A Multimodal Approach to Blood Conservation in Cardiac Surgery

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Disclosures

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Provincial Blood Conservation Program

- 25 hospitals, 27 nurses/coordinators
- Physician director (Dr. J. Freedman)
- Program manager (K. Luke RN, BScN, MHS)
- Coordinators have developed and maintain blood conservation programs at each site
- Database developed: each site collects prospective data on targeted procedures at regular intervals
- Aggregate data submitted to the Ontario Ministry of Health and Long Term Care
St. Mary’s General Hospital

In the tradition of the Sisters of St. Joseph of Hamilton ~ Leading our Community in Health Care
St. Mary’s Stats and Facts

- 191 acute care beds
- 1,250 staff
- 176 medical staff
- 403 volunteers
- 7,000+ admissions/year
- 100,000+ outpatient visits/year
- 45,000+ emergency department visits/year
- 18,000+ surgical procedures/year
- 4,000+ cardiac procedures/year
- Approx. 750 cardiac surgeries/year
Region was serviced by surrounding hospitals > 90 km away

CABG rate was 64 cases /10^6 population

Ontario average was 100 cases/10^6 population

In 1999, St. Mary's General Hospital was named as the site for a new Regional Cardiac Care Centre
South-western Ontario
Area Served
Started with diagnostic angiography in 2001

July 7, 2003 first CABG and Angioplasty performed

July 14, 2003 doors were opened to all emergencies from the region
Cardiac surgery has historically been associated with high utilization of all allogeneic blood products…..

Why?
Anemia in Cardiac Patients

Few cardiologists seem to acknowledge/recognize anemia in their patients.

Anemia is noted in patients with increased use of ACE, ARB’s, Beta Blockers and ASA.

Owen et al J. Cardiac Failure 2006; 12: 257.

Transfusions in Cardiac surgery associated with:

- Increased length of stay
- Increased infection rates
- Transfusion of “Old blood” associated with increased mortality, prolonged ventilation, renal failure & sepsis

cont’d
Increased overall morbidity
Increased overall mortality
Decreased quality of life
Increased resource utilization

Especially in Women

Koch et al. (2006) Critical Care Medicine; 34: 1608 – 1616
If you keep doing what you have always done

You’ll keep getting what you’ve always gotten
“The beginning of any new initiative or program presents a rare opportunity to critically evaluate and integrate the very latest evidence based practice initiatives in medicine.” (Jones, 2005)
Our Vision
St. Mary’s General Hospital will be a leader in healthcare excellence, characterized by compassion, innovation and respect for the individual.

Multimodal Blood Conservation

- PATIENT CENTERED.
- Comprehensive
- Multidisciplinary team
- Cost effective
- Reduce dependence on allogeneic blood components and products
Initial Pre-op Approach

- review of patient information with Regional Cardiac Care Coordinator (RCCC)
- Identify risks and plan optimization of patient
- Multidisciplinary approach
  - GU – screen for UTI’s
  - Nephrology – consults prn
  - Radiology; carotid dopplers: previous CVA, > 75 yo, TIA or PVD
  - PFT’s if current or recent ex smoker
  - Cardiology – medication management
Intra-operative Approach

1. Meticulous Surgical Technique
   Dry in – Dry Out!
2. Antifibrinolytics

- Tranexamic acid
- Bolus followed by a continuous infusion throughout the case.
3. Minimal Hemodilution

- Maximizes $O_2$ delivery
- Limits dilutional coagulopathy
- Limits volume overload
- Limits interstitial edema
- Retrograde Autologous Prime (RAP) when possible
Universal adoption of biocompatible coated perfusion circuitry offers superior protection of the coagulation system and platelets.

Surface coating blunts the significant systemic inflammatory response associated with cardiopulmonary bypass due to large foreign surface contact activation.

**HIT**: use another proprietary line devoid of heparin.
5. Sequestration of Surgical Suction

- reduction or complete elimination of all surgical suction exposed to pericardial and pleural spaces

Avoid a host of deleterious effects;
- pathological activation of the coagulation system
- associated with tissue factor pathway activation of the intrinsic pathway
- most important source of non-surgical post-op bleeding
6. Intraoperative Cell Salvage

blood loss is salvaged, washed and re-infused real-time as a red cell concentrate, as required (25% of the time), throughout all phases of the surgery
7. Advanced Point of Care (POC) Laboratory Testing

- Provides rapid, critical, time sensitive information for immediate diagnosis & definitive treatment of bleeding.

