Continuing Education

Adjusting IV Iron and EPO Doses in Patients on Hemodialysis Prior to Surgery: Can We Protect Our Patients From Iron-Deficiency Anemia?

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Ongoing blood loss and iron-deficiency anemia are common problems in patients on hemodialysis; therefore, nephrology clinicians are particularly concerned with their patients who are scheduled for surgery. Surgery can cause significant blood and iron losses, thereby worsening their preexisting anemia. However, patients on hemodialysis can be effectively treated preoperatively by adjusting their continued doses of intravenous (IV) iron and recombinant human erythropoietin (EPO) therapy, based on expected blood and iron losses. This valuable strategy can help improve surgical and anemia outcomes as well as decrease EPO requirements and the need for transfusions. This article examines the use of IV iron and EPO therapy as preventive therapy for anemia in patients on hemodialysis prior to invasive surgical procedures, illustrated with an experience from a dialysis unit and patient case studies.

Goal
To increase the knowledge of those caring for patients on hemodialysis about adequate dosing of iron and EPO prior to surgery.

Objectives
1. Examine the implications of anemia in patients on hemodialysis who are scheduled for surgery.
2. Describe key strategies to improve anemia management in presurgical patients on hemodialysis.
3. Summarize patient case studies in which IV iron and EPO doses were adjusted prior to surgery in order to improve anemia outcomes.

Ongoing blood loss in patients receiving hemodialysis has been well documented and is a major contributor to iron deficiency. Compounding this problem is the use of recombinant human erythropoietin (EPO) therapy, which can stimulate erythropoiesis to abnormally high levels, thereby increasing iron requirements in patients who may already have inadequate iron stores. In addition, some patients on hemodialysis may require surgical procedures to remedy disease-related or other comorbidities, which increase their risk for blood (and iron) loss and further worsen their anemia and health status. To manage unwanted fluctuations in iron levels and red blood cell (RBC) counts, patients on hemodialysis are given a combination of intravenous (IV) iron and EPO therapy on a regular basis. However, there are no studies to date that thoroughly address the issue of prophylactic therapy with these agents for postoperative anemia in this patient population. This article explores the use of IV iron and EPO therapy and the potential benefit of dose adjustments prior to invasive surgical procedures in patients on hemodialysis, illustrated with an experience from the University of Virginia Augusta Dialysis Unit and brief patient case studies. Patients undergoing hemodialysis can often benefit from preoperative adjustments to their continuous IV iron and EPO regimens.

Historic Perspective of Anemia Management

Iron-deficiency anemia is common in patients with chronic kidney disease (CKD), especially those on hemodialysis. Before EPO therapy became available, the only treatment for patients with anemia due to chronic renal failure (CRF) was regular blood transfusions to maintain adequate hemoglobin (Hb) levels. However, transfusion-related problems, including concerns about iron overload and increased risk for bacterial infection, significantly compromised the management and outcome

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of these patients. Clinical trials in the mid-to-late 1980s demonstrated that EPO restored the packed cell volume, reduced the need for regular blood transfusions, and improved the overall well-being in patients requiring dialysis (Ng, Marx, Littlewood, & Macdougall, 2003). Soon after its approval, EPO therapy was routinely used in patients on hemodialysis. However, many patients fail to adequately respond to EPO, with iron deficiency being cited as the most common cause of an incomplete response (National Kidney Foundation [NKF], 2001). The use of IV iron improves the response to EPO and reduces the EPO dose required for many patients (Ng et al., 2003). Therefore, a continued IV iron regimen is recommended in conjunction with EPO therapy to manage iron-deficiency anemia (NKF, 2001).

Table 1
Factors Contributing to Anemia in Patients With CKD

- Decreased erythropoietin production due to damaged kidneys
- Shortened RBC survival
- Iron deficiency
- Blood loss from repeated laboratory testing, needle punctures
- Blood retention in dialyzer and tubing
- Gastrointestinal bleeding
- Acute and chronic inflammatory conditions
- Aluminum toxicity
- Folate deficiency
- Hypothyroidism
- Severe hyperparathyroidism
- Hemoglobinopathies

Source: National Kidney Foundation, 2001.

