Blood Conservation in Spine Surgery

Bishr Haydar, M.D.
Goal:
Discuss techniques for blood conservation and transfusion therapy during spine surgery

Disclosures:
I have no financial disclosures that are relevant to this presentation
Outline

• Describe the scope of the problem of bleeding in spine fusion for idiopathic adolescent scoliosis
• Review the competing priorities in pRBC transfusion
• Survey strategies for blood conservation their and relative utility in preoperative care.
• Survey strategies for blood conservation their and relative utility in intraoperative care.
Bleeding and spinal fusion

Commentary

Commentary: True blood—changes in blood management in pediatric deformity surgery

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• “Because most risk factors for blood transfusion in pediatric spinal deformity surgery are patient specific and cannot be avoided…”

Imrie MN. Spine J, 2012
Bleeding and spinal fusion

• Large surgical exposure with extensive instrumentation
• Historically, bleeding > 50% blood volume
• ~200 mL/segment EBL over 1st 24 hours; 1/3 post-op
• Bleeding predicted by
  – Type of Scoliosis (Idiopathic vs NM)
  – Degree of curvature
  – Lumbosacral fusion
  – Patient weight <30 kg
  – Length of surgical procedure
• Coagulopathy: dilutional and consumptive

Vitale MG et al, Spine J. 2002
Why Avoid Transfusion?

- Blood-borne infectious disease
- Transfusion reactions, TRALI, TACO
- GVHD, Immunomodulation, wound infection
- Associated with Non-Hodgkin’s Lymphoma (RR 1.2) (Castillo JJ et al, Blood 2010)

- Delayed wound healing, wound infections; co-morbid with prolonged OR time

Spahn DR, Casutt M, Anesthesiology 2000
Raw DA, Br J Anaesth 2003
Blood Conservation

- Preoperative
  - Assessment
  - Pharmacotherapy
  - Autologous Donation
- Intraoperative
  - Surgical technique
  - Non-pharmacotherapy
  - Anesthetic technique
  - Pharmacotherapy
  - Transfusion guidelines
Preoperative Assessment

• Screening for preoperative anemia +/- Ferritin
• Iron supplementation x 4-8 weeks
• Erythropoietin:
  – Vitale MG: Retrospective study, EPO cut transfusion incidence by half (11% vs 27%)
  – Vitale MG: Prospective study in NM Scoliosis, no reduction in incidence of transfusion (57% control vs 50% EPO)
  – Costly (up to $2000), requires multiple visits
• Interview: Screen for bleeding diathesis, review medications

Basta MN et al, Ped Surg Int 2012
Preoperative Assessment

• Autologous Donation
  – May reduce allogeneic pRBC transfusion by 50% in retrospective study
  – Cost-effectiveness recently questioned
    • Risk of clerical error
    • Up to 20% units not transfused (Bess 2006)
    • Poor accuracy in prediction # needed units
  – Cost is much lower than cell saver (Elgafy 2010)

Gibson PRJ, Anaesth Intensive Care 2004
Intraoperative

- Surgical technique (not covered here)
- **Non-pharmacotherapy**
- Anesthetic technique
- Pharmacotherapy
- Transfusion guidelines
Intraoperative Non-pharmacotherapy

• Positioning:
  – Optimal positioning reduces EBL by ~50% in adult lumbar spinal fusion (Park)
  – Mechanism:
    • Decreased IVC pressure (Lee), improving drainage from venous channels around the spine
    • Markedly decreased abdominal pressure (Park)

• Prevention of Coagulopathy
  – Even mild hypothermia (35°C) prolongs PT, PTT, bleeding time
  – Sample warmed by lab, read as normal
  – Profound hypothermia -> irreversible changes

Park CK, Anesthesiology 2000; Lee TC et al, Spine 1998
Davis PJ, Cladis FP, Motoyama EK, Smith's Anesthesia. 8th Ed 2011
Intraoperative

- Surgical technique (not covered here)
- Non-pharmacotherapy
- Anesthetic technique
- Pharmacotherapy
- Transfusion guidelines
Anesthetic Technique

- Intrathecal Morphine
  - Goodarzi 1998 – RCT IT morphine
  - 25 ug/kg plus 50 ug Sufentanil vs no spinal

<table>
<thead>
<tr>
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<th>IT Morphine</th>
<th>Control</th>
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<tr>
<td>EBL (% EBV)</td>
<td>27.4%*</td>
<td>53.5%</td>
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<tr>
<td>Standard Deviation</td>
<td>42.9%</td>
<td>33.5%</td>
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</table>

