# Blood Conservation in Spine Surgery

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Goal:

Discuss techniques for blood conservation and transfusion therapy during spine surgery

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# 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

Gibson PRJ, Anaesth Intensive Care 2004.
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

Vitale MG et al, Spine 2002, Vitale MG et al, Spine 2007
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
Bess RS et al, Spine 2006, Murray DJ et al, Spine 1997

# 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

| | IT Morphine | Control |
|---|---|---|
| EBL (% EBV) | 27.4%* | 53.5% |
| Standard Deviation | 42.9% | 33.5% |

  - 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)

Goodarzi M. The advantages of intrathecal opioids for spinal fusion in children.Paediatr Anaesth. 1998;8(2):131-4.

# Anesthetic Technique

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

| | 5 ug/kg | 2 ug/kg | Control |
|---|---|---|---|
| EBL (mL/kg) | 14* | 34 | 41 |
| Standard Deviation | 10 | 19 | 23 |

  - 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

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# 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

| | 15 ug/kg | 5 ug/kg | Control |
|---|---|---|---|
| EBL (mL/kg) | 37.5* | 41.4* | 76.9 |
| Standard Deviation | 6.9 | 18.8 | 15.3 |

- Mechanism: Sympatholysis (Goodarzi 2001)

Eschertzhuber S. et al Comparison of high- and low-dose intrathecal morphine for spinal fusion in children BJA 2008
Goodarzi M, Narasimhan RR. Anesth. Analg. 2001.

# 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

Copley LA et al. Spine (Phila Pa 1976). 1999

# Intraoperative

- Surgical technique (not covered here)
- Non-pharmacotherapy
- Anesthetic technique
- **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

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# 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)
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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