Understanding Anemia in Your Patients

The anemia of CRF is characterized by normocytic, normochromic RBCs and an inappropriately low reticulocyte response. The anemia is partly explained by decreased production of erythroid precursors and increased destruction of erythrocytes. However, it is caused primarily by an insufficient production of erythropoietin due to damaged kidneys (see Table 1) (Sakiewicz & Paganini, 1998; Shander, 2004; NKF, 2001). In addition, the normal response to hypoxemia (increased secretion of erythropoietin) is partially blunted in uremic patients. Therefore, the stimulus for erythropoiesis is insufficient.

A decrease in erythropoiesis usually begins when the glomerular filtration rate (GFR) reaches 20 to 30 mL/min/1.73m^2 (Sakiewicz & Paganini, 1998). Anemia may be present in patients with only mildly impaired renal function, suggesting it may develop early in the course of CKD (Locatelli et al., 2004). Anemia can develop slowly (from weeks to months) in patients with renal disease from RBC underproduction or rapidly (from days to weeks) from bleeding or hemolysis (Drews, 2003).

The anemia of CRF is associated with major alterations in internal iron kinetics and iron balance (Cook & Eschbach, 1975). As anemia in CKD worsens, iron normally contained in circulating RBCs becomes sequestered in reticuloendothelial (RE) cells and iron stores increase. However, by the time dialysis is needed, up to one-third of patients may be iron deficient, possibly due to previous excessive blood losses. Further compounding this problem, patients can lose up to 3 grams of iron annually from blood lost through the hemodialysis procedure itself.

Because patients with CRF and those on hemodialysis often have some degree of iron-deficiency anemia, clinicians are particularly concerned with those patients who are scheduled for surgery. Surgery can cause significant blood losses, further worsening their preexisting anemia and resulting in postoperative sequelae.

Postoperative Sequelae Due to Anemia

Postoperative anemia leads to decreased exercise capacity, fatigue, dizziness, disorientation, digestive disturbances, loss of appetite, slower recovery from surgery, increased length of hospital stay, and delayed postoperative recovery (Karkouti et al., 2006).

Lower Hb levels (pre- and postoperatively) in patients can increase the risk for transfusion and subsequent transfusion-related morbidity and mortality. Preoperative Hb levels (less than 8 g/dL) are inversely related to operative mortality (Dunne, Malone, Tracy, Gannon, & Napolitano, 2002). In a case-control study of 125 surgical patients who declined blood transfusions for religious reasons, operative mortality was inversely related to the preoperative Hb level and amount of blood loss (Carson, Poses, Spence, & Bonavita, 1988). Operative mortality increased from 7.1% for patients with Hb levels greater than 10 g/dL to 61.5% for those with Hb levels less than 6 g/dL and from 8% for patients with blood loss less than 500 mL to 42.9% for those with blood loss greater than 2000 mL.

In addition, perioperative anemia is an independent risk factor for infection and mortality in surgery. In a study of 6301 noncardiac surgery patients, 92% of all infections

occurred in patients with anemia. Anemic patients also received 5 times more blood than nonanemic patients. Low perioperative hematocrit (Hct) levels and use of blood transfusion were significant independent predictors of mortality, postoperative pneumonia, and length of hospital stay (Dunne et al., 2002).

Patients on hemodialysis frequently have underlying cardiovascular disease (CVD) and anemia. Anemia is a risk factor for cardiovascular complications in those undergoing surgery (National Anemia Action Council [NAAC], 2002). Regardless of whether it is a result of a preexisting condition or surgical blood loss, anemia worsens outcomes in patients with coronary artery disease (CAD) who undergo cardiac surgery (Nappi, 2003).

Given the risk of morbidity and mortality from preoperative anemia, protocols for identification and correction of anemia, including the evaluation of iron status, should be established before surgery (Dunne et al., 2002). Research on this topic is crucial, but severely lacking, in CKD and hemodialysis populations.