- Heparin-protamine titration instrumentation provides superior protection of the coagulation system during CPB and measured dosing strategies of both heparin & protamine.

- Plans to add INR & thromboelastography (TEG)
8. Acute Normovolemic Hemodilution (ANH)

Select patient population

- Require circ. arrest for aortic arch work
- High pre-op HGB (150 range)
- Phlebotomize 1200 cc (2 citrated bags)

Use ANH to provide fresh whole blood primarily for fresh platelet content post protamine
Post-operative Approach

CV-ICU staffed by experienced CV-anesthetists 24/7

Fluid Restriction; goal of *1500 cc first 24 hours

Vasopressors vs volume cont’d
Post-Operative Approach

- Transfusion Trigger; patient specific: based on comorbidities (carotid disease, COPD, renal disease), type of surgery and rate of blood loss
- Frequent patient assessments to evaluate interventions
- POC; Selective point of care testing for rapid differential diagnosis of bleeding
St Mary’s Regional Cardiovascular Program
Baseline Data Compared to 24 MONTHS Aggregate ONTraC

ONTRAC BASELINE TRANSFUSION RATE
24 MONTHS
12 MONTHS
St. Mary’s General BASELINE
18 MONTHS

61.5
52.0
49.3
49.8
16.6

Transfusion Rates: Primary Elective CABG

Four Cardiac Surgery Centers in Ontario have submitted data to ONTraC, the provincial blood conservation program, at various intervals.
Pre-operative Approach
Enhanced

- Added Transfusion coordinator
- Anemia Management
- Pre-op Hemoglobin Optimization
- Hematology consultations
- GI work up

} as required
Perioperative Blood Conservation Committee

Purpose:

- To optimize utilization, educate health care providers and patients, recommend evidence based blood conservation strategies
- Data: collection, review and evaluation
- Ultimate Benefit: panel of experts (hematology, nephrology, anesthesia, perfusion, surgery, pathology, transfusion coordinator) increased confidence of end users
Risk Factors for Transfusion in Cardiac Surgery

- Hemoglobin <130
- Urgency
- weight <65 kg
- elderly (over 65)
- female gender
- complex or repeat surgical procedure
- renal insufficiency (creatinine clearance < 40)
- Pharmaceuticals; ASA, anticoagulants, antiplatelet therapy, herbs, vitamins, steroids
- Language barrier
Prevalence of Anemia

- Large cohort of patients > 65 yo
- the prevalence of anemia increases with age and varies based on ethnicity and sex.
  - 33% of patients in study were co-factor deficient
  - 20% were iron deficient
  - 13% were B12 &/or folate deficient
  - 30% were attributed to Anemia of Chronic Disease (ACD)

Hemoglobin ranges in Female Population
Tested N=68

- hgb 80 - 100: 50%
- hgb 100 - 130: 43%
- hgb 130 - 150: 6%
- hgb >150: 1%
It’s all about the drop!

- Majority of “major” surgeries HGB drops 40 – 50 Gms
- Predictability component
- Not just about anemic patients
- Hemoglobin Optimization Strategies
Right therapy for the right patient!

Need to stratify the correct intervention to each individual patient

Lead to algorithm development
Algorithm for Preoperative Hemoglobin Optimization and Anemia Management for the Perioperative Blood Conservation Program

**Goals:**
1. To increase awareness and availability of transfusion alternatives.
2. To identify preoperative anemia for appropriate treatment by physicians.
3. To decrease patient's exposure to the risks of allogeneic transfusions.
4. To enhance postoperative rehabilitation and potentially decrease infection rates and length of stay.

**Strategies:**
1. Early assessment of patients undergoing surgical procedures associated with >10% blood loss.
2. Early identification of Risk Factors for Transfusion: Hemoglobin <130 g/L, weight >65 kg, elderly, female gender, complex or repeat surgical procedure, renal insufficiency (creatinine clearance <40 mL/min), postoperative drug use (ASA, anticoagulants, herbs, vitamins).
3. Assess for appropriate interventions and arrange for implementation.

