# How do we develop and implement a preoperative anemia clinic designed to improve perioperative outcomes and reduce cost?

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Treatment of anemia is one of the four pillars of patient blood management programs. Preoperative anemia is common and associated with increased perioperative morbidity after surgery and increased rates of blood transfusion. Effective treatment of preoperative anemia, however, requires advanced screening, diagnosis, and initiation of therapy weeks before elective surgery. Here we describe the development and implementation of a preoperative anemia screening and treatment program at Duke University Hospital.

Anemia is common in patients presenting for elective surgery and is predictive of poor postoperative outcomes after surgery as well as increased resource utilization. Previously undiagnosed anemia has been reported to occur in 5% to 75% of elective presurgical patients, depending on the patient population.[1] In addition to being an independent risk factor for perioperative morbidity and mortality,[2,3] preoperative anemia is one of the strongest predictors of perioperative blood transfusion.[4,5] Perioperative blood transfusion in turn is independently associated with an increased risk of perioperative morbidity, including lung injury, renal failure, hemolysis, and transfusion reaction, as well as mortality.[6,7] Besides its direct contribution to worsened outcomes, blood transfusion imposes a significant financial burden on health institutions. In addition to the immediate material and labor costs, there are longer-term costs associated with blood transfusion including prolonged ventilator dependence, increased intensive care unit and hospital length of stay, and postoperative loss of productivity, which together significantly increase the health resource burden.[8] Accordingly, reducing unnecessary blood product transfusion has been shown to reduce health care costs.[9] Among the nearly 21 million blood components transfused per year in the United States, approximately half were transfused in the perioperative setting (National Blood Collection and Utilization Survey Report, 2011). Costs associated with transfusion are estimated at $522 to $1183 per unit of red blood cells (RBCs) administered, with estimates of perioperative cost of transfusion ranging from $1.6M to $6M per hospital per year.[8]

Although analysis of the cost effectiveness of erythropoietin (EPO) for treating anemia in presurgical populations shows mixed results,[10-12] preoperative EPO and/or iron therapy has been shown to reduce allogeneic blood transfusion associated with major, predominantly orthopedic, surgical procedures.[13-16] While it has been demonstrated that preoperative anemia management can reduce transfusion requirements, the optimal preoperative care delivery model for anemia management remains unclear. We describe a method for the rational development and implementation of a preoperative anemia clinic (PAC) using a systematic approach and strategy adapted from the Duke Perioperative Enhancement Team (POET) that

**ABBREVIATIONS:** EHR = electronic health record; FTE = full-time equivalent; PAC = preoperative anemia clinic; PAT = preanesthesia testing; POET = Duke Perioperative Enhancement Team; UHC = University Health System Consortium.

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Funded by departmental sources.

Received for publication June 16, 2015; revision received October 15, 2015; and accepted October 15, 2015.

doi:10.1111/trf.13426



**TRANSFUSION** 2016;56;297–303

can be easily adapted to serve the needs of other health care institutions.

## CREATION OF POET

In July 2013, Duke Anesthesiology with support from other institutional stakeholders created POET. The general principles of POET are to enhance the value of perioperative care through a disciplined care reengineering process. The collective competencies of strategy, operations, finance, workflow, project management, electronic medical record integration, and data mart are brought together to redesign existing clinical care processes.

The process begins with generative discussion and a supportive business case rationalization to implement care design change. Once the clinical outcome improvement and financial return analysis is completed and judged to be compelling, multidisciplinary leaders are engaged to help redesign work streams with the assistance of an assigned clinical lead and project manager to facilitate operational changes. At the same time, clinical metrics are developed and informatics resources are leveraged to enable continuous data tracking. In our experience, the steps required for developing and implementing a PAC include:

1. Institutional rationalization of the project;
2. Determine a target pilot population;
3. Define institutional thresholds for transfusion based on hemoglobin (Hb);
4. Create a financial plan and business case;
5. Develop an institution target–specific treatment algorithm;
6. Design the clinical workflow;
7. Integrate clinical and laboratory workflow into the electronic health record (EHR).