Current Patient Management Practices

Implementing pre-, intra-, and postoperative management strategies can reduce blood loss and anemia. During surgery, skillful surgical techniques combined with blood-saving procedures and careful management of coagulation help reduce unnecessary blood loss. Proper positioning, meticulous hemostasis, control of blood pressure, judicious fluid replacement, maintenance of normothermia, and correction of clotting factor deficiencies all decrease the risk of anemia during surgery (Mahdy & Webster, 2004).

Allogeneic blood transfusion has been the most common strategy to treat blood loss and anemia. However, because blood transfusion is a risk factor for mortality, infection, and an inflammatory reaction, current practice is to make every effort to avoid transfusion by utilizing other techniques. These include restricting transfusion to patients with a Hb less than 7 g/dL or only to patients with anemia-associated clinical sequelae postsurgery; presurgical autologous blood donation; hemodilution during surgery (Karkouti et al., 2006); reinfusion of salvaged blood; and maintaining the patient in a hypotensive state during surgery (Lofthouse, Boitano, Davis, & Jinnah, 2000). However, these techniques are often not practical and may be contraindicated in elderly patients because of comorbid illness. Therefore, preoperative treatment with EPO and IV iron is an effective alternative to manage perioperative anemia (Lofthouse et al., 2000).

Improving Anemia Management in Presurgical Patients on Hemodialysis

Increased Hb levels usually translate into clinical benefits. Clinical trials in end stage renal disease (ESRD), orthopedic surgery, and patients undergoing cancer-chemotherapy consistently show measurable improvement in fatigue, exercise capacity, muscle strength, performance of activities of daily living, and cardiac and cognitive function as anemia is corrected (Carson, Terrin, & Jay, 2003). Therefore, it is important to have effective preoperative anemia management strategies and protocols to correct anemia in patients on hemodialysis undergoing surgical procedures, including adjusting doses of continuous IV iron and EPO therapy in anticipation of blood and iron loss.

Preventive IV Iron and EPO Therapy

From 1991 to 2002, as the routine use of EPO among patients on hemodialysis became common, the mean Hb among these patients increased from 9.5 to 11.7 g/dL. Currently an estimated 95% of patients undergoing hemodialysis receive treatment for anemia (Robinson et al., 2005). Because routine administration of EPO without IV iron can lead to iron-deficiency anemia, national guidelines have been published recommending the use of IV iron on a regular basis in patients with CKD and on hemodialysis to help achieve and maintain target Hb levels (NKF, 2001).

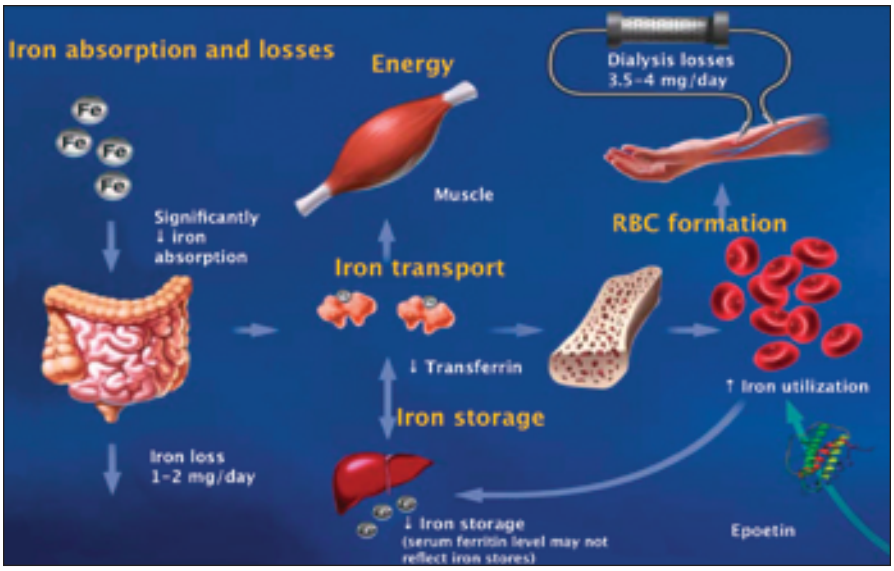
Most clinical trials demonstrating a benefit from EPO and IV iron in surgical patients exclude patients with renal failure because of their well-known preexisting anemia. Therefore, information on presurgical prophylaxis with EPO and IV iron needs to be considered from studies in non-renal failure patients.