**HGB <10 g/L:**
- Consider delaying surgery; refer to the appropriate physician for investigation.
- Evaluate for blood loss: GI, menstrual, recurrent epistaxis.
- Evaluate anticoagulant status (e.g., Coumadin, heparin).
- Look for signs of nephritis (e.g., proteinuria, hematuria).
- Start iron therapy: 1. Oral iron (e.g., Ferrous Fumarate 300 mg qid oral); 2. IV iron (e.g., ferric carboxymaltose 500 mg IV weekly).

**HGB 100-130 g/L:**
- Evaluate iron deficiency.
- Consider iron therapy: 1. Oral iron (e.g., Ferrous Gluconate); 2. IV iron (e.g., ferric carboxymaltose).

**HGB >130-150 g/L:**
- Evaluate hematocrit and consider transfusion if necessary.
- Consider iron therapy: 1. Oral iron (e.g., Ferrous Gluconate); 2. IV iron (e.g., ferric carboxymaltose).

**HGB >150 g/L:**
- Consider iron therapy: 1. Oral iron (e.g., Ferrous Gluconate); 2. IV iron (e.g., ferric carboxymaltose).

**Microcytic (MCV <80):**
- Consider: iron deficiency, thalassemia, anemia of chronic disease, sideroblastic anemia, renal failure.
- Consider: Appropriate Medical Consult and Lab Investigation as per Physicians Orders.
- Check: Serum Ferritin OR TIBC & Iron saturation. False elevations in Ferritin may occur with infections, e.g., rheumatoid arthritis, lupus, sepsis, inflammatory bowel disease.

**Normocytic (MCV 80-100):**
- Consider: Chronic disease, cancer, inflammation, marrow problem, hemolytic anemia, hereditary spherocytosis, renal failure.
- Consider: Appropriate Medical Consult and Lab Investigation as per Physicians Orders.

**Macrocytic (MCV >100):**
- Consider: alcoholism, hypothyroidism, hepatic disease, medications: HIV antiviral, Hydralazine, Selegiline, Methotrexate, myelodysplastic syndrome, pernicious anemia, recurrent anemia.
- Consider: Appropriate Medical Consult and Lab Investigation as per Physicians Orders.

**TIBC <45 mmol/L**
- Ferritin <15 mcg/L.
- Start iron therapy: 1. Oral iron (e.g., Ferrous Fumarate 300 mg qid oral); 2. IV iron (e.g., ferric carboxymaltose 500 mg IV weekly).

**TIBC >72 mmol/L**
- Ferritin >15 mcg/L.
- Iron deficiency: Consider: iron deficiency anemia.
- Start iron therapy: 1. Oral iron (e.g., Ferrous Fumarate 300 mg qid oral); 2. IV iron (e.g., ferric carboxymaltose 500 mg IV weekly).

**Folate and B12 Normal:**
- Or
- Folate Low.
- Start folate therapy: Folic Acid 5 mg daily.

**Folate and B12 Low:**
- Consider: vitamin B12 deficiency, anemia of unknown cause.
- Start vitamin B12 therapy: Parenteral B12 1 mg weekly.

**Erythropoietin:**
- Standard Dosing: Eprex 20,000-40,000 units subcutaneously (600 units/kg) weekly to a maximum of 4 doses depending on patient's response and time to surgery.
- Access: 3rd party coverage, cash, or government benefit plans (e.g., Trillium Individual Clinical Review DRG [formerly OCEE]).

**HGB ≤130 g/L:**
- Trial of Erythropoietin with iron.

**HGB >130 g/L:**
- Consider needs of surgical procedure.

**Notes:**
- Hemoglobin optimization and anemia management strategies must be patient specific (e.g., age, gender, and preexisting medical conditions). CAUTION: Target maximum HGB optimization using erythropoietin in renal and oncology patients ≤120 g/L. Patients with preexisting thrombotic events should be monitored closely.