- However:
  - MAPs significantly different - 50-55 mmHg in IT group vs 65-70 mmHg in control
  - Narcotic infusion used only in control group
  - Two IT morphine patients had delayed extubation (> 1 hour)

Anesthetic Technique

• Intrathecal Morphine
  – Gall et al 2001– RCT IT morphine
    • 2 ug/kg vs 5 ug/kg vs saline control

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<th>5 ug/kg</th>
<th>2 ug/kg</th>
<th>Control</th>
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<tbody>
<tr>
<td>EBL (mL/kg)</td>
<td>14*</td>
<td>34</td>
<td>41</td>
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<tr>
<td>Standard Deviation</td>
<td>10</td>
<td>19</td>
<td>23</td>
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</table>

– No difference in MAP
– Lower intraop anesthetic requirements in 5 ug/kg

Gall O. et al Analgesic Effect of Low-dose Intrathecal Morphine after Spinal Fusion in Children Anesthesiology 2001
Anesthetic Technique

- **Intrathecal Morphine**
  - Eschertzhuber 2008– RCT IT morphine 5 ug/kg, vs 15 ug/kg vs saline control
  - Both IT morphine groups received Sufentanil 1 ug/kg IT

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<th>15 ug/kg</th>
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<td>EBL (mL/kg)</td>
<td>37.5*</td>
<td>41.4*</td>
<td>76.9</td>
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<tr>
<td>Standard Deviation</td>
<td>6.9</td>
<td>18.8</td>
<td>15.3</td>
</tr>
</tbody>
</table>

- **Mechanism: Sympatholysis** (Goodarzi 2001)

  Eschertzhuber S. et al Comparison of high- and low-dose intrathecal morphine for spinal fusion in children BJA 2008
Anesthetic Technique

• Induced Hypotension
  – Early reports – 58% lower EBL using MAP ~ 50 mmHg
  – Spinal cord autoregulation 60-150 mm Hg
  – MAP < 60 mmHg somewhat controversial
    • Additive effect of surgical distraction and hypoperfusion
    • May increase SSEP false-positive rate (Papastefanou SL et al, 2000)
    • May require higher Hct to maintain adequate end-organ perfusion

Papastefanou, SL et al, Spine 2000
Gibson Anaesth Intensive Care 2004
Anesthetic Technique

• Normovolemic Hemodilution
  – Removal of 1 – 3 units of whole blood after induction, replacement with crystalloid or colloid

• Copley et al (1999): Retrospective study; reduced incidence of transfusion from 79% to 37% and reduced transfusion

• Cell saver only effective in ~50% of these patients

Intraoperative

• Surgical technique (not covered here)
• Non-pharmacotherapy
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• Pharmacotherapy
• Transfusion guidelines
Pharmacotherapy

- Antifibrinolytic agents
  - Epsilon Aminocaproic Acid (EACA)
  - Tranexamic Acid (TXA)
    - Lysine analogs, bind to plasminogen, inhibiting it from binding to Fibrin
    - TXA 6-10 times more potent than EACA

- Adverse effects:
  - Hypotension, hypersensitivity
  - Thromboembolism, seizures (high dose)

Eubanks JD, JAAOS 2010
Goobie S. Paediatr Anaesth. 2014
Pharmacotherapy

• Aprotinin (not covered)
  – Withdrawn, now reintroduced in Canada, Europe
    • Increased mortality, renal failure in adult high-risk cardiac surgery
  • However, in pediatric cardiac surgery:
    • Pasquali et al, Wilder et al: reduced mortality, reoperation, bleeding, transfusion, and renal dysfunction

Eubanks JD, JAAOS 2010
Goobie S. Paediatr Anaesth. 2014
Pharmacotherapy

• Antifibrinolytics dosing:
  – EACA 100 mg/kg (up to 5g) then 10 mg/kg/h until closure (4 studies, Thompson, Florentino)
  – TXA 10 mg/kg then 1 mg/kg/h (Neilipovitz, Grant)
  – TXA 20 mg/kg then 10 mg/kg/h (Grant)
  – TXA 100 mg/kg then 10 mg/kg/h (Sethna, Shapiro)

• TXA Pharmacokinetics study by Grassin-Delyle S et al recommended an infusion rate of ~2 mg/kg/h for patients >30 kg

