Intraocular pressure changes in patients undergoing cataract extraction and lens implantation: laryngeal mask airway versus endotracheal tube

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ABSTRACT

Objectives: To investigate the influence on intraocular pressure (IOP) of airway management with a laryngeal mask airway (LMA) or tracheal tube (ETT), and secondly to compare the devices with regard to their impact on IOP.

Design: Prospective, randomized observational study over a four-month period (August – November 2002)

Setting: University-affiliated tertiary level hospital in Pretoria, South Africa

Subjects: Forty ASA I and II adult patients undergoing unilateral cataract extraction and lens implantation under general anaesthesia

Outcome measures: Changes in intraocular pressure after placement of airway device

Methods: Following a standard anaesthetic induction with propofol and atracurium, airway management was randomized to LMA or ETT.

IOP was measured pre-induction, 3 min post induction but before airway manipulation, 20 sec post LMA or ETT insertion and finally 2 min post airway instrumentation.

Results: There was a small increase in mean IOP in the LMA group, which was statistically insignificant. However there was a significant rise in mean IOP in the ETT group (p = 0.0001) which returned to almost pre-insertion levels at 2 minutes.

Conclusions: The LMA causes minimal changes in intraocular pressure when used to secure the airway during cataract surgery. The rise in IOP following tracheal intubation is significant, yet transient and probably clinically insignificant.

Introduction

Cataract surgery with lens implantation is one of the most commonly performed elective operations in the elderly. The surgery, under general anaesthesia, has conventionally required endotracheal intubation. The stress response to intubation, which entails laryngoscopy, is associated with a rise in intraocular pressure mainly due to increased ocular blood flow. Increased sympathetic activity has also been postulated in the mechanism of IOP increase. Adrenergic stimulation causes vasoconstriction and leads to acute increase in IOP by increasing the resistance to the outflow of aqueous humour in the trabecular meshwork between the anterior chamber and Schlem's canal.

Tracheal intubation is also associated with hypertension and tachycardia as well as straining, coughing and breath holding.

The laryngeal mask airway (LMA) has seen increasing application in patients undergoing cataract extraction and lens implantation. This is the result of a desire to minimize the rise in IOP because there is minimal laryngo-tracheal stimulation associated with LMA placement. The LMA offers many advantages, e.g. the insertion technique is easily learnt; it can be inserted without the use of a neuromuscular blocking agent and it is rarely associated with trauma to the larynx or pharynx. Other potential benefits are shortened overall operating theatre time and less coughing during emergence from anaesthesia.

A rise in IOP is preferably avoided during eye surgery as the control of intraocular contents is of paramount concern. Surgical access to the lens is most commonly via the anterior chamber and it is inevitable for some aqueous humour to be lost through the incision. If at this time the IOP is increased, the intraocular contents are forced towards the incision. The iris, lens or vitreous may prolapse either immediately or when the surgeon attempts to move the lens. Another complication may arise in patients with impaired perfusion of the optic nerve as a result of a pre-existing raised intraocular pressure. In this setting, a further rise in IOP during anaesthesia may result in loss of visual field and acuity, with eventual blindness.

This study aimed to assess the influence on intraocular pressure of placement of the airway devices under investigation, and to compare the devices regarding their impact on IOP following a standard anaesthetic induction.

METHODS

Following ethics approval and informed written consent, forty ASA I and II adult patients were recruited into the study. They ranged in age from 40-90 years, had normal intraocular pressure.
and were scheduled for unilateral cataract extraction under general anaesthesia. Patients presenting with the following conditions were excluded from selection.

- Glaucoma
- Diabetes mellitus
- Severe respiratory disease
- Uncontrolled hypertension
- Known allergy to any of the drugs to be used
- Mallampati Class III and IV airway assessment score.

The patients were randomized to two groups of twenty patients each. In the LMA group, the airway was secured with a Laryngeal Mask Airway, while the ETT group represented patients in whom the airway was secured with a tracheal tube. Premedication was standardized to Hydroxyzine 1mg/kg orally 2 hours preoperatively.

Anaesthesia was induced with Propofol titrated to loss of eyelash reflex and this was followed by an intubating dose of Atracurium (0.6mg/kg). Tracheal intubation or LMA placement proceeded three minutes thereafter. A peripheral nerve stimulator was used to monitor the degree of muscle relaxation. Anaesthesia was maintained with isoflurane and a 67% nitrous oxide in oxygen mixture. Ventilation of the lungs was controlled on volume control mode and adjusted to maintain EtCO₂ at 32 - 35mmHg. Monitoring consisted of continuous three lead electrocardiography, non-invasive blood pressure, pulse oximetry, capnography and peripheral nerve stimulator. A Schiotz tonometer was used to measure IOP after instillation of one drop of 0.4% benoxinate, in the non-operated eye pre-induction.

