Role of IONM in reducing the incidence and severity in pediatric patients with AIS

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Objectives:

• Literature Review on neurological complications of scoliosis corrective surgeries and role of IONM
  - Incidence and risk factors.
  - The evidence of IONM in reducing these complications.
  - Implications of IONM on anesthetic management.

• Our study
  - Objectives
  - Design/s
  - Patients selection
  - Data Collection Form
  - Outcomes
  - Statistical methods
Scoliosis Overview

- **Definition:** > 10 degrees of lateral curvature of the spine assessed radiologically using COBB angle.
- **Incidence:** 2-3 %
- **Nomenclature**
  - Age of onset: Infantile (0-3), Juvenile (4-9), Adolescent (10-17).
  - Etiology: neuromuscular, Congenital, Idiopathic.
- **Complications**
  - Cardiac
  - Respiratory
  - Chronic pain
  - Psychological
- **Treatment**
  - Conservative
  - Surgical
## Incidence of Neurological Complications in pediatric scoliosis correction surgery

<table>
<thead>
<tr>
<th>Reference</th>
<th>Year Published</th>
<th>Diagnosis</th>
<th>No. of cases</th>
<th>Incidence of NND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qiu et al</td>
<td>2008</td>
<td>AIS, CS, NMS</td>
<td>756, 381, 131</td>
<td>1.06%, 2.89%, 3.05%</td>
</tr>
<tr>
<td>Theut et al</td>
<td>2010</td>
<td>AIS, CS, NMS</td>
<td>1618, 234, 626</td>
<td>0.7% *, 2.6% *, 2.6% *</td>
</tr>
<tr>
<td>Diab et al</td>
<td>2007</td>
<td>AIS</td>
<td>1301</td>
<td>0.3%</td>
</tr>
<tr>
<td>Schwartz et al</td>
<td>2007</td>
<td>AIS</td>
<td>1121</td>
<td>0.8%</td>
</tr>
<tr>
<td>Y. Imajo et al</td>
<td>2014</td>
<td>Mixed</td>
<td>1485</td>
<td>2.1%</td>
</tr>
</tbody>
</table>
## Risk factors for Neurological Complications in pediatric scoliosis correction surgery

### Table 4. The Total Incidence of Neurological Deficits in 1373 Patients With Scoliosis

<table>
<thead>
<tr>
<th>Title</th>
<th>Item</th>
<th>Cases of Patients</th>
<th>Cases of Neurological Deficits</th>
<th>Incidence (%)</th>
<th>Fisher Exact Test (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>440</td>
<td>6</td>
<td>1.36</td>
<td>0.322</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>933</td>
<td>20</td>
<td>2.14</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>&lt;18 yr</td>
<td>1074</td>
<td>20</td>
<td>1.88</td>
<td>0.871</td>
</tr>
<tr>
<td></td>
<td>≥18 yr</td>
<td>299</td>
<td>6</td>
<td>2.01</td>
<td></td>
</tr>
<tr>
<td>Etiology</td>
<td>AIS</td>
<td>756</td>
<td>8</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CS</td>
<td>361</td>
<td>11</td>
<td>2.89</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NMS</td>
<td>131</td>
<td>4</td>
<td>3.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NFS</td>
<td>47</td>
<td>1</td>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SecS</td>
<td>58</td>
<td>2</td>
<td>3.45</td>
<td></td>
</tr>
<tr>
<td>Hyperkyphosis</td>
<td>With hyperkyphosis</td>
<td>361</td>
<td>12</td>
<td>3.32</td>
<td>0.013</td>
</tr>
<tr>
<td></td>
<td>Without hyperkyphosis</td>
<td>1012</td>
<td>14</td>
<td>1.38</td>
<td></td>
</tr>
<tr>
<td>Procedures</td>
<td>Anterior (An)</td>
<td>211</td>
<td>2</td>
<td>0.95</td>
<td>1.000 (An vs. Po)</td>
</tr>
<tr>
<td></td>
<td>Posterior (Po)</td>
<td>725</td>
<td>9</td>
<td>1.24</td>
<td>0.011 (Po vs. Co)</td>
</tr>
<tr>
<td></td>
<td>Combined (Co)</td>
<td>437</td>
<td>15</td>
<td>3.43</td>
<td>0.070 (An vs. Co)</td>
</tr>
<tr>
<td>Cobb’s angles (major curve)</td>
<td>&lt;90°</td>
<td>1102</td>
<td>16</td>
<td>1.45</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>≥90°</td>
<td>271</td>
<td>10</td>
<td>3.69</td>
<td></td>
</tr>
<tr>
<td>Primary or Revision</td>
<td>Primary</td>
<td>1306</td>
<td>22</td>
<td>1.68</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>Revision</td>
<td>67</td>
<td>4</td>
<td>5.97</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1373</td>
<td>26</td>
<td>1.89</td>
<td></td>
</tr>
</tbody>
</table>