Basta MN et al, Ped Surg Int 2012
Grassin-Delyle S et al, Anesthesiology 2013
Pharmacotherapy

- Meta-analysis EACA, TXA efficacy (Basta):
  - EBL -846 mL [95% CI -1207 - -485]
  - Transfusion volume -504 mL [-706 - -304]
  - Relative Risk of transfusion 0.82 [0.70 – 0.95]
  - No individual study showed reduced risk of transfusion
  - Adverse event rate not calculable

Basta MN et al, Ped Surg Int 2012
Autologous RBC Salvage

• Bowen et al, 2010 – Retrospective
  – All patients > 6 hours with EBL > 30% TBV received blood
  – Relative risk of allogeneic pRBC 5.87 in patients not receiving cell saver blood
  – Allogeneic pRBC transfusion rate 6% in cell saver vs 55% non-cell saver

• Not cost-effective if patient donated autologous blood, unless EBL > 2 L (Simpson et al 1993)

Bowen RE et al. Spine 2010
Simpson MB et al, J Ped Ortho 1993
Intraoperative

- Surgical technique (not covered here)
- Non-pharmacotherapy
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- Transfusion guidelines
Transfusion guidelines

• Absolutely Indicated Hgb < 6 g/dL
• Indicated Hgb 6-10 if:
  – Ongoing or potential for ongoing bleeding
  – Signs of inadequate end-organ perfusion
  – Low volume status
  – Risk factors for inadequate oxygenation
  – Low cardiopulmonary reserve
  – High O2 consumption

Practice Guidelines for Perioperative Blood Transfusion and Adjuvant Therapies, Anesthesiology 2006
Transfusion guidelines

• Temporarily using elevated FiO2 (Weiskopf 2002)
  – Decrement in higher cerebral function with hemodilution below Hgb 7
  – Hemodiluted to Hgb 5.7, PaO2 400 restores awake volunteers to baseline

• Per European Society of Anaesthesiology only recommended in hemorrhagic shock as a temporizing measure.

Weiskopf RB et al Anesthesiology 2002
Kozek-Langenecker, SA et al, Euro J of Anaesth 2013
Summary: Blood Conservation

• Should begin weeks pre-operatively with history, screening for anemia and possible autologous donation
• Optimal positioning and normothermia for every patient
• Consider spinal morphine, avoidance of hypertension, antifibrinolytics, normovolemic hemodilution, cell saver
• \( \frac{1}{3} \)rd of blood loss is postoperative
<table>
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<tr>
<th>Preoperative</th>
<th>Optimise erythropoiesis</th>
<th>Minimise blood loss</th>
<th>Manage anaemia</th>
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<tbody>
<tr>
<td>Identify, assess, and treat anaemia</td>
<td>Identify and manage bleeding risk (past and family history)</td>
<td>Compare estimated blood loss with patient-specific tolerable blood loss</td>
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<tr>
<td>Consider preoperative autologous blood donation</td>
<td>Review medications (antiplatelet, anticoagulation treatment)</td>
<td>Assess and optimise patient’s physiological reserve (e.g., pulmonary and cardiac function)</td>
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<tr>
<td>Consider erythropoiesis-stimulating agents if nutritional anaemia is ruled out or treated</td>
<td>Minimise iatrogenic blood loss</td>
<td>Formulate patient-specific management plan with appropriate blood conservation modalities to manage anaemia</td>
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<td>Refer for further assessment if necessary</td>
<td>Procedure planning and rehearsal</td>
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<tr>
<td>Unmanaged anaemia (haemoglobin in women &lt;120 g/L, haemoglobin in men &lt;130 g/L) is a contraindication for elective surgery</td>
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<th>Intraoperative</th>
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<tr>
<td>Time surgery with optimisation of red blood cell mass</td>
<td>Meticulous haemostasis and surgical techniques</td>
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<thead>
<tr>
<th>Postoperative</th>
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<tbody>
<tr>
<td>Manage nutritional or correctable anaemia (e.g., avoid folate deficiency, iron-restricted erythropoiesis)</td>
<td>Monitor and manage bleeding</td>
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<tr>
<td>Treatment with erythropoiesis-stimulating agents if appropriate</td>
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<tr>
<td>Be aware of drug interactions that can cause anaemia (e.g., ACE inhibitor)</td>
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Figure 1, from Spahn DR, Goodnough LT. Alternatives to blood transfusion. Lancet. 2013 May 25;381(9880):1855-65. (Syllabus only)
References