These steps (from planning to clinic operation) took just over 1 year at our institution and are presented below in detail.

## INSTITUTIONAL RATIONALIZATION

One of the early objectives of POET was to explore ways to enhance blood management in surgical patients at high risk for perioperative blood product transfusion. We recognized that the "triple-aim" approach for optimizing perioperative blood management includes optimizing the patient's preoperative RBC mass, minimizing intraoperative surgical blood loss, and augmenting perioperative management strategies aimed at safely expanding the physiologic tolerance of anemia. Patients with existing anemia undergoing elective procedures with the potential for significant surgical blood loss at Duke University Hospital were thus identified as a pilot population.

Areas of high impact for anemia management were identified and matched to utilization data by case mix. We used the EHR and the University Health System Consortium (UHC) data to explore variables including patient's age, sex, preoperative Hb, and surgery type, to determine how each impacted transfusion rates in our target population. Because guidelines for defining tolerable intraoperative anemia thresholds as well as the index case mix protocol for management of preoperative anemia vary among institutions, we chose historic clinical variables to reflect real-world experiences recognizing that the medical decision to transfuse a patient is complex and best served by a pragmatic approach.

## DETERMINING A TARGET POPULATION

The ideal target patient population for a PAC should have significant rates of anemia amenable to treatment (iron deficiency and anemia of chronic disease), high perioperative transfusion rates, consistent follow-up, and a group of surgeons amenable to interventions aimed at improving patient safety and outcomes, even if that means potentially delaying surgery. POET along with Duke University Department of Anesthesiology, in collaboration with the Duke Center for Blood Conservation and the Department of Orthopedic Surgery, determined that it had the ability to leverage the current process of preoperative patient evaluation to diagnose and treat preoperative anemia. After reviewing the literature and discussions with our hospital's transfusion services department regarding transfusion rates among operative services, it was hypothesized that patients presenting for lower-extremity total joint surgery were an appropriate group to pilot.[13,16-18] POET therefore partnered with joint replacement surgeons to launch the anemia clinic program. To better quantify incidence of transfusion in our lower extremity total joint replacement or revision surgery population, POET queried and compared our institution's average transfusion rate (identified by ICD-9 code) to aggregated UHC data for the same procedure. We found an overall UHC transfusion incidence of approximately 24% compared to 20% at our institution. Although slightly lower than peer institutions' rate, despite restrictive transfusion practices as supported by the literature[19] and routine use of the antifibrinolytic tranexamic acid for all patients that do not have exclusion criteria, and use of cell salvage for revision surgeries, this still afforded opportunity to decrease transfusion in this population. As a tertiary referral center, we hypothesized that this relatively high rate of transfusion may be related to high rates of anemia in a population with significant comorbidities, which may therefore be amenable to treatment.

## ANEMIA DEFINITION IMPLEMENTATION

Having identified an ideal pilot population, we received institutional review board approval to perform a retrospective EHR chart review of a random sample of 200

**TABLE 1. Net present value of anemia clinic (1 and 5 years)***

| | |
|---|---|
| Present value of costs (1 year)† | |
| HemoCue machines (10 @ $725 each) | $(7,250.00) |
| HemoCue test strips ($1.50 each, one per patient screened) | $(1,517.41) |
| Midlevel provider ($73,825 per FTE with 3% YOY growth) | |
| Laboratory costs ($47.26 per patient seen in clinic) | $(4,219.64) |
| IV ESA infusion costs ($1820 per patient treated) | $(81,250.00) |
| Parking passes ($6 per pass, three passes per patient treated) | $(1,339.29) |
| Sum of present value of costs (1 year) | $(95,576.34) |
| Present value of revenues (1 year) | |
| Decrease in transfusions ($208 per transfusion avoided)§ | $84,165.71 |
| IV ESA infusion revenues ($3360 per patient treated) | $150,000.00 |
| Sum of present value of revenues (1 year) | $234,165.71 |
| *Net present value (1 year)* | *$138,589.38* |
| Present value of costs (5 years)‡ | |
| HemoCue machines (10 @ $725 each) | $(7,250.00) |
| HemoCue test strips ($1.50 each, one per patient) | $(29,374.15) |
| Midlevel provider ($73,825 per FTE with 3% YOY growth) | $(65,828.88) |
| Laboratory costs ($47.26 per patient seen in clinic) | $(125,239.00) |
| IV ESA infusion costs ($1820 per patient treated) | $(1,572,843.47) |
| Parking passes ($6 per pass, three passes per patient treated) | $(39,750.00) |
| Sum of present value of costs (5 years) | $(1,840,285.50) |
| Present value of revenues (5 years) | |
| Decrease in transfusions ($208 per transfusion avoided)§ | $1,629,286.08 |
| IV ESA infusion revenues ($3360 per patient treated) | $2,903,711.02 |
| Sum of present value of revenues (5 years) | $4,532,997.10 |
| *Net present value (5 years)* | *$2,692,711.60* |