In normal healthy surgical patients, administration of IV iron generally accelerates the level of Hb recovery and reduces the need for transfusion after surgery (Cuenca et al., 2005). In a study by Cuenca et al., patients older than 65 years of age undergoing hip fracture surgery received 100 mg of IV iron upon admission and just before surgery and another 100-mg dose between admission and surgery if the Hb level was less than 12 g/dL. The group receiving IV iron whose admission Hb level was greater than 12 g/dL had lower transfusion rates, 30-day mortality, and infection rates and shorter-length hospital stays. This study suggests that IV iron is an effective alternative to reduce allogenic blood transfusion requirements. Allogenic blood transfusion is not a risk-free therapy and is associated with concerns about possible adverse events in surgical patients, especially increased risk of bacterial infection.

Anticipating Blood and Iron Loss

One key strategy to minimize postoperative anemia is to anticipate the patient's iron needs prior to surgery in order to provide appropriate prophylactic measures, such as IV iron supplementation. Many factors can lead to an iron imbalance in patients on hemodialysis, even before they are admitted to the hospital for surgery (see Figure 1). For example, these patients experience significant

Figure 1
Iron Cycle Is Altered in Patients on Hemodialysis



ongoing blood loss from repeated laboratory testing, needle punctures, blood retention in the dialyzer and tubing, bleeding postdialysis, and frequent access surgery, resulting in iron losses of up to 3 g per year (Eschbach, 2005; NKF, 2001). These patients also have decreased iron absorption due to reduced dietary intake and the use of medications that interfere with iron absorption, such as phosphate binders to treat secondary hyperparathyroidism. In fact, iron absorption in patients who are iron-deficient and on hemodialysis may be up to 44% less efficient than in iron-deficient patients who are healthy (Chang, Chang, & Chiang, 2002). Furthermore, the presence of inflammation, malnutrition, and chronic disease can decrease transferrin synthesis (i.e., the iron transport protein that carries iron from the RE system to the bone marrow). Finally, EPO therapy stimulates a supraphysiological production of RBCs that, in turn, increases iron utilization and leads to functional iron deficiency. Functional iron deficiency occurs when the need for an increase in iron to support Hb synthesis is greater than the amount that can be released from iron stores (NKF, 2001).

These conditions can result in a compromised supply of iron: while demand for iron is increased (driven by EPO), iron storage is low and transport is delayed (Fishbane, Mittal, & Maesaka, 1999). Nephrology nurses need to consider this altered state of iron balance when managing anemia prior to surgery in patients on hemodialysis and to calculate iron replacement therapy based on individual patient needs.

Proactive iron dosing is especially warranted in presurgical patients because surgery is followed by a systemic inflammatory response, which can impact iron balance and lead to anemia. An inflammatory state can inhibit erythropoiesis by suppressing erythropoietin production and inducing a state of functional iron deficiency, in which available iron is diminished (Cuenca et al., 2005). Biesma Van de Wiel, Beguin, Kraaigenhagen, and Marx (1995) investigated postoperative anemia in 48 elderly patients after total hip replacement surgery and demonstrated the inflammatory effects of surgery on iron metabolism. In this study, Hb levels fell from preoperative levels of 14 to 11.1 g/dL on postoperative day 1, and there was a pronounced increase in measures of inflammation (interleukin-6 and C-reactive protein) following surgery. The authors concluded that the inflammatory state induced a marked effect on iron metabolism, in which postoperative serum ferritin levels increased and serum iron, transferrin, and transferrin saturation (TSAT) levels decreased significantly. They also postulated that the inflammatory response might explain the persistence of anemia after surgery.

Another strategy to better manage anemia prior to surgery is for clinicians to be familiar with those patients who are at a high risk for postoperative anemia. The risk profile for postoperative anemia is multifactorial, depending on the type of surgery and patient factors (see Table 2). Blood loss during surgery is a major cause of postoperative anemia. Surgical technique, the type of operation, longer operative times, and techniques used to minimize blood loss are important predictors of anemia (Cuenca et al., 2005; NAAC, 2002). For example, patients undergoing surgery for colon cancer have a much greater risk of bleeding than those undergoing hip fracture surgery (NAAC, 2002).