Developed by Ontario Transfusion Coordinators (ONTraC), a blood conservation initiative by the Ministry of Health and Long Term Care of Ontario (MOHLTC) – February 2007.

www.ontracprogram.com
Herbals: stop for 7 days pre-op
ASA: outpatients stop for 7 days, inpatients often stay on 81 mg dose until day before OR
Clopidogrel all patients stop for 5 -7 days ideally, variable; ?DES 3 days
Warfarin stop for 5 days – +/- tinzaparin
Tinzaparin bridging; stop coumadin → next 3 consecutive days tinzaparin inj.→ 4th day none → 5th day OR (20 – 28 hrs tinzaparin out of system)
Low molecular weight heparin (inpatients)24 hours
Vitamin & Mineral Supplementation

- Aim for at least 2 weeks lead time
- Oral iron given to patients with normal HGB
- Transferrin rate stayed the same but they had a smaller HGB drop

- 100 mg elemental Iron on an empty stomach with 8 oz. of water or juice once or twice daily (100) *not within 2 hours of other meds
- Folic acid 2 - 5 mg. by mouth once a day (50)
- Vitamin B12 1,000 – 2,000 mcg by mouth once daily (50)
## Comparison of Iron supplements

<table>
<thead>
<tr>
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<th>Total dose</th>
<th>Elemental iron</th>
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<tbody>
<tr>
<td>Ferrous gluconate</td>
<td>300 mg</td>
<td>35</td>
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<tr>
<td>Ferrous sulphate</td>
<td>300 mg</td>
<td>66</td>
</tr>
<tr>
<td>Ferrous fumarate</td>
<td>300 mg</td>
<td>100</td>
</tr>
<tr>
<td>heme iron (porphyrin derivative)</td>
<td>11 mg</td>
<td>11 mg (approx 23 times absorption)</td>
</tr>
<tr>
<td>Polysaccharide iron complex</td>
<td>150 mg</td>
<td>150 mg (slow release)</td>
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</table>
Intravenous Iron

- confirmed iron deficiency * notify GP
- unable to tolerate oral iron preparations
- very short time line.

Products available
- iron sucrose,
- sodium ferric gluconate
- iron dextran

We prefer Iron sucrose; 300 mg iron sucrose in 250 cc Normal saline infused at 100 mg/hour X 3 doses; doses 48 hours apart

10 – 15 patients a year
Low molecular weight iron dextran is gaining popularity in US and Europe

- 1 Gm. dose in 1 hour.
- Pre-medicate with methylprednisolone

Erythropoiesis Stimulating Agents (ESA’s)

- stimulate red cell production
- Iron supplements \textit{required} during therapy
- folic acid and oral vitamin B12 supplements \textit{recommended} during therapy
- Must be used judiciously
- Patients must be monitored very closely
- Precautions and Exclusion criteria must be respected
- Epoetin Alfa is the only product approved for use in the surgical patient population
Exclusion Criteria for ESA’s

- Pure red cell aplasia (PRCA) following treatment with any erythropoiesis regulating hormone
- Uncontrolled hypertension
- Patients with known hypersensitivity to mammalian cell-derived products, albumin (human) or any component of the product.
- Epoetin Alfa is available in some formats, formulated without serum albumin
- Patients who for any reason cannot receive adequate antithrombotic treatment
- If serum Ferritin is less than 14 ug/L patient is ineligible for receiving Epoetin Alfa
- Concurrent active malignancy
Precautions for ESA’s

- Hypertension: blood pressure may rise during ESA therapy, especially in chronic renal failure patients.
- Seizures
- Thrombotic events: any patient, regardless of thrombotic history, may have an increased risk of venothromboembolism with treatment to higher hemoglobin concentration (greater than 145).
- Liver disease
- Drug and/or alcohol abuse
- Severe gout
“In the absence of Level I evidence Epoetin Alfa use is at the discretion of the surgeon and/or anaesthetist in the following circumstances” 1 thru 9
1. Unstable Angina Pectoris defined as:
   - new onset angina
   - change in pattern of angina over last 2 months
   - acute coronary insufficiency (pain lasting more than 20-30 minutes within the last 2 months)
   - angina followed by an acute myocardial infarction within the last 3 months
2. critical or severe stenotic aortic valve disease with peak valve gradient more than 70 mm Hg  Valve Surface Area less than 1.0 cm$^2$
3. significant left main coronary artery disease >50%
4. Significant coronary artery disease
5. Recent Trans-ischemic Attacks
6. Uncontrolled congestive heart failure
7. Idiopathic hypertrophic subaortic stenosis
8. Ventricular arrhythmia
9. Atrio-ventricular block
Epoetin Alfa use at SMGH