AIS indicates adolescent idiopathic scoliosis; CS, congenital scoliosis; NMS, neuromuscular scoliosis; NFS, scoliosis associated with neurofibromatosis type 1 (NF1); SecS, scoliosis associated with or secondary to other conditions (collagen defects, Marfan syndrome, and bone dysplasias, etc.).
Risk factors for Neurological Complications in pediatric scoliosis correction surgery

- **Factors that increase the risk:**
  1. Cobb angle >90
  2. Scoliosis with Kyphosis
  3. Combined Anterior and Posterior approach
  4. Revision surgery
  5. Surgeons with <5 years of experience

( Y. Imajo et al, 2014).
Mechanisms of Neurological Complications in pediatric scoliosis correction surgery

74/3436 (2.2%)

Instrumentation 35 (47%)
  - Hypotension alone (11) 15%
  - Retraction 11 (15%)
  - Positioning 6 (8%)
  - Halotraction 7 (8%)
  - Others 4

Theut et al 2010
Intraoperative Neuromonitoring

- SSEPs
- MEPs
- EEG
- Pedicle Screw stimulation
- Wake up test
Does IONM reduce the incidence of Neurological complications?

Validity and Reliability of Intraoperative Monitoring in Pediatric Spinal Deformity Surgery
A 23-Year Experience of 3436 Surgical Cases

Table 5. Percentage of True-Positive and False-Negative Events by Diagnostic Category

<table>
<thead>
<tr>
<th>Diagnostic Group</th>
<th>Total Patients</th>
<th>True Positive</th>
<th>False Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyphosis/kyphoscoliosis</td>
<td>226</td>
<td>21 (9.3%)</td>
<td>1 (0.4%)</td>
</tr>
<tr>
<td>Syndrome</td>
<td>143</td>
<td>6 (4.2%)</td>
<td>0</td>
</tr>
<tr>
<td>Revision</td>
<td>329</td>
<td>10 (3.0%)</td>
<td>1 (0.3%)</td>
</tr>
<tr>
<td>Neuromuscular scoliosis</td>
<td>626</td>
<td>16 (2.6%)</td>
<td>0</td>
</tr>
<tr>
<td>Congenital</td>
<td>234</td>
<td>6 (2.6%)</td>
<td>1 (0.4%)</td>
</tr>
<tr>
<td>Spondylolisthesis</td>
<td>154</td>
<td>3 (1.9%)</td>
<td>4 (2.6%)</td>
</tr>
<tr>
<td><strong>Idiopathic scoliosis</strong></td>
<td><strong>1618</strong></td>
<td><strong>12 (0.7%)</strong></td>
<td><strong>0</strong></td>
</tr>
<tr>
<td>Fracture/trauma</td>
<td>47</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pathologic</td>
<td>31</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Degenerative</td>
<td>28</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Does IONM reduce the incidence of Neurological complications?

74 / 3436 (2.2%) True Positives

- 59 No neurological deficit

10 Transient neurological deficit**

5 Permanent neurological deficit

7 / 3436 False Negatives

- 6 Transient neurological deficit

1 Permanent neurological deficit
IONM + TIVA, SO WHAT?

- More difficulty maintaining BP especially with excessive bleeding
- Prolonged awakening time
- Platelets Dysfunction
- Metabolic Acidosis
- Lipidemia
- Technical issues
- Cost **
Research question

In adolescents with idiopathic scoliosis undergoing posterior spinal fusion (PSF) with instrumentation, does intraoperative neuromonitoring reduce the incidence of new neurological deficit (NND)?

- P: Pediatric patients with AIS undergoing PSF with instrumentation
- I: IONM
- C: No IONM
- O: Postoperative NND
Study Objectives

• To compare the incidence and severity of NND in patients with AIS undergoing PSF with and without IONM.

• To form hypotheses regarding the utility of IONM in reducing the incidence and/or the severity of NND in low risk AIS cases.
Study Design

• A retrospective chart review

• McMaster Children’s hospital and Children’s hospital of Eastern Ontario (CHEO)

• Group A: AIS cases done with IONM (N = 400)

• Group B: AIS cases done without IONM (N=400)
Patient Selection

\textit{Inclusion criteria:}
- Pediatric patients between 10 - 17 years
- Underwent posterior spinal fusion (PSF) surgery with instrumentation.
- No previous spine surgeries except if the patient underwent uneventful anterior spinal release surgery in a separate operation prior to PSF.
- No other major medical comorbidities (ASA class I or II).

