The Use of Local Analgesic Agents in Scoliosis Surgery

The Implications for Spinal Cord Monitoring

Bernadette Ann Loughnan

BSc MB ChB FRCA

A Thesis Submitted for the Degree of Doctor of Medicine

University of Auckland

1993
ABSTRACT

The thesis examines the use of local analgesics as part of the anaesthetic technique for scoliosis surgery. Any agents used must have minimal interference with monitoring of spinal cord integrity.

The literature on the anaesthetic requirements for scoliosis surgery is reviewed and the various methods of monitoring spinal cord function are discussed.

The historical background and experimental rationale for the use of the somatosensory evoked potential (SEP) in scoliosis surgery is examined. The advantages of the epidural SEP over the scalp-recorded SEP are demonstrated. Spinal cord monitoring at many UK centres consists of measuring the SEP recorded from the C7 - T1 epidural space to stimulation of the posterior tibial nerve (PTN) at the popliteal fossa.

The effects of a lumbar epidural injection of different local analgesic solutions on the SEP to posterior tibial nerve stimulation were investigated. In the initial study, epidural lignocaine 2% 10 ml was evaluated. The next two experiments assessed the changes after epidural diamorphine 0.1 mg kg\(^{-1}\) and epidural etidocaine 1% 10 ml respectively on the SEP. The final study compared the effects of epidural bupivacaine 0.25%, 0.5% and 0.75% 10 ml on the SEP.

These studies showed that 10 ml of lignocaine 2%, bupivacaine 0.5% or bupivacaine 0.75% depressed significantly the epidural SEP. Diamorphine 0.1 mg kg\(^{-1}\) had no measurable effect. Etidocaine 1% caused a profound decrease, and in some cases an obliteration of the SEP. There was a clear concentration-dependent effect of increasing concentrations bupivacaine on the SEP.

The effects of the different local analgesic agents on the neurophysiological variables are considered in the light of their known physicochemical properties. The literature on the neural generators of the epidural SEP is reviewed. My studies are compared to similar experiments on the scalp-recorded SEP and the SEP to dermatomal stimulation. Possible differences in the epidural SEP between scoliosis and non-scoliosis patients are noted. The possible relevance of the changes in mean arterial pressure when assessing alterations in SEP is examined.
Etidocaine, and local anaesthetics of high lipid solubility, have no place in anaesthesia for scoliosis surgery. Furthermore, lignocaine 2%, bupivacaine 0.75% or bupivacaine 0.5% cannot be recommended because they interfere with monitoring of the SEP in the perioperative period. However, lower concentrations of bupivacaine such as 0.25%, together with diamorphine 0.1 mg kg\(^{-1}\), may be appropriate, since they have minimal effects on the SEP.
ACKNOWLEDGMENTS

I wish to acknowledge the staff of the Royal National Orthopaedic Hospital, Stanmore, Middlesex for their help, but most particularly the Scoliosis Surgeons for their patience and Mr. John Farrell of the Medical Physics Department for technical assistance. I also thank the North West Thames Regional Health Authority for an equipment grant which enabled me to complete the work at Northwick Park Hospital. Finally, I wish to acknowledge the help and guidance given to me by Professor George Hall of St. George’s Hospital London (formerly of the Hammersmith Hospital), without whom this work would not have been possible.
LIST OF PUBLICATIONS

The following is a list of publications on work which is described in the thesis.


# TABLE OF CONTENTS

**ABSTRACT** .......................................................... i

**ACKNOWLEDGMENTS** ............................................. iii

**LIST OF PUBLICATIONS** ........................................ iv

**TABLE OF CONTENTS** ............................................. v

**LIST OF FIGURES** ................................................ viii

**LIST OF TABLES** ................................................ ix

## CHAPTER 1 - INTRODUCTION

1.1 Introduction ..................................................... 1
1.2 Methods of Monitoring ........................................ 2
  1.2.1 The wake-up test ........................................... 2
  1.2.2 Somatosensory evoked potentials (SEP) ..................... 2
1.3 The Effects of Arterial Pressure .............................. 5
1.4 The Case for Epidural Anaesthesia ............................ 5
1.5 Conclusion ......................................................... 7
1.6 Objectives of the Thesis ....................................... 8

## CHAPTER 2 - LITERATURE REVIEW

2.1 Anaesthesia for Scoliosis Surgery ............................ 10
2.2 Somatosensory Evoked Potentials ............................. 14
  2.2.1 Experimental Background .................................. 14
  2.2.2 Hypotensive Considerations ............................... 15
  2.2.3 Clinical Application ....................................... 16
2.3 Effects of Local Analgesics on the SEP ...................... 18
  2.3.1 Experimental studies ...................................... 18
    2.3.1.1 *In vitro* studies of local analgesics .............. 18
    2.3.1.2 *In vivo* studies ..................................... 19
  2.3.2 Clinical Studies .......................................... 21
2.4 Summary .......................................................... 22
# CHAPTER III - METHODS