- 2005 – 16 elective patients
- 2006 – 31 elective patients
- 2007 – 33 elective patients
- 2008 – so far 22 elective patients
Outcomes

Data Speaks
Collect it
Use it
<table>
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<tr>
<th>Year</th>
<th>Canada (except ON &amp; QC)</th>
<th>Ontario</th>
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<tr>
<td>1999/00</td>
<td>26</td>
<td></td>
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<tr>
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<td>2005/06</td>
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<tr>
<td>2006/07</td>
<td>34</td>
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Proportion of patients transfused with allogeneic blood

Baseline and five subsequent time periods (2002-2007)
The data presented relate to cohorts of all consecutive patients with the specified diagnoses over that time period. When, however, patients within the cohort were evaluated based on whether they were or were not seen by the Transfusion Coordinator, there was a significant difference. For CABG patients at 12 mos, there was an overall 21.6% decrease in patients transfused with allogeneic blood. If not seen pre-op by Coordinator = a 12% reduction in transfusion rate, but if were seen, = a 50.2% reduction.
Average length of stay (ALOS)

- Knee
- Hip
- Rad prost
- CABG

No Tx

Allogeneic Tx
Odds ratios compared to no transfusion

Infection

Number of allogeneic units transfused

Odds ratio compared to no transfusion

LOS

Number of allogeneic units transfused

Dose dependence

Odds ratios compared to no transfusion
<table>
<thead>
<tr>
<th></th>
<th>knees</th>
<th>hips</th>
<th>rad prost</th>
<th>CABG</th>
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<tr>
<td><strong>Overall mortality</strong></td>
<td>0.2%</td>
<td>0.5%</td>
<td>0.0014%</td>
<td>1.1%</td>
</tr>
<tr>
<td><strong>no Tx</strong></td>
<td>0%</td>
<td>33%</td>
<td>0%</td>
<td>33%</td>
</tr>
<tr>
<td><strong>allogeneic Tx</strong></td>
<td>100%</td>
<td>67%</td>
<td>100%</td>
<td>67%</td>
</tr>
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St. Mary’s vs ONTraC

ONTraC Data 2007

Transfusion rates (%)

0  20  40  60  80

10 Individual Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Transfusion Rate (%)</th>
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<tbody>
<tr>
<td>1</td>
<td>9.1</td>
</tr>
<tr>
<td>2</td>
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<td>3</td>
<td>18.5</td>
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<tr>
<td>9</td>
<td>71.7</td>
</tr>
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<td>10</td>
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</table>
PACKED RCC UTILIZATION BY PROGRAM PERCENT TRANSFUSED CABG 2006/07

- Hamilton: 26.3%
- Sudbury: 54.6%
- Kingston: 33.2%
- London: 47.6%
- Southlake: 39.4%
- St. Mary’s: 17.4%
- St. Michael’s: 31.0%
- Sunnybrook: 55.5%
- Trillium: 65.0%
- UHN: 60.0%
- Ottawa: 45.6%

Legend:
- RCC
- PROVINCIAL AVERAGE %
- SMGH RATE %
PLASMA OR PLATELETS UTILIZATION
PERCENT TRANSFUSED
CABG 2006/07

- Hamilton: 33.2%
- Sudbury: 12.2%
- Kingston: 25.8%
- London: 10.1%
- Southlake: 14.1%
- St. Mary’s: 6.6%
- St. Michael’s: 9.7%
- Sunnybrook: 28.9%
- Trillium: 27.5%
- UHN: 22.8%
- Ottawa Provincial: 24.4%
- Provincial Average: 20.1%

Report of Coronary Artery Bypass Surgery in Ontario
Fiscal Years 2005/06-2006/07
Gary Spencer, Julie Wang, Linda Donavan, Jack Tu
The Institute for Clinical and Evaluative Sciences
Toronto, Ontario, Canada
In collaboration with the Informatics Committee of the Cardiac Care Network of Ontario
In house mortality
30-Day Mortality
Thank You!