Patient factors such as older age, female gender, and small body size may contribute to postoperative anemia (NAAC, 2002). Preoperative Hb levels (less than 9 g/dL) are also independent predictors of anemia and transfusion requirement (Cuenca et al., 2005). In addition, underlying health status is an important predictor of anemia because preexisting conditions affect Hb levels. For example, the presence of CVD is a special consideration because it is common in patients with renal disease and contributes to anemia. In a study of perioperative anemia by Dunne et al. (2002), patients with CAD had higher preoperative anemia rates (74%) compared with those without CAD (33%). The presence of CVD in patients with a low Hb increases the risk of postoperative mortality to a greater degree than in

Table 2
Risk Factors for Postoperative Anemia

Factors associated with surgery
- Blood loss during surgery
- Type of surgery
- Longer operative times
- Techniques utilized to minimize blood loss
- Inflammatory response
- Iatrogenic hemodilution

Factors associated with the patient
- Older age
- Female gender
- Small body size
- Underlying health status
- Preoperative hemoglobin levels
- Immunosuppressive treatment pre- or postoperatively

Source: National Anemia Action Council, 2002.

Table 3
Anemia Lab Trending Methodology: Practical Techniques

- Review most recent Hb, TSAT, and serum ferritin
- Examine labs from the past 3 months to 1 year to assess overall trends
- Analyze IV iron and EPO dosing changes that coordinate with notable lab changes
- If trending is inconclusive, review other lab indices and patient-specific conditions

those without CVD (NAAC, 2002).

With regard to all of these risk factors, optimizing the patient's iron status before surgery is essential, especially if the patient has preexisting conditions that may worsen his or her anemia.

Adjusting IV Iron and EPO Doses to Manage Perioperative Anemia: Experiences From the University of Virginia Augusta Dialysis Unit

Currently there are no studies that examine the effects of adjusting the dose of IV iron and EPO on outcomes in patients on hemodialysis who undergo surgery. However, studies have shown that IV iron therapy is an efficient means to help improve Hb levels in this population (Chang et al., 2002). Given this fact and the effectiveness of IV iron and EPO in surgical patients without kidney disease and the poorer outcomes in patients with anemia, it is reasonable to assume that optimizing IV iron and EPO doses preoperatively would improve outcomes.

Adjusting continuous IV iron and EPO doses prior to surgery for patients on hemodialysis is a nursing clinical practice that is followed at the University of Virginia Augusta Dialysis Unit. Our unit recognized the value of a preoperative dose adjustment program because we were seeing patients discharged from the hospital with Hb levels as low as 7 g/dL who required transfusions in the dialysis facility, as well as patients with TSAT levels below 15%. In all of our population of patients on hemodialysis, the goal is to achieve and maintain a Hb level between 11 and 12 g/dL, a TSAT level between 20% to 30%, and a serum ferritin level between 100 to 800 ng/mL. In our presurgery patients, our goal is to achieve and maintain an Hb level between 12 and 13 g/dL and a TSAT level greater than 30%. We do not consider serum ferritin levels when making dose adjustments to EPO and/or IV iron prior to surgery because of the many factors that can negatively affect the value, such as inflammation, infection, and arthritic flares.

The first step in our dose adjustment program is to assess the patient's Hb, TSAT, and serum ferritin levels as soon as we are notified of a patient's upcoming surgery. A low level of any of these markers may indicate the need for supplemental IV iron to support erythropoiesis. Although TSAT (measure of readily available iron for erythropoiesis) and serum ferritin (an indicator of total body iron stores) are the currently recommended tests for diagnosing iron deficiency, these markers have some disadvantages. Both are indirect measures of iron status, and studies have shown that serum ferritin may be falsely elevated in the presence of inflammation and malnutrition (Kalantar-Zadeh, Rodriguez, & Humphreys, 2004).