* Values in parentheses represent negative numbers (costs).

† One-hundred *anemic* patients are assumed to be seen in Year 1 (conservative assumption of 9% rate of anemia [actual 18.8%] multiplied times 1133 lower extremity total joint patients per year).

‡ One-thousand *anemic* patients are assumed to be seen in Year 5 (conservative assumption of 9% rate of anemia [actual 18.8%] multiplied times 37,500 elective surgeries per year at DUH = 3375 patients, then revised down to more conservative assumption of 1000, and assumes straight-line growth until this point).

§ Assumes four transfusions avoided per patient who would otherwise be transfused currently.

ESA = EPO-stimulating agent; DUH = Duke University Hospital; YOY = year over year.

patients that had total joint replacement (60 primary knee replacements, 60 primary hip replacements, 40 revision knee replacements, 40 revision hip replacements) in the immediate previous calendar year to determine rates of anemia and Hb thresholds associated with transfusion in this patient population. Anemia was defined according to the World Health Organization (WHO) definition of anemia (Hb < 12 g/dL for females, Hb < 13 g/dL for males). In addition, retrospective rates of transfusion were compared to preoperative Hb for the same four procedures.

The prevalence of preoperative anemia according to the WHO definition was found to be 18.8% overall (i.e., prevalence of preoperative anemia was 13.3% for primary knee, 25% for revision knee, 20% for primary hip, and 30% for revision hip replacement) whereas perioperative transfusion rates were 21% overall (7% for primary knee, 21% for revision knee, 21% for primary hip, and 42% for revision hip replacement). Transfusion varied inversely with preoperative Hb, generally with values below the WHO definition of anemia.

Based on this preliminary data analysis, estimated blood loss for each procedure, and surgical complexity, we determined that we could further narrow the target population that would most benefit from preoperative Hb optimization for transfusion avoidance. We targeted patients presenting for primary knee replacement with Hb level of less than 11.0 g/dL, revision knee with Hb level of less than 11.5 g/dL, primary hip with Hb level of less than 11.5 g/dL, and revision hip replacement with Hb level of less than 12.0 g/dL, regardless of sex. To determine initial clinic volume projections, we used health system data describing total cases done annually for total joint replacement and made a conservative estimate of seeing approximately 9% (100 patients) of these patients based on our data analysis on rates of anemia in this population.

## FINANCIAL MODELING

Financial modeling of the clinic's impact demonstrated a positive net present value of more than $100K over 1 year and more than $2.5M over 5 years (range based on transfusion reduction of 25% to 90%; Table 1). Assumptions included 1) 50% rate of EPO infusion; 2) all costs except for acquisition costs for RBCs excluded, including laboratory (crossmatch), nursing, supplies, and downstream effects of adverse events associated with transfusion; 3) utilizing an institutional anemia threshold more conservative than WHO guidelines, resulting in an anemia rate of 9% to impute clinic volume; 4) predicting a 50% reduction in transfusion, compared to the 90% reduction seen in other centers; and 5) a slow clinic ramp-up, as well as a lower than predicted final clinic volume (1000 patients per year vs. 3375 predicted by WHO guidelines).

