (40)</td>
<td>69 (37)</td>
<td>58 (31)</td>
<td>48 (22)</td>
<td>39 (17)</td>
</tr>
<tr>
<td>No. of units transfused</td>
<td>151</td>
<td>198</td>
<td>167</td>
<td>144</td>
<td>114</td>
<td>90</td>
</tr>
<tr>
<td>Median No. of units transfused per patient</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>No. (%) of patients transfused on day of surgery</td>
<td>24 (14)</td>
<td>33 (19)</td>
<td>30 (16)</td>
<td>23 (12)</td>
<td>13 (6)</td>
<td>16 (7)</td>
</tr>
<tr>
<td>Mean trigger Hb, g/L</td>
<td>79.0</td>
<td>78.1</td>
<td>72.5</td>
<td>76.2</td>
<td>76.1</td>
<td>73.2</td>
</tr>
<tr>
<td>No. (%) of patients transfused (excluding day of surgery)</td>
<td>36 (22)</td>
<td>36 (21)</td>
<td>39 (21)</td>
<td>35 (19)</td>
<td>35 (16)</td>
<td>23 (10)</td>
</tr>
<tr>
<td>Mean preoperative Hb of transfused patients, g/L</td>
<td>122.5</td>
<td>124.8</td>
<td>121.7</td>
<td>125.9</td>
<td>122.8</td>
<td>123.8</td>
</tr>
<tr>
<td>Mean preoperative Hb of nontransfused patients, g/L</td>
<td>136.7</td>
<td>134.4</td>
<td>131.6</td>
<td>134.8</td>
<td>133.6</td>
<td>133.1</td>
</tr>
<tr>
<td>Mean length of stay, d</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Abbreviations: F, female; Hb, hemoglobin; M, male; THA, total hip arthroplasty.

*Mean postoperative day 1 Hb level in patients who were transfused.

Figure 1: Proportion of transfused total hip arthroplasties (THAs) per year.
tered without formal documentation of a laboratory full blood count.

Mean preoperative hemoglobin for patients undergoing allogeneic blood transfusion was significantly lower (10 g/L) than that of patients who did not undergo transfusion (124 vs 134 g/L; Student’s t test, \( P < .0001 \)). However, preoperative hemoglobin levels remained comparable across the years (Table 3).

Length of stay and 30-day mortality data were reviewed for all patients using hospital episode statistics data. A decreasing median length of stay was observed during the study period from 7 (2003) to 4 days (2008), which reflected another progressive change of practice in the institution. This finding was of high statistical significance (Kruskal-Wallis test and Dunn’s multiple comparisons test, \( P < .0001 \)) (Table 1). Patients who underwent allogeneic blood transfusion had a significantly longer median length of stay than those who did not (7 vs 5 days; Mann-Whitney \( U \) test, \( P < .0001 \)).

During the study period, 5 (0.4%) patients died within 30 days postoperatively. Two deaths occurred in 2004, two in 2007, and one in 2008. No deaths were related to hypovolemia or anemia.

**Discussion**

A significant reduction in allogeneic blood transfusion requirements occurred at the authors’ institution during the study period despite an increase in the total number of THAs performed. The incidence of blood transfusion in patients undergoing THA decreased from 35% (2003) to 17% (2008).

A reduction in mean transfusion trigger hemoglobin level from 79 (2003) to 73.2 g/L (2008) occurred, and this was driven by a change in philosophy regarding indications for blood transfusion. Mean transfusion trigger hemoglobin level was lowest in 2005. This year also had the second highest rates of transfusion, for several possible reasons. A higher proportion of patients had a preoperative hemoglobin level of 100 g/L or less compared with all years other than 2003 (Table 3). Also, a higher percentage of patients had a transfusion trigger of 70 g/L or less in 2005 than in any other year (Table 2). The increase in the proportion of patients with a transfusion trigger of 70 g/L or less in the later years of the study period may be due to the reduction in intra- or perioperative transfusions prescribed.

Although a reduction in intra- or perioperative transfusions occurred, a reduction in the percentage of postoperative blood transfusions prescribed was observed (excluding intra- or perioperative transfusions) (Table 1).

A general trend toward a reduction in the trigger hemoglobin was seen over the 6 years. A parallel significant reduction (19% to 7%) of perioperative and day-of-surgery transfusions was observed.

Although the finding that patients who underwent allogeneic blood transfusion had a significantly longer median length of hospital stay than those who did not was interesting, the authors cannot prove that this was a direct causal relationship.

Historically, the widely accepted clinical standard was to transfuse patients when the hemoglobin level dropped below 100 g/L or if hematocrit fell below 30%. This was known as the 10/30 rule and was first proposed by Adams and Lundy in 1942. More recently, several studies have attempted to clarify the hemoglobin level...
The current study had limitations. It was performed retrospectively and did not record the use of wound drainage. However, the authors felt this would have no effect on the findings of the study because only 1 surgeon at their institution routinely used surgical drainage during the study period and discontinued this practice in 2007. The study also did not record the use or type of chemical thromboprophylaxis, which became an increasingly common practice over the study period. During the study, no uniform departmental policy existed regarding thromboprophylaxis, and various consultant practices were used in this respect.