Next, we review current lab values in conjunction with the patient's lab trends. When reviewing current and past lab results, it is important to think about the patient with those results (e.g., medical history and prior responses to therapy) and identify all possible causes of compromised RBC production (see Table 3). In addition, we calculate anticipated blood loss resulting from the surgery in order to avoid transfusions. Typical blood loss for a specific surgery can be estimated through a search of the literature and clinical experience. For example, blood loss for joint or knee surgery has been estimated to be between 750 to 1500 mL. Cardiac surgery, such as coronary artery bypass graft (CABG) has an expected blood loss of 800 to 1600 mL. Access surgery or other interventions can be between 150 to 500 mL (Cable et al., 2002; Donahue, Gailani, Higgins, Drinkwater, & George 2003; Furuya, Oda, Tachiki, & Miyao, 2003; Huddleston, 2005; Kalairajah Simpson, Cossey, Verrall, & Spriggins

2005; Popovsky, Audet, & Andrzejewski, 1996).

Our next priority is to develop an individualized IV iron and EPO dose adjustment plan based on the patient's lab values and expected blood loss. EPO doses may be increased up to 50% based on the patient's past responses to EPO therapy. For example, some patients respond quickly to a 25% increase in EPO. In general, if the Hb level is 11 to 11.5 g/dL, most patients may get a 50% increase in the EPO dose if their dose had been below 5000 units. If the Hb level is 11.5 to 12 g/dL, most patients will usually receive a 25% increase in EPO. When the Hb level is above 12 g/dL prior to surgery, consideration of dose increase depends on the EPO dose the patient had been receiving. EPO dose increases are avoided if it is contraindicated in the patient due to an already high Hb level.

Adjustments to the IV iron doses to maximize the patient's iron status may be beneficial and improve outcomes after surgery. Currently our goal for either starting IV iron therapy or increasing the IV iron dose is to reach a TSAT level of 30% to 40% prior to surgery. Typically, if the patient is on a continued IV iron regimen, the dose adjustment would be the administration of a larger dose. If the patient is not on IV iron, the dose adjustment would be to initiate a continued dosage regimen, in which doses can range from 25 to 125 mg/week. Judgments made concerning EPO and IV iron therapy are made by our clinical staff who have experience managing anemia and knowledge of each patient's trends.

Ideally, prophylactic therapy is started a few months before surgery, but it is usually not possible to know the surgery dates that far in advance. The preoperative regimen for administering EPO plus IV iron usually consists of subcutaneous injections of EPO at weeks 3, 2, and 1 before surgery, and on the day of surgery (Feagan et al., 2000). Typically, IV iron is administered preoperatively in patients with ESRD because oral iron supplementation is often not sufficient to meet iron needs in this population. In addition, poor absorption, poor patient tolerance leading to nonadherence, and gastrointestinal irritation limit the usefulness of oral iron (Nissenson & Charytan, 2003).

Inpatient labs are performed on postoperative day 1, but no dose adjustments are made at this time. Adjustments are based on postoperative labs drawn the Monday or Tuesday after discharge from the hospital. The patient's Hb level is used to determine the appropriate EPO dose and TSAT levels are used to determine the appropriate IV iron dose.

Because all our patients are undergoing hemodialysis, we can expect a worsening of anemia postoperatively if we do not optimize their iron status before surgery. When IV iron and EPO doses are increased prophylactically, based on anticipated blood loss, the patient's Hb, TSAT, and serum ferritin levels usually take about 1 month for normalization and return to baseline. In addition, our strategy decreases the use of transfusion as well as the dose of EPO.

Because the usual finding of preoperative anemia in patients on hemodialysis can complicate surgery, we consider the practice of dose adjustments prior to surgery to be a valuable strategy to improve surgical outcomes in these patients with iron-deficiency anemia.

Case Studies of Patients on Hemodialysis Undergoing Surgery

The following are patient cases in which IV iron and EPO doses were adjusted prior to surgery in anticipation of blood loss.