Costs associated with clinic implementation included purchasing HemoCue (HemoCue America, Brea, CA) testing machines (two per clinic) and test strips (one per patient), laboratory costs (anemia diagnostic panel), midlevel provider costs, and costs of providing infusion therapy. Midlevel provider costs were modeled with a 3% annual rate of increase in salary and fringe benefits, with 40 patients seen per week representing a full-time equivalent (FTE). Costs of iron and EPO included those associated with venipuncture, infusion, drug acquisition, and monitoring laboratory tests. Implementation costs were minimized with the use of existing space for patient evaluation and management, the low cost of screening all patients with point of care testing (with more expensive laboratory evaluation costs only incurred for patients found to be anemic), and midlevel costs that begin as a partial FTE and then subsequently increased to mirror clinic growth.

Return was determined as: 1) cost avoidance through transfusion reduction and 2) revenue generation through EPO infusion therapy (Table 1). Costs of transfusion avoided on a per-patient basis were determined by multiplying the cost of acquisition of a unit of RBCs from the American Red Cross by the mean number of RBC units transfused per case. This number was then multiplied by the number of patients predicted to avoid transfusion. Revenues per patient from infusion were determined by multiplying revenues per infusion visit by the number of infusion visits per patient.

As with all medical services, when billing for infusions, the physician should clearly document the services rendered to the patient during the encounter to enable the charges to be correctly coded with the appropriate CPT or HCPC code. Hb and hematocrit levels should also be noted within the record for medical necessity purposes. Once the patient's plan of care is decided, the authorization staff should check the patient's insurance plan before treatment to avoid unnecessary denials for medical necessity or non-authorization. Accurate coding of the patient's ICD-10 code is important as many payers have specific guidelines for paying these services. Specific modifiers as well as laboratory values may be required for billing but this should be confirmed with the local payer before billing as the guidelines vary state by state depending on the payer.

## DEVELOPING A TREATMENT ALGORITHM

There are several algorithms available in the literature that can be utilized to help identify the major causes of anemia in a preoperative surgical population,[17,18,20] with most patients amenable to treatment with EPO-stimulating agents and/or iron therapy. That said, it is important to recognize that although a PAC may identify and treat a patient's anemia in the short term to optimize them for surgery and decrease the risk of transfusion, postoperatively, these patients will require follow-up of their newly diagnosed anemia. Patients with existing hematologic or oncologic disease, with severe unexplained anemia ($Hb < 8.0$ g/dL), with evidence of hemolysis, or with decrease in multiple cell lines (neutropenia, thrombocytopenia, RBC aplastic anemia), are scheduled for evaluation by a hematologist. Patients with renal insufficiency ($eGFR < 60$ mL/min) may require evaluation by a nephrologist. In addition, all patients identified with a new diagnosis of anemia are referred back to their primary care physician through use of a form letter for appropriate work-up (i.e., colonoscopy) and follow-up, regardless of whether this occurs pre- or postoperatively.

With these considerations, we adapted the protocol published by Goodnough and colleagues[18] to an institution-specific protocol (Fig. 1). EPO is dosed at 600 units/kg intravenously (IV) weekly on Days 21, 14, and 7 before surgery and on the day of surgery. This dosing regimen has been shown to increase preoperative Hb by 1.44 g/dL on average, compared to 0.73 g/dL with previously utilized 15-day daily 300 unit/kg dosing regimens.[14] Despite the Food and Drug Administration's black box warning against use of EPO in cardiac and vascular surgical patients due to concerns over increased risk of thrombosis, it has been used extensively in preoperative orthopedic populations. However, due to concerns of this increased risk, our standard is to use pharmacologic deep vein thrombosis prophylaxis in postoperative patients that have been treated with EPO. Iron is given with EPO as a substrate for RBC synthesis in the case of anemia of chronic disease or is dosed independently in the case of iron deficiency anemia. Because of low rates of patient tolerance of oral iron, poor absorption in patients with coexisting gastrointestinal disease or inflammatory states, and in an attempt to optimize patients with only weeks before scheduled surgery, IV iron is preferred. For patients with iron deficiency anemia and a large iron deficit (>600-mg deficit), low-molecular-weight iron dextran may be the preferred formulation as up to 1000 mg can be given in one visit. For patients receiving weekly infusions with EPO, other formulations available at our institution include iron sucrose (given as 200 mg per dose), sodium ferric gluconate (125 mg per dose), and ferumoxytol (up to 510 mg per dose).