Information regarding compliance with the transfusion policy was not collected for the purposes of this study; therefore, no conclusions can be drawn regarding this. Intraoperative blood loss was not analyzed.

Although the main purpose of the study was to quantify the reduction in blood transfusion during a period of change of awareness of the need for blood transfusion, a dramatic reduction of median length of stay (7 days in 2003 vs 4 days in 2008) was observed during the study period. Hospital Episode Statistics data confirmed that neither of these changes was associated with any change in mortality rate.

The majority of patients undergoing THA at the authors’ institution were discharged, and few needed to be discharged to a rehabilitation institution. On the rare occasion that this was required, it was usually anticipated at the preoperative assessment, and arrangements were made before surgery. Therefore, the authors do not believe that this confounds the length of stay data.

Apart from the benefits of cost reduction (from 198 units in 2004 to 90 units in 2008, equating to savings of £14,040), other compelling reasons exist for avoiding transfusion of allogeneic blood. Foremost are the reduction of the risk of patient exposure to serious hazards of transfusion in-

### Table 3

<table>
<thead>
<tr>
<th>Year</th>
<th>Hb ≤100</th>
<th>Hb &gt;100 to ≤120</th>
<th>Hb &gt;120</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>7 (3.9)</td>
<td>26 (14.8)</td>
<td>143 (81.3)</td>
<td>176</td>
</tr>
<tr>
<td>2004</td>
<td>2 (1.2)</td>
<td>42 (24.7)</td>
<td>127 (74.7)</td>
<td>171</td>
</tr>
<tr>
<td>2005</td>
<td>7 (3.7)</td>
<td>53 (28)</td>
<td>129 (68.3)</td>
<td>189</td>
</tr>
<tr>
<td>2006</td>
<td>1 (0.5)</td>
<td>26 (14)</td>
<td>159 (85.5)</td>
<td>186</td>
</tr>
<tr>
<td>2007</td>
<td>1 (0.5)</td>
<td>43 (20)</td>
<td>171 (79.5)</td>
<td>215</td>
</tr>
<tr>
<td>2008</td>
<td>1 (0.4)</td>
<td>46 (19.8)</td>
<td>185 (79.7)</td>
<td>232</td>
</tr>
</tbody>
</table>

Abbreviation: Hb, hemoglobin.

or hematocrit that should be used as a trigger for transfusion. A recent Cochrane review analyzed 17 controlled trials with restrictive transfusion protocols and found that restrictive transfusion strategies did not appear to affect the rate of adverse events compared with liberal transfusion strategies. This review concluded that a blood transfusion is likely not essential until hemoglobin levels drop below 70 g/L, with the caveat that patients who suffer from serious cardiac disease should not be treated according to this policy.

Restrictive transfusion policies have proven effective and safe in large randomized, controlled trials. The most notable of these was the Transfusion Requirements in Critical Care study, in which 838 critically ill patients with a hemoglobin level less than 90 g/L were randomized to a restrictive (hemoglobin trigger of 70 g/L) or liberal (hemoglobin trigger of 100 g/L) transfusion strategy. The study found no significant difference in all causes of 30- and 60-day mortality, with significantly fewer cardiac complications, including acute myocardial infarction and pulmonary edema, in the restrictive transfusion strategy group.

The current study identified a statistically significant difference between the mean preoperative hemoglobin of transfused (mean, 124 g/L) and nontransfused (mean, 134 g/L) patients undergoing THA. A previous study reached similar conclusions, reporting that patients with a preoperative hemoglobin level less than 110 g/L required a blood transfusion 100% of the time, whereas those with a preoperative hemoglobin level more than 150 g/L received a transfusion only 13% of the time.

The women-to-men ratio increased over the study period. It is unclear why this was the case. The authors’ institution’s catchment population consists of a higher percentage of retirement-aged individuals than many areas of the United Kingdom. Therefore, the authors hypothesized that because women are more likely to live to an older age, they are more likely to operate on women than men. Because the region attracts more retirees, this trend may be exaggerated. A previous study reported the women-to-men ratio in THA surgery in the United Kingdom to be 1.63:1 in 2006, with a consistently higher number of women undergoing THA in the preceding 10 years. The current authors do not believe that the change in sex ratio over the study period led to the transfusion reductions reported in this study. If the proportion of women undergoing THA increases, one may expect to see an increase in the transfusion rate because previous studies have reported female sex to be an increased risk factor for transfusion in orthopedic surgery.
cidents and preservation of limited blood stock for other patients who require transfusion for life-saving indications.

**Conclusion**

A 55% reduction in blood transfusion in patients undergoing THA was observed during a 6-year period at the authors' institution. This was achieved by a change in transfusion policy that the primary indication for postoperative transfusion was symptomatic postoperative anemia rather than a reduced hemoglobin level in an otherwise asymptomatic patient.

No adverse effect on postoperative mortality occurred during the study period, which coincided with a progressive reduction in length of stay. The authors’ institution’s policy is to only transfuse patients symptomatic of anemia and with a hemoglobin level less than 80 g/L, unless a patient has serious comorbidities.

**References**