\textit{Exclusion Criteria:}
- Patients with scoliosis etiology other than AIS.
- Patients with significant kyphosis.
- Patients with preoperative neuromuscular disorders whether related or unrelated to scoliosis.
- Patients underwent combined anterior and posterior approach in the same session.
Variables (Data collection)

Preoperative Data

- **Demographics** (Age, Gender, Weight, Height, BMI)
- **Surgical Risk Factors** Scoliosis Etiology Scoliosis levels Number of levels COBB angle Revision surgery Kyphosis angle
- **Medical Risk Factors**
  - ASA class (1,2,3,4)
  - Cardiac risk factors (Congenital Heart disease – Valvular heart disease – HTN)
  - Respiratory risk factors (Smoking, Asthma)
  - Hematological (Anemia, Hemoglobinopathy, Thrombophilia, Coagulopathy)
  - Endocrine (DM, Hypothyroid)
  - Renal: Renal insufficiency, Nephritic $, Nephrotic $.
  - GI/Hepatic: GERD, IBD, hepatic impairment
  - Neurological: Seizure disorder, CP, Hydrocephalus,
  - Musculoskeletal: Myopathy, Muscular dystrophy, Metabolic myopathy, Mitochondrial disorders
  - Malnutrition
  - Chronic Pain
- **Pre-op medications**
- **Pre-op Lab** Hb (g/L) HCT % Platelets INR PTT Creatinine
- **Admission information**
  - Admission date
  - Discharge date
  - Surgeon’s code
  - In-hospital LOS (days) In-hospital total cost?
Variables
(Data collection)

Intra operative Data

◆ **OR time data**
  - Total OR time (patient in – patient out) (min)
  - Surgical time (skin incision – skin closure) (min)
  - Anesthesia readiness time (patient in – skin incision)
  - Anesthesia recovery time (skin closure – patient out)

◆ **Monitoring**
  - Art line, CVP, Temp, BIS
  - SSEPs, MEPs, EEG
  - Pedicle screw stimulation

◆ **Anesthetic Management**
  - Intrathecal Morphine
  - Steroids (Type, dose)
  - Induction (IV – Inhalational)
  - Maintenance (TIVA – Volatile – Volatile then TIVA - TIVA + MAC aware)
  - Adjuncts (Remifentanil – Ketamine – Dexmedetomidine – Tranexamic acid)
  - Extubation (OR – ICU)
  - Vasopressor infusion (phenylephrine – Norepi – Epi)
  - Controlled hypotension: Y/N
  - HCT nadir, Temp nadir, Estimated Blood loss (ml/Kg)
  - Total Crystalloids (mL), Total colloids (mL), RBCs units, FFP
Intra operative Data

**Surgical Management**
- Surgical approach (Posterior – Anterior – Combined)
- Upper instrumentation vertebra
- Lower instrumentation vertebra
- Number of levels
- Construct (Pedicle screws – Hooks- Hybrid – Cross link – interbodoy – Sublaminar wires)
- Osteotomy (facetectomy – Ponty type)

**Intraoperative events**
- True IOM alerts (Type – Stage- Distribution – MAP – Temp – EEG - HCT – Surgical distraction – screw insertion)
- Abnormal wake up test
- Anesthetic Intervention (vasoactive – blood transfusion – Adjustment of anesthetic depth – Change technique – Steroid administration)
- Surgical intervention (Hardware adjustment – release distraction – Modify surgery – termination of the procedure)
- IOM Response to intervention (full recovery – Partial recovery – no recovery)
- Inadvertent dural tear
Variables
(Data collection)

Intra operative Data

◆ **Postop data**
  • ICU Length of stay (hours)
  • Duration of mechanical ventilation (hours)
  • ICU Admission HCT
  • ICU Admission temperature
  • Total RBCs given
  • Total FFPs given
  • Total platelets

◆ **New neurological deficit**
  • Distribution (partial spinal cord – complete spinal cord – nerve root – Cauda equina)
  • Recovery (Complete – Partial – No recovery)
OPTION 1
Retrospective chart review comparing 2 groups
1. Group 1: IONM monitoring (Incidence 1%)
2. Group 2: No IONM (Incidence 2%)
SAMPLE SIZE = 2000 patients in each group

OPTION 2
Regression analysis