## CLINIC OPERATIONALIZATION

Clinic workflow design, staffing requirements, physical space arrangement, and plan for medical oversight incorporated input from multiple stakeholders, including surgeons, operational directors of the surgery clinics, nurse managers, preanesthesia testing (PAT) clinic medical director and operational management, appropriate Center for Blood Conservation staff, and infusion center operational management. This effort sought to maximize the efficiency and effectiveness of appropriate patient identification, treatment of anemia, patient convenience, and staff satisfaction, while minimizing staff workflow disruption, communication errors, patient loss to follow-up, and cost.

Primary consideration was given to identification of anemic patients early enough in their clinical course to

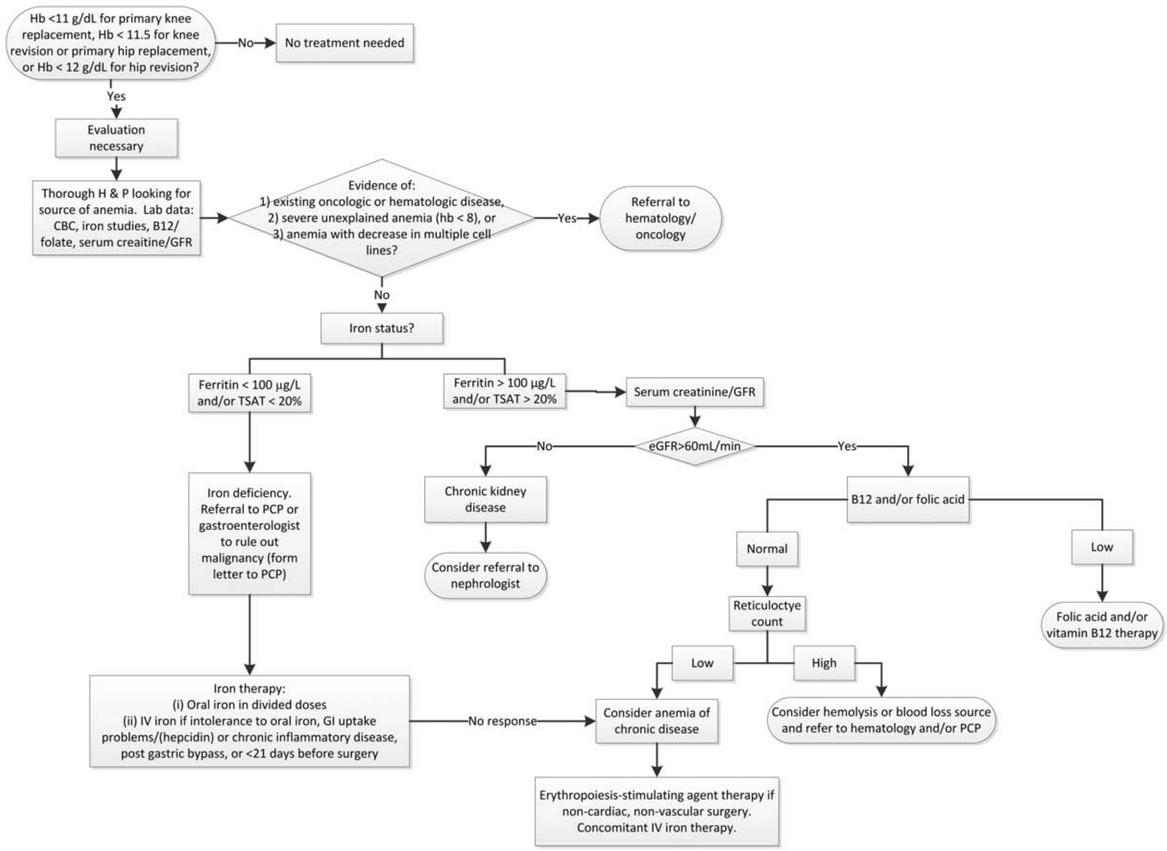


**Fig. 1. Preoperative anemia treatment algorithm.**

allow for the requisite time necessary to effectively treat the anemia (i.e., as soon as possible after the surgeon's decision to operate). Point-of-care testing with a HemoCue blood Hb analyzer in the surgery clinic represented the optimal approach to patient identification, particularly in light of its ease of use, accuracy, and low cost. After the initial diagnosis of anemia, a series of events commence simultaneously to permit laboratory evaluation of type and cause of anemia, patient education, appropriate surgical scheduling (≥4 weeks), appropriate referral to primary care, gastroenterology (in the setting of iron deficiency), nephrology (in the setting of chronic kidney disease), and/or hematology and initiation, monitoring, and titration of infusion treatment (Fig. 2).

Face-to-face patient education, distribution of educational materials, and an initial introduction to the preoperative anemia management program are facilitated by the patient's surgeon (or his/her surrogate) immediately after Hb testing. Additional personalized education is provided by PAC staff after interpretation of complete laboratory testing to characterize the patient's anemia. Integration of laboratory ordering into an electronic medical record order set was prioritized to minimize surgical clinic staff time utilized and the likelihood of an ordering error. The blood draw for evaluation of anemia was coordinated to occur in the existing PAT laboratory immediately after the patient's appointment in the orthopedic clinic to avoid a separate trip to a medical facility. After availability of laboratory results, evaluation of cause of anemia and entry into an appropriate protocol treatment algorithm would be undertaken utilizing PAT clinic workspace, followed by infusion center visits with intermittent assessment for response to treatment.

## INTEGRATED EHR

To be effective, innovative care redesign initiatives like a PAC must be integrated into clinical workflow as well as the enterprise EHR, as operational success can be facilitated by an effective user interfacing and provider workflow. The clinical informatics strategy was outlined upon commencement of the project and was customized to the needs as the plan for the clinic developed (which included