Patient A is a 73-year-old man admitted for revision of a malfunctioning arteriovenous fistula. He has a history of diabetes mellitus and hypertension. Three weeks prior to surgery, his IV iron dose was increased from 62.5 to 125 mg weekly. EPO was maintained at 4000 units weekly. No adjustment was made due to expected minimal blood loss. Presurgical lab results were Hb 13.3 g/dL (normal elderly male 12.4 to 14.9 g/dL), TSAT 16.1%, and iron 40 µg/dL. Postsurgical lab results were Hb 11.3 g/dL, TSAT 19%, and iron 48 µg/dL. No postoperative EPO adjustment was made and no transfusion was needed. One month after discharge, Hb was 11.7 g/dL and TSAT was 20.2%. IV iron and EPO dosages have been maintained at 125 mg and 4000 units weekly, respectively, during the past 6 months because the patient continued to have minor surgeries and infections. On these doses, labs have remained stable each month and no further adjustments have been needed.

Patient B is a 64-year-old woman admitted for removal of a clot in her hemodialysis access graft. Her continuous IV iron dose was 25 mg weekly. In each of the 3 weeks before surgery, she was given EPO 1000 units twice weekly and IV iron 62.5 mg weekly. Presurgical lab results showed Hb 12.2 g/dL, TSAT 35.1%, and iron 64 µg/dL. Postsurgical lab results showed Hb 9.7 g/dL, TSAT 24.9%, and iron 48 µg/dL. No transfusion was needed postoperatively. One week postsurgery, EPO was increased to 3000 units every treatment because of the postoperative decrease in Hb. No IV iron adjustment was made. Within 1 month after discharge, all labs were within normal limits and were stable at 3 months. The patient returned to her presurgery continuous IV iron dose of 25 mg weekly. EPO has been maintained at 3000 units every treatment.

Patient C is an 80-year-old man admitted for hip replacement surgery. Three weeks before surgery, his EPO was increased from 3000 to 6000 units every treatment and IV iron from 25 mg weekly to 62.5 mg weekly. Presurgical lab results showed Hb 12 g/dL, TSAT 24%, and iron 51 g/dL. The patient required no transfusions during hospitaliza-

tion. One week after surgery, lab results showed Hb 9.2 g/dL, TSAT 29.6%, and iron 61 g/dL. EPO was increased to 9000 units every treatment. Within 1 month postoperatively, all labs were within normal limits. The IV iron dose was maintained at 62.5 mg weekly, but the EPO dose was decreased 2 months postsurgery to maintenance dose of 3000 units. Five months after surgery, the IV iron maintenance dose was decreased to 25 mg weekly. Lab results have remained stable.

Common Surgical Procedures: Special Concerns for Patients on Hemodialysis

CABG and orthopedic surgery warrant special mention because they are particularly important concerns in patients on hemodialysis. With advances in technology, these patients are surviving longer, which increases their risk for CAD and cardiac events. CAD has traditionally been treated conservatively in this population. However, cardiac surgical techniques are constantly being improved and patients on dialysis for ESRD are undergoing cardiac surgery with increasing frequency (Powell et al., 2004). Therefore, further research is warranted on prophylactic regimens to improve iron status.

Winkelmayer, Levin, and Avorn (2003) investigated the relationship between glomerular filtration rate and the likelihood of postoperative bleeding in patients undergoing CABG who were not on maintenance dialysis. Lower GFR was associated with a greater likelihood of postoperative bleeding (patients administered 3 or more units of blood products). The likelihood of postoperative bleeding increased as GFR decreased. In univariate analysis, patients with a GFR less than 40 mL/min/1.73m^2 or less were 5 times more likely to have postoperative bleeding compared with those with a GFR greater than 100 mL/min/1.73m^2. This increased bleeding tendency in normal patients with decreasing GFRs has implications for patients with CKD or undergoing hemodialysis preparing for surgery.

Fluid overload and pulmonary congestion related to cardiopulmonary bypass, anemia, and a bleeding tendency in patients on hemodialysis are concerns for most surgeons (Kan & Yang, 2004). Pre- and postoperative management of these conditions and the choice of surgical procedure and techniques to avoid transfusions have important implications for patients with CRF undergoing CABG surgery (Erentug et al., 2004). Because patients on hemodialysis who have undergone "on-pump" CABG have a greater risk of bleeding complications, off-pump CABG has been shown to be a suitable alternative.