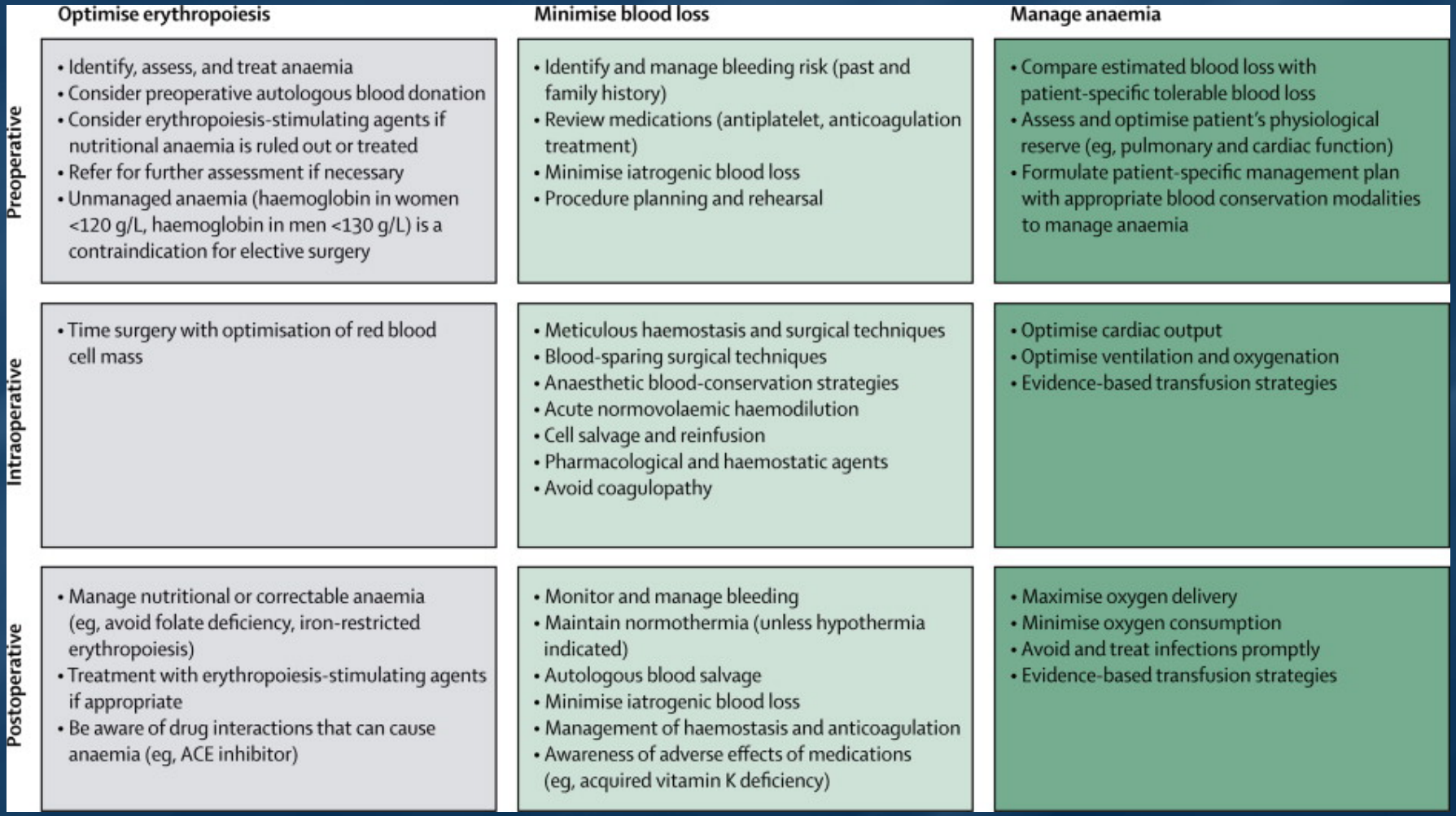
# Transfusion guidelines

- Temporarily using elevated FiO2 (Weiskopf 2002)
  - Decrement in higher cerebral function with hemodilution below Hgb 7
  - Hemodliuted 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
- 1/3$^{rd}$ of blood loss is postoperative



| | Optimise erythropoiesis | Minimise blood loss | Manage anaemia |
|---|---|---|---|
| Preoperative | • Identify, assess, and treat anaemia<br>• Consider preoperative autologous blood donation<br>• Consider erythropoiesis-stimulating agents if nutritional anaemia is ruled out or treated<br>• Refer for further assessment if necessary<br>• Unmanaged anaemia (haemoglobin in women <120 g/L, haemoglobin in men <130 g/L) is a contraindication for elective surgery | • Identify and manage bleeding risk (past and family history)<br>• Review medications (antiplatelet, anticoagulation treatment)<br>• Minimise iatrogenic blood loss<br>• Procedure planning and rehearsal | • Compare estimated blood loss with patient-specific tolerable blood loss<br>• Assess and optimise patient's physiological reserve (eg, pulmonary and cardiac function)<br>• Formulate patient-specific management plan with appropriate blood conservation modalities to manage anaemia |
| Intraoperative | • Time surgery with optimisation of red blood cell mass | • Meticulous haemostasis and surgical techniques<br>• Blood-sparing surgical techniques<br>• Anaesthetic blood-conservation strategies<br>• Acute normovolaemic haemodilution<br>• Cell salvage and reinfusion<br>• Pharmacological and haemostatic agents<br>• Avoid coagulopathy | • Optimise cardiac output<br>• Optimise ventilation and oxygenation<br>• Evidence-based transfusion strategies |
| Postoperative | • Manage nutritional or correctable anaemia (eg, avoid folate deficiency, iron-restricted erythropoiesis)<br>• Treatment with erythropoiesis-stimulating agents if appropriate<br>• Be aware of drug interactions that can cause anaemia (eg, ACE inhibitor) | • Monitor and manage bleeding<br>• Maintain normothermia (unless hypothermia indicated)<br>• Autologous blood salvage<br>• Minimise iatrogenic blood loss<br>• Management of haemostasis and anticoagulation<br>• Awareness of adverse effects of medications (eg, acquired vitamin K deficiency) | • Maximise oxygen delivery<br>• Minimise oxygen consumption<br>• Avoid and treat infections promptly<br>• Evidence-based transfusion strategies |

Figure 1, from Spahn DR, Goodnough LT. Alternatives to blood transfusion. Lancet. 2013 May 25;381(9880):1855-65.

(Syllabus only)

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