3.1 Patients Studied ......................................................... 23
   3.1.1 At the Royal National Orthopaedic Hospital ................. 23
   3.1.2 At Northwick Park Hospital .................................. 24
3.2 Equipment Used ......................................................... 24
3.3 Anaesthetic Protocol .................................................. 25
3.4 Epidural Analgesia ...................................................... 26
3.5 Routine Monitoring ...................................................... 26
3.6 Intravenous Fluids ...................................................... 27
3.7 Positioning of Patient .................................................. 27
3.8 Description of the Traces .............................................. 27
3.9 Statistical Analysis ..................................................... 28

# CHAPTER IV - EFFECT OF LIGNOCAINE ON THE EPIDURAL SEP

4.1 Introduction .............................................................. 31
4.2 Methods ................................................................. 31
4.3 Results ................................................................. 32
   4.3.1 Patient Characteristics ....................................... 32
   4.3.2 SEP - Within Group Differences ............................... 32
   4.3.3 SEP - Between Group Differences ............................. 33
       4.3.3.1 Effects of Saline ...................................... 33
       4.3.3.2 Effects of Lignocaine .................................. 33
   4.3.4 Arterial pressure ................................................. 33
4.4 Discussion ............................................................... 34
4.5 Conclusions ............................................................. 35

# CHAPTER V - EFFECT OF DIAMORPHINE ON THE EPIDURAL SEP

5.1 Introduction ............................................................. 45
5.2 Methods ................................................................. 45
5.3 Results ................................................................. 46
   5.3.1 Patient Characteristics ....................................... 46
   5.3.2 SEP - Within-Group Analysis .................................. 46
   5.3.3 SEP - Between-Group Analysis ................................. 46
   5.3.4 Arterial Pressure ............................................... 46
5.4 Discussion ............................................................... 47
5.5 Conclusions ............................................................. 48
## CHAPTER VI - EFFECT OF ETIDOCAIN ON THE EPIDURAL SEP

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Introduction</td>
<td>56</td>
</tr>
<tr>
<td>6.2</td>
<td>Methods and Materials</td>
<td>56</td>
</tr>
<tr>
<td>6.3</td>
<td>Results</td>
<td>58</td>
</tr>
<tr>
<td>6.3.1</td>
<td>Patient Characteristics</td>
<td>58</td>
</tr>
<tr>
<td>6.3.2</td>
<td>SEP - Within-Group Analysis</td>
<td>58</td>
</tr>
<tr>
<td>6.3.3</td>
<td>SEP - Between-Group Analysis</td>
<td>58</td>
</tr>
<tr>
<td>6.3.4</td>
<td>Arterial Pressure</td>
<td>59</td>
</tr>
<tr>
<td>6.4</td>
<td>Discussion</td>
<td>59</td>
</tr>
<tr>
<td>6.5</td>
<td>Conclusions</td>
<td>61</td>
</tr>
</tbody>
</table>

## CHAPTER VII - EFFECT OF DIFFERING CONCENTRATIONS OF BUPIVACAINE ON THE EPIDURAL SEP

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>Introduction</td>
<td>70</td>
</tr>
<tr>
<td>7.2</td>
<td>Methods</td>
<td>70</td>
</tr>
<tr>
<td>7.3</td>
<td>Results</td>
<td>71</td>
</tr>
<tr>
<td>7.3.1</td>
<td>Patient Characteristics</td>
<td>71</td>
</tr>
<tr>
<td>7.3.2</td>
<td>SEP - Within-Group Differences</td>
<td>71</td>
</tr>
<tr>
<td>7.3.3</td>
<td>SEP - Description of Changes and Between-Group Differences</td>
<td>72</td>
</tr>
<tr>
<td>7.3.4</td>
<td>SEP - Effect of Concentration</td>
<td>73</td>
</tr>
<tr>
<td>7.3.5</td>
<td>Arterial Pressure</td>
<td>73</td>
</tr>
<tr>
<td>7.4</td>
<td>Discussion</td>
<td>73</td>
</tr>
<tr>
<td>7.5</td>
<td>Conclusions</td>
<td>75</td>
</tr>
</tbody>
</table>