Repeat measurements were undertaken 3 min post induction but before airway manipulation, 20sec after LMA or ETT insertion and 2 min after placement of the airway device. No patients were excluded subsequent to recruitment.

Statistics

Changes in IOP, systolic blood pressure (SBP) and heart rate were compared within each group as well as between groups before airway instrumentation and alternately at 20sec and 2 min post airway device insertion. The two groups were compared using a two sample students t-test. A p-value < 0.05 was considered statistically significant.

Results

There was no significant difference in demographic characteristics, ASA class or duration of anaesthesia between the two groups. Our results show a small increase in IOP in the LMA group at 20sec, which was statistically insignificant (p = 0.4296). However, there was a significant rise in IOP at 20sec following ETT placement (p = 0.0001). Also, the difference between the groups was statistically significant (p < 0.001).

The study also demonstrates a significant increase in SBP at 20s (p < 0.05) in the ETT group, but mean heart rate changes were not significantly different from baseline.

From the table below it can be seen that in the LMA group the IOP increased by 0.44 for the period spanning pre-insertion to 20s post-insertion. This is a statistically insignificant change (p = 0.450).

In the ETT group, there was an increase of 5.35 from pre-insertion to 20 s, which was statistically significant (p < 0.001).

When comparing the groups for change in IOP, the difference was significant (p<0.001).

Figure 1: Mean values for Intra-ocular Pressure over time for both groups.

<table>
<thead>
<tr>
<th></th>
<th>Pre-insertion</th>
<th>20 s</th>
<th>2 Min</th>
<th>Change</th>
<th>P Value</th>
<th>Change</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMA</td>
<td>P1 P2 P3 P4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>20 20 20 20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>0.44</td>
<td>0.450</td>
<td>-0.10</td>
</tr>
<tr>
<td>Mean</td>
<td>6.77 7.21 6.67 0.44</td>
<td>0.44</td>
<td>0.450</td>
<td>-0.10</td>
<td>0.792</td>
<td></td>
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<tr>
<td>SD</td>
<td>3.00 2.40 2.41</td>
<td>1.67</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ETT</td>
<td>P1 P2 P3 P4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>20 20 20 20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>8.50 5.85 11.85 5.35</td>
<td>&lt;0.001</td>
<td>5.55</td>
<td>&lt;0.001</td>
<td></td>
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<tr>
<td>SD</td>
<td>3.88 4.47 4.34 2.70</td>
<td>3.55</td>
<td></td>
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<tr>
<td>LMA vs ETT</td>
<td>P = Value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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<td></td>
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</tr>
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</table>

Table 1: Intraocular pressure (mmHg)
Table 2: Systolic blood pressure mmHg (SBP)

<table>
<thead>
<tr>
<th></th>
<th>Pre-insertion P1</th>
<th>20 s P2</th>
<th>2 Min P3</th>
<th>Change P1-P2</th>
<th>P Value</th>
<th>Change P1-P3</th>
<th>p-Value</th>
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</thead>
<tbody>
<tr>
<td>LMA N</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>-3.65</td>
<td>0.617</td>
<td>-8.00</td>
<td>0.246</td>
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<tr>
<td>Mean</td>
<td>121.30</td>
<td>117.65</td>
<td>113.30</td>
<td>-3.65</td>
<td>0.617</td>
<td>-8.00</td>
<td>0.246</td>
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<tr>
<td>SD</td>
<td>29.00</td>
<td>22.61</td>
<td>19.95</td>
<td>32.07</td>
<td>0.010</td>
<td>29.91</td>
<td>&lt; 0.05</td>
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<tr>
<td>ETT N</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>23.10</td>
<td>0.032</td>
<td>10.35</td>
<td>0.099</td>
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<tr>
<td>Mean</td>
<td>121.55</td>
<td>144.65</td>
<td>131.90</td>
<td>23.10</td>
<td>0.032</td>
<td>10.35</td>
<td>0.099</td>
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<tr>
<td>SD</td>
<td>20.45</td>
<td>30.50</td>
<td>24.23</td>
<td>30.64</td>
<td></td>
<td>26.58</td>
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</table>

There was a decrease of –3.65 in the mean SBP in the LMA group, which was statistically insignificant (p = 0.617). However, in the ETT group there was an increase of 23.10 which was statistically significant (p < 0.05).

When compared for changes in systolic blood pressure the difference between the groups was significant (p < 0.05).

Discussion:
The goal of anaesthesia for intraocular surgery is two-fold. It entails firstly ensuring an immobile field to facilitate the fine surgical manipulations and secondly to prevent excessive increases in intraocular pressure which may result in bleeding complications or the unplanned extrusion of intraocular contents. In patients with long-standing increases in intraocular pressure additional operative increases in ocular pressure may further compromise perfusion of the optic nerve, with resultant impairment or loss of vision in that eye.