Finally, hip and knee replacement surgery are prevalent in the older population and are also a concern in patients on hemodialysis. Older patients who have been on long-term hemodialysis have higher rates of bone and joint disease (Sano et al., 2004). A small Japanese study showed that patients who were on hemodialysis longest (greater than 13 years) had higher postoperative mortality (not necessarily related to surgery) and the greatest blood loss in hip fracture surgery (Sano et al., 2004). Bleeding, infections, and vulnerability of bone are prognostic factors for postoperative sepsis and infection. In patients who are dialyzed, bone union is delayed, contributing to postoperative morbidity. Because anemia itself contributes to the risk of infection, patients on hemodialysis undergoing orthopedic surgery may have a greater risk for complications.

Conclusions

Patients undergoing hemodialysis who are candidates for surgery can be successfully treated preoperatively with dose adjustments, based on expected blood loss, to their continued IV iron and EPO regimens. In order to estimate a patient's iron needs, nephrology nurses need to remember all the iron losses that can occur in those undergoing hemodialysis and assess each patient individually. This may be a valuable strategy to improve surgical outcomes for patients with iron-deficiency anemia who are receiving hemodialysis. In addition, this strategy can decrease the use of transfusion as well as the EPO dose.

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ANNJ617

ANSWER/EVALUATION FORM

Adjusting IV Iron and EPO Doses in Patients on Hemodialysis Prior to Surgery: Can We Protect Our Patients From Iron-Deficiency Anemia?

Kim Deaver, BSN, RN, CNN & Lori Bennington, RN, CDN

Posttest Instructions

- Answer the open-ended question(s) below.
- Complete the evaluation.
- Send only the answer form to the ANNA National Office; East Holly Avenue Box 56; Pitman, NJ 08071-0056; or fax this form to (856) 589-7463.
- Enclose a check or money order payable to ANNA. Fees listed in payment section.
- Posttests must be postmarked by August 20, 2008. Upon completion of the answer/evaluation form, a certificate for 1.5 contact hours for RN and 1 pharmacology CE hour will be awarded and sent to you.
- Please allow 2-3 weeks for processing. You may submit multiple answer forms in one mailing, however, because of various processing procedures for each answer form, you may not receive all of your certificates returned in one mailing.

Complete the Following:

Name: _____

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Telephone: _____ Email: _____

CNN: ___ Yes ___ No **CDN:** ___ Yes ___ No **CCHT:** ___ Yes ___ No

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Special Note

Your posttest can be processed in 1 week for an additional rush charge of $5.00.

☐ Yes, I would like this posttest rush processed. I have included an additional fee of $5.00 for rush processing.

Note: If you wish to keep the journal intact, you may photocopy the answer sheet or access this posttest at www.nephrologynursingjournal.net.

Submit Online!

Online submissions through a partnership with HDCN.com are accepted on this posttest at $20 for ANNA members and $30 for nonmembers. CE certificates will be available immediately upon successful completion of the posttest.

1. What would be different in your practice if you applied what you have learned from this activity?

_____

_____

_____

_____

_____

_____

_____

GOAL To increase the knowledge of those caring for patients on hemodialysis about adequate dosing of iron and EPO prior to surgery.

New Posttest Format

Please note that this continuing education activity does not contain multiple-choice questions. We have introduced a new type of posttest that substitutes the multiple-choice questions with an open-ended question. Simply answer the open-ended question(s) directly above the evaluation portion of the Answer/Evaluation Form and return the form, with payment, to the National Office as usual.

Evaluation	Strongly disagree				Strongly agree
2. By completing this offering, I was able to meet the stated objectives					
a. Examine the implications of anemia in patients on hemodialysis who are scheduled for surgery.	1	2	3	4	5
b. Describe key strategies to improve anemia management in presurgical patients on hemodialysis.	1	2	3	4	5
c. Summarize patient case studies in which IV iron and EPO doses were adjusted prior to surgery in order to improve anemia outcomes.	1	2	3	4	5
3. The content was current and relevant.	1	2	3	4	5
4. This was an effective method to learn this content.	1	2	3	4	5
5. Time required to complete reading assignment: _____ minutes.					

I verify that I have completed this activity _____

(Signature)