## CHAPTER VIII - DISCUSSION

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1</td>
<td>Pathways Involved in Generation of the SEP</td>
<td>87</td>
</tr>
<tr>
<td>8.2</td>
<td>Comparison of Epidural With Scalp-Recorded SEP</td>
<td>88</td>
</tr>
<tr>
<td>8.3</td>
<td>Comparison of Posterior Tibial Nerve With Dermatomal SEP</td>
<td>89</td>
</tr>
<tr>
<td>8.4</td>
<td>Scoliosis Model and Use of Normal Patients</td>
<td>90</td>
</tr>
<tr>
<td>8.5</td>
<td>Difference Between Local Analgesic Agents</td>
<td>92</td>
</tr>
<tr>
<td>8.6</td>
<td>Physical Determinants</td>
<td>93</td>
</tr>
<tr>
<td>8.7</td>
<td>Statistics - Non-Normal Distribution</td>
<td>94</td>
</tr>
<tr>
<td>8.8</td>
<td>Implications for Other Methods of Monitoring</td>
<td>96</td>
</tr>
<tr>
<td>8.9</td>
<td>Effects of Arterial Pressure</td>
<td>97</td>
</tr>
<tr>
<td>8.10</td>
<td>Future Studies</td>
<td>99</td>
</tr>
<tr>
<td>8.10.1</td>
<td>In Scoliosis Patients</td>
<td>99</td>
</tr>
<tr>
<td>8.10.1.1</td>
<td>Intraoperative Analgesia</td>
<td>99</td>
</tr>
<tr>
<td>8.10.1.2</td>
<td>Postoperative Analgesia</td>
<td>100</td>
</tr>
<tr>
<td>8.10.2</td>
<td>In Neurophysiology</td>
<td>102</td>
</tr>
</tbody>
</table>

## REFERENCES

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>111</td>
</tr>
</tbody>
</table>
## FIGURES

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Typical SEP</td>
<td>29</td>
</tr>
<tr>
<td>4.1</td>
<td>Effect of 2% lignocaine on SEP</td>
<td>37</td>
</tr>
<tr>
<td>6.1</td>
<td>Effect of 1% etidocaine on SEP</td>
<td>62</td>
</tr>
<tr>
<td>7.1</td>
<td>Effect of 0.75% bupivacaine on SEP</td>
<td>76</td>
</tr>
<tr>
<td>7.2</td>
<td>Median changes in SEP data with increasing concentrations of bupivacaine</td>
<td>77</td>
</tr>
<tr>
<td>8.1</td>
<td>Scoliosis patients: left leg SEP frequency distribution</td>
<td>105</td>
</tr>
<tr>
<td>8.2</td>
<td>Scoliosis patients: logarithmic transformation of left leg SEP frequency distribution</td>
<td>106</td>
</tr>
<tr>
<td>8.3</td>
<td>Scoliosis patients: right leg SEP frequency distribution</td>
<td>107</td>
</tr>
<tr>
<td>8.4</td>
<td>Scoliosis patients: logarithmic transformation of right leg SEP frequency distribution</td>
<td>108</td>
</tr>
</tbody>
</table>
## TABLES

3.1 Summary of studies ........................................... 30

4.1 Lignocaine: within-group analysis of SEP changes ............... 38
4.2 Lignocaine: between-group differences in overall amplitude ...... 39
4.3 Lignocaine: between-group differences in first peak amplitude .... 40
4.4 Lignocaine: between-group differences in second peak amplitude ... 41
4.5 Lignocaine: between-group differences in third peak amplitude ... 42
4.6 Lignocaine: between-group differences in SEP latency ............. 43
4.7 Lignocaine: mean arterial pressures ................................ 44

5.1 Diamorphine: within-group analysis of SEP changes ............... 49
5.2 Diamorphine: between-group differences in overall amplitude ...... 50
5.3 Diamorphine: between-group differences in first peak amplitude ... 51
5.4 Diamorphine: between-group differences in second peak amplitude ... 52
5.5 Diamorphine: between-group differences in third peak amplitude ... 53
5.6 Diamorphine: between-group differences in SEP latency ............. 54
5.7 Diamorphine: mean arterial pressures ................................ 55

6.1 Etidocaine: within-group analysis of SEP changes ............... 63
6.2 Etidocaine: between-group differences in overall amplitude ...... 64
6.3 Etidocaine: between-group differences in first peak amplitude .... 65
6.4 Etidocaine: between-group differences in second peak amplitude ... 66
6.5 Etidocaine: between-group differences in third peak amplitude ... 67
6.6 Etidocaine: between-group differences in SEP latency ............. 68
6.7 Etidocaine: mean arterial pressures ................................ 69

7.1 Bupivacaine: within-group analysis of SEP changes ............... 78
7.2 Bupivacaine: between-group differences in overall amplitude ...... 79
7.3 Bupivacaine: between-group differences in first peak amplitude .... 80
7.4 Bupivacaine: between-group differences in second peak amplitude ... 81
7.5 Bupivacaine: between-group differences in third peak amplitude ... 82
7.6 Bupivacaine: between-group differences in SEP latency ............. 83
7.7 Bupivacaine: results of Kruskal Wallis test for overall amplitude changes ... 84
7.8 Bupivacaine: results of multiple comparison test for overall amplitude changes 85
7.9 Bupivacaine: mean arterial pressures ................................ 86

8.1 Scoliosis patients: SEP data .................................... 109
8.2 Scoliosis patients: skewness values and log transformation of SEP data ... 110