Table 3: Heart Rate (HR) b/min

<table>
<thead>
<tr>
<th></th>
<th>Pre-insertion HR1</th>
<th>20 s HR2</th>
<th>2 Min HR3</th>
<th>Change HR1-HR2</th>
<th>P Value</th>
<th>Change HR1-HR3</th>
<th>p-Value</th>
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</thead>
<tbody>
<tr>
<td>LMA N</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>1.50</td>
<td>0.555</td>
<td>2.00</td>
<td>0.276</td>
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<tr>
<td>Mean</td>
<td>78.75</td>
<td>80.25</td>
<td>81.95</td>
<td>1.50</td>
<td>0.555</td>
<td>2.00</td>
<td>0.276</td>
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<tr>
<td>SD</td>
<td>16.36</td>
<td>18.40</td>
<td>18.82</td>
<td>11.16</td>
<td></td>
<td>12.76</td>
<td></td>
</tr>
<tr>
<td>ETT N</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>5.85</td>
<td>0.225</td>
<td>1.60</td>
<td>0.726</td>
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<tr>
<td>Mean</td>
<td>84.48</td>
<td>90.30</td>
<td>86.05</td>
<td>5.85</td>
<td>0.225</td>
<td>1.60</td>
<td>0.726</td>
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<tr>
<td>SD</td>
<td>18.38</td>
<td>30.50</td>
<td>15.96</td>
<td>20.86</td>
<td></td>
<td>20.08</td>
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</tbody>
</table>

The heart rate increase for both the LMA and ETT groups was statistically insignificant. The difference between the two groups was also insignificant.
Our findings are also in agreement with those of Whitford et al. who reported a statistically significant increase in IOP following tracheal tube placement.9 However, they concluded that the stress of laryngoscopy and intubation led to a significant rise in IOP despite the use of atracurium.8 Gulati et al. They compared the LMA with tracheal intubation and found an insignificant rise in mean IOP after LMA placement, but a significant rise in IOP increase following tracheal intubation.10 Similar conclusions of IOP increase following tracheal intubation.10 Previous research has found no significant difference in the pressor response to insertion of either the LMA or tracheal tube, although Braude and colleagues reported an attenuated increase in systolic blood pressure in the tracheal tube group.15 16

Our study conditions were carefully controlled to ensure that factors other than insertion of the airway device were not responsible for changes in IOP. Thus, neuromuscular blocking agents were used in both groups, even though not required for LMA placement. Care was also taken not to exert pressure on the eye with the face mask in the period preceding placement of the selected airway device. No difficulty was encountered in the placement of either device and respiratory parameters were satisfactory in all subjects.

LMA insertion is associated with minimal haemodynamic perturbations. Its placement does not require a laryngoscope, although introduction of the device and inflation of the cuff stimulates and exerts pressure on the anterior pharyngeal wall. This is almost certainly the mechanism by which the increases in blood pressure and pulse rate occur. The transient nature of the response suggests that it is not due to the continuous pressure exerted by the sealing cuff.15

Three of our study patients in the LMA group had a significant increase in IOP and SBP at 20 sec whereas there was a significant increase in all patients in the ETT group. Both these groups had an associated insignificant change in heart rate and this is in agreement with studies by Wilson.14 15 Previous research has found no significant difference in the pressor response to insertion of either the LMA or tracheal tube, although Braude and colleagues reported an attenuated increase in systolic blood pressure in the tracheal tube group.15 16

Our study shows a gradual and sustained decrease of about 7% from the mean in the LMA group during the study period. The ETT group on the other hand, showed an initial sharp increase in mean SBP, peaking at 16% of baseline at 20 sec post-insertion and then declining to within 8% of baseline at 2 min. This is in keeping with the known haemodynamic impact associated with placement of these devices and further confirms that placement of the tracheal tube has a transient and unsustained ocular and haemodynamic effect.
Although the mean heart rate changes were not significantly different between groups in this study we can assume that it would have remained elevated beyond 2 minutes in the intubation group due to a continued effect caused by the tracheal tube.19, 20

Although the LMA has been used successfully for head and neck surgery, there remains the possibility that it may be displaced during surgery with subsequent difficulty in maintaining a clear airway. None of the study patients suffered this complication.

A modification of the LMA with an armoured tube to maintain patency has been described for use in otolaryngological and dental anaesthesia, and it may also be useful in ophthalmic anaesthesia. Other advantages of the LMA over the tracheal tube include less chance of injury to surrounding structures, smooth recovery and reduced post operative oropharyngeal discomfort.21

Our study confirms the findings of previous studies in showing a transient but significant rise in IOP following tracheal intubation, which did not have immediate clinical implications for surgical outcome. However, increases in IOP may be clinically significant in patients with glaucoma because of the possible risk of loss of visual field and acuity.

In conclusion, our study confirms the superiority of the LMA over the tracheal tube as an airway management device during cataract surgery under general anaesthesia.

Acknowledgements
The authors would like to thank Dr S Sebiloane, Prof H S Schoeman and Dr D R Bhagwandass for their contribution to the study.

References