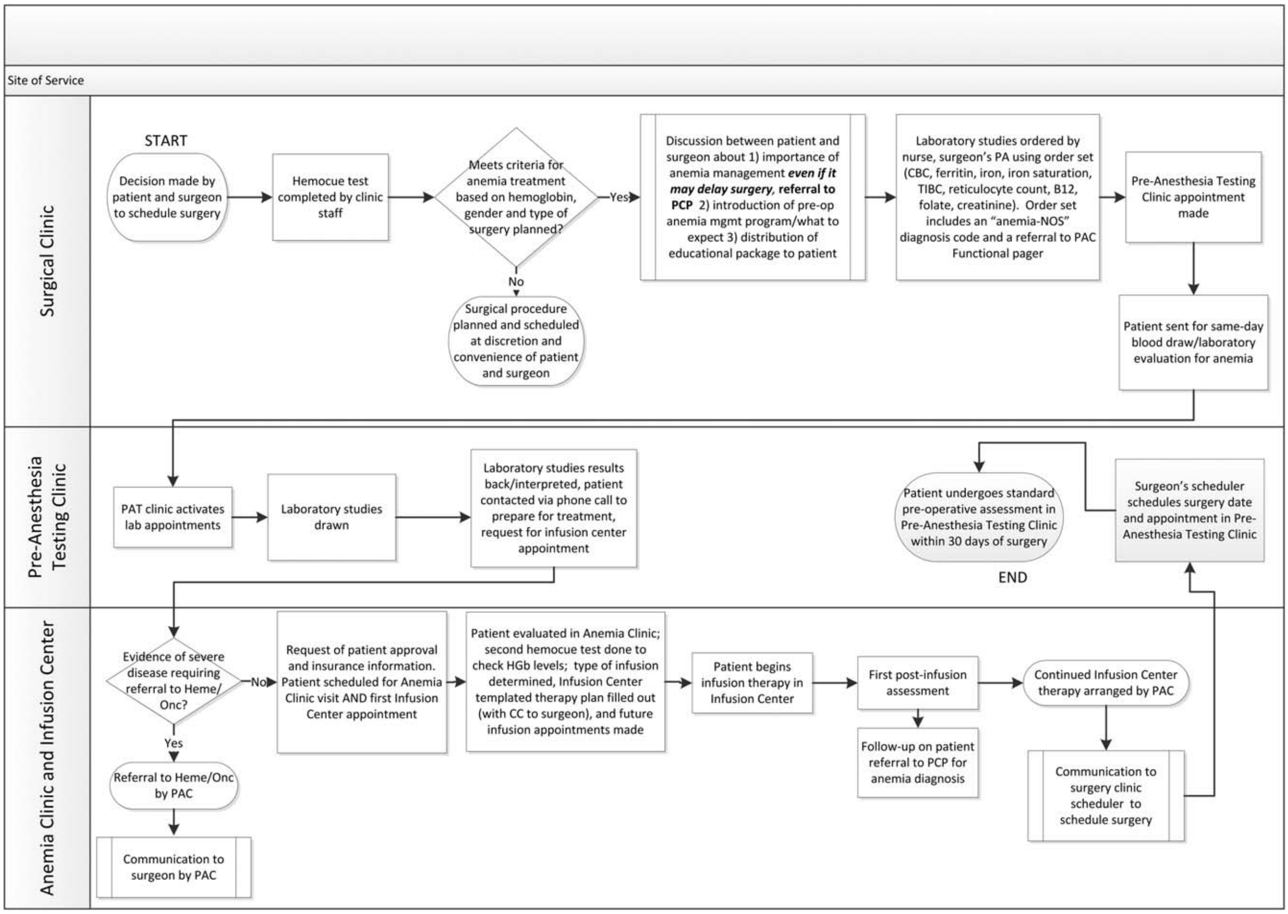


**Fig. 2. Preoperative anemia clinic workflow.**

electronic ordering for HemoCue testing, an electronic order set to facilitate efficient ordering of laboratory studies to support the initial evaluation in the PAC, and modifications of the electronic scheduling system to accommodate PAC appointment requests). Predeployment build was tested before go-live and postdeployment validation and modification was performed.

## DISCUSSION

The decision to treat anemia by transfusion incorporates institutional and provider bias regarding sensitivity toward acute patient needs, perioperative complications ascribed to transfusion practices, and health care resource utilization impact. Nonetheless, the presenting Hb of a patient before surgery significantly influences blood management and transfusion decision-making. By developing and implementing a PAC to diagnose and treat anemia in patients presenting for elective surgery, we aimed to decrease transfusion rates and improve patient outcomes, which would in turn decrease costs to the institution.

This multidisciplinary plan benefits multiple departments as well as the health system as a whole. Decreased transfusion rates and fewer crossmatches can drive down blood bank costs of blood procurement, storage, release, and unused product return, as well as decrease acquisition cost and staff burden of unnecessary crossmatches. The division of hematology benefits through consult support for patients that cannot be managed within the clinic protocol and by the ability to provide education services. The infusion center benefits from an increase in revenues from IV iron and EPO therapy. The surgical departments benefit from fewer case cancelations due to unmanaged perioperative anemia, decreased patient length of stay, and improved perioperative outcomes. Finally, and most importantly, patients benefit from transfusion avoidance and its associated morbidity and mortality.

Since launching the program, 175 patients scheduled for joint surgery have been screened, and 25 have been referred to the PAC, completed treatment, and gone on to have surgery, only one of which has been transfused. Furthermore, the PAC program has seen effective spread to other perioperative services (obstetrics, spine surgery). Through following the steps outlined in this article, this plan can certainly be adapted to fit within other institutions.

## CONFLICT OF INTEREST

The authors have disclosed no conflicts of interest.

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