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# Increasing Transfusion Efficacy of Stored Blood by using Quality-Based Alternatives to First-In-First-Out Inventory Planning

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## SCIENTIFIC: ANEMIA MANAGEMENT

### 2011-01 PREOPERATIVE DETERMINANTS OF TRANSFUSION AND THEIR EFFECTS ON TRANSFUSION RATES

Freedman J., Vernich L., Howell A., Luke K. and the Transfusion Coordinators of the ONTraC program, Ontario, Canada

Preoperative anemia is a major determinant of intra- and post-operative transfusion. Our program of Transfusion Coordinators (TC) in 25 hospitals in Ontario aims to evaluate patients early preoperatively to facilitate appropriate management of anemia. Data will be presented on orthopedic patients (knee arthroplasty N=4235; hip N=2805; revision hip N=348; spine surgery N=178), and on cardiac surgery patients (CABG N=1010; CABG+valve N=144; valves N=197; AAA N=63) seen in 2010. In CABG patients seen by the TC, 23.2% were transfused; in those not seen 32.4% were transfused. Transfusion rates were affected by gender and elderly status, initial, preoperative and nadir hemoglobin (Hb) levels, lead times prior to surgery, and by preoperative treatment of anemia. In CABG patients with initial Hb <130 g/L, 56.3% were transfused, when initial Hb was >130 g/L 16.5% were transfused, and for those with initial Hb >140 g/L, transfusion rate was 10.2%. Women were twice as likely to be transfused than men (50.6% versus 22.9%). Mean initial Hb levels were 128.2±14.9 and 141.6±13.1 g/L in women and men respectively: in transfused men, mean initial Hb was 129.3 and in women 121.3 g/L, in contrast to initial Hb in nontransfused patients of 143.6 versus 133.2 g/L for men and women respectively). Cardiac surgery patients generally had shorter lead times e.g. 42% of CABG patients, in contrast to 70% of orthopedic patients, had lead time >14 days. Transfusion rates were inversely proportional to lead time.

In CABG, transfusion rates were 40.7% when lead time was <7 day, 25.7% when 7-15 days, and 20.3% when >14 days. As lead time increased, there was an increase in use of preoperative blood conservation measures. 4.4% of CABG patients, 13% of CABG+valve, 15% of valves, and 7% of minimally invasive cardiac surgery patients received ESAs; 2.2% of CABG patients, 6.3% of CABG+valve, 7.6% of valves, and 7% of minimally invasive cardiac surgery patients received IV iron. 7% of knee, hip and revision hip arthroplasty and 17% of spine surgery patients received ESAs; 3.2% of knee, 2.4% of hip, 3.2 % revision hip arthroplasties, and 0.6% spine surgery patients received IV iron. Use of these therapies increased mean Hb levels e.g. in CABG patients mean dose of ESA was 100,000 IU and mean Hb increase was 14.9 g/L; mean Hb increase with IV iron was 10.6 g/L.

Patients treated preoperatively with ESAs and/or with intravenous iron had lower transfusion rates than those not treated. Length of stay and infection rates were significantly lower in nontransfused patients and incidence of thrombotic events was not higher in patients who received ESAs. Transfusion rates have decreased progressively since the program's inception in 2002 (60.1% in CABG in 2002 vs 23.6% in 2010) and transfused patients receive fewer units (0.60 units in 2010 versus 2.01 units in 2002 per transfused patient).

While other factors, including intra-and post-operative patient blood management measures, and education and "culture change", also play important roles, we conclude that appropriate anemia management can significantly reduce transfusion rate and improve quality of care.

## SCIENTIFIC: BLOOD UTILIZATION

### 2011-02 INCREASING TRANSFUSION EFFICACY OF STORED BLOOD BY USING QUALITY-BASED ALTERNATIVES TO FIRST-IN-FIRST-OUT INVENTORY PLANNING

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**Introduction** The effect of red blood cell (RBC) storage on transfusion efficacy is a topic of considerable debate. While significant data exist linking "older" blood to "worse" outcomes, other studies question any such correlation. Within today's maximum FDA-allowed 42-day shelf life for RBC, hospital blood banks routinely use First-In-First-Out (FIFO) inventory management protocols. The predominant use of FIFO means a heavy reliance on time as the only indicator of prospective transfusion efficacy. Focusing on storage time as the sole metric for viability loss ignores the variability in properties of RBC even of the same age. Inherent as well as conditional differences between units can markedly affect both the scope and rates of RBC quality loss. Emerging in-vitro tests aim to correlate unit-specific data with transfusion efficacy and clinical outcomes.

This study presents a basic model for Blood Bank inventory management based on in-vitro RBC quality testing to supplant FIFO. It demonstrates the potential impact on transfusion efficacy for a sample Blood Bank inventory, from reorganizing inventory in a Blood Bank based on measured RBC properties of individual units - and their respective projected degradation rates.

**Methods** The model, built as a linear program in AMPL, determined the times of transfusion for each unit of RBC in inventory, to maximize cumulative anticipated efficacy (CAE) of all inventory at transfusion. Inputs included blood type, collection date, and the date(s) and results of quality test(s) performed upon each unit. Each test provides actual efficacy (ACT) of a given unit as of that day, and a rate of degradation ($R_{AE}$) used to calculate the anticipated efficacy (AE) on any subsequent date. Constraints included a minimum required level of AE for every unit transfused and full satisfaction of daily blood demand. Model output was simulated using sample inventory data provided by Dr. Davenport and Ms. Downs from the University of Michigan Hospital Blood Bank.

**Results** Preliminary simulations of inventory management process resulted in 10-15% improvement in overall efficacy over traditional FIFO. Modifying the date of quality testing and/or the number of times it is performed during storage can further improve the model. Efficacy improvements also significantly depended on the variability in RBC initial quality (IAE) at t=0 and upon the variability among rates of decline of AE. Increase in overall inventory efficacy (CAE) notably did not result in any shorter average storage time.

**Conclusions** The replacement of FIFO with an inventory management system based on RBC unit quality testing allows for significant improvement of overall transfusion efficacy, while fully satisfying the demand. Implementation of such testing for inventory optimization is expected to improve clinical outcomes while reducing blood usage and associated costs.

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