Haemodynamic changes and intubating conditions during tracheal intubation in children under anaesthesia: a comparative study of two induction regiments

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ABSTRACT

Aim To compare the haemodynamic changes and intubation conditions following induction of anaesthesia with alfentanil-propofol-rocuronium with those following alfentanil-propofol combination in children.

Methods A prospective, non-randomized and non blinded trial was performed in 208 children (ASA I-II, both gender, aged 2-12 years) undergoing elective adenoidectomy with or without tonsillectomy. Children scheduled for tonsillectomy or adenotonsillectomy received alfentanil 0.02 mg kg⁻¹, propofol 2 mg kg⁻¹ and rocuronium 0.45 mg kg⁻¹ before tracheal intubation (R-group). Children scheduled for adenoidectomy received alfentanil 0.02 mg kg⁻¹ and propofol 3 mg kg⁻¹ before intubation (C-group). Haemodynamic values (heart rate, systolic arterial pressure, diastolic arterial pressure, mean arterial pressure) were recorded at predetermined time intervals before surgical incision. The intubating conditions were evaluated applying the Copenhagen Scoring System (excellent, good, poor).

Results There was no statistical difference in haemodynamic baseline values, neither prior nor after the intubation between the two groups. There was a statistically significant increase in heart rate, systolic and diastolic arterial pressure after intubation in both groups (p<0.05). Mean arterial pressure after the intubation increased statistically significantly only in R-group (p=0.001). There was no hypotension, bradycardia, hypoxemia or other complications. Overall intubation conditions were scored excellent in 72.3%, good in 21.5% and poor in 6.2% patients. There were no significant differences in intubation conditions between the two groups (p=0.244)

Conclusion Both induction regiments provided the clinically acceptable haemodynamics and intubation conditions during tracheal intubation in children.

Keywords: tracheal intubation; propofol; alfentanil; rocuronium; haemodynamic effects
INTRODUCTION

Tracheal intubation is a usual method of airway protection during a surgical procedure. However, it is rather an invasive method and is associated with significant changes in mean arterial pressure (MAP) and heart rate (HR). In most cases it is performed when the patient is under anaesthesia. If the depth of anaesthesia is low, cardiovascular responses to laryngoscopy include hypertension, tachycardia and dysrhythmias (1). On the other hand, if the patient is under anaesthesia too deeply, cardiac depression, hypotension and bradycardia may appear as potential drug side effects (2,3). Clinically acceptable anaesthetic induction protocol has to accomplish two aims simultaneously: good intubation conditions and haemodynamic stability (1).

So far, it has been generally accepted that a balanced approach to anaesthesia for intubation, combining a moderate depth of anaesthesia with the use of a nondepolarising muscle relaxants, provides the best intubation conditions with the minimal potential for adverse haemodynamic effects (4). However, recent developments introduced new anaesthetic protocols without a muscle relaxant as an alternative to the protocols with muscle relaxant (4,5).

We decided to review our current anaesthetic practice in children scheduled for ear-nose-throat surgery where we use anaesthetic induction protocols with or without muscle relaxant rocuronium, and to compare the haemodynamic changes and intubation conditions following these two different induction regimens.

PATIENTS AND METHODS

Patients

In the General Hospital “Sveti Duh” in Zagreb, at the Department of Otorhinolaryngology, we use on a regular basis anaesthetic induction protocols that include a combination of alfentanil/propofol with or without muscle relaxant rocuronium in children scheduled for ear-nose-throat surgery. In children, who are scheduled for an ultra short surgical procedure such as adenoidectomy, we use the anaesthetic protocol without muscle relaxant. In children, who are scheduled for short surgical procedures such as tonsillectomy or adenotonsillectomy, we use the protocol with muscle relaxant rocuronium.

Since June 2007, following each ear-nose-throat operation, selected vital parameters had been entered into a database. After one year the database of all our paediatric patients scheduled for tonsillectomy, adenotonsillectomy and adenoidectomy was reviewed. This study is in compliance with the Helsinki Declaration.

We reviewed 222 paediatric patients scheduled for tonsillectomy, adenotonsillectomy and adenoidectomy between June 2007 and July 2008 for the study. Children who received other than the studied anaesthetic induction protocols were excluded from the study. The final study sample consisted of 208 children, 128 boys and 80 girls, with normal cardiovascular and pulmonary status, haematological parameters in the normal range, and American Society of Anesthesiologists (ASA) score I/II. The children were aged between 2 and 12 years. The body weight ranged from 11 kg to 65 kg.

Anaesthesia

All children were premedicated with midazolam 0.5 mg/kg (Dormicum®, F. Hoffman-La Roche Ltd., Basel, Switzerland) administered orally 60 minutes before being transferred to an operating suite. On arrival to the operating suite, all children were immediately pre-induced with sevoflurane (5-8 vol%) (Sevorane®, Abbott Laboratories S.A., Abbott Park, IL, USA) in 60% nitrous oxide /40% oxygen administered via a face-mask to ease the insertion of an i.v. canulla. After intravenous access was established, sevoflurane and nitrous oxide were discontinued and the children were assigned to receive the induction protocol according to the expected duration of a surgical procedure. Children scheduled for tonsillectomy or adenotonsillectomy received the protocol with
a muscle relaxant rocuronium (R-group). Children scheduled for adenoidectomy, who served as a control group (C-group), received the anaesthetic protocol without muscle relaxant. In R-group, anaesthesia was induced with propofol 2 mg kg$^{-1}$ (Disoprivan®, AstraZeneca, UK Ltd, Macclesfield, Cheshire, United Kingdom) alfentanil 0.02 mg kg$^{-1}$ (Rapifen®, Janssen Pharmaceutica, Beerse, Belgium), and rocuronium 0.45 mg kg$^{-1}$ (Esmeron®, N.V. Organon, Oss, Netherlands). The order of induction drugs in R-group was alfentanil, propofol, and, after mask ventilation check, rocuronium was given. The children in R-group were manually ventilated with oxygen for the following 2 minutes before the assessment of the intubation conditions. In C-group, anaesthesia was induced with propofol 3 mg kg$^{-1}$ (Disoprivan®, AstraZeneca, UK Ltd, Macclesfield, Cheshire, United Kingdom), and alfentanil 0.02 mg kg$^{-1}$ (Rapifen®, Janssen Pharmaceutica, Beerse, Belgium). The order of induction drugs in C-group was alfentanil, and propofol. The children in C-group were manually ventilated with oxygen for a few seconds before the assessment of the intubation conditions. After assessment of intubation conditions, laryngoscopy and intubation were attempted using a Macintosh laryngoscope blade of appropriate size and a cuffed orotracheal tube the internal diameter of which was calculated using the formula $4.0 + \text{age}/4$ mm. Anaesthesia was always administered by one of the two anaesthesiologists at the Department of Otorhinolaryngology, who were experienced in both anaesthetic techniques.

During the induction of anaesthesia and the whole surgery, children were monitored using a standard three-lead electrocardiography, pulse oxymetry, capnometry and non-invasive arterial pressure monitoring. Preoperative, intraoperative, and postoperative data on oxygen saturation, heart rate (ECG, lead II), non-invasive arterial pressure (oscillometry) and minimal alveolar concentration (MAC) of anaesthetic gases were recorded automatically every 5 minutes by anaesthetic monitor machine. Additional measurements of heart rate, non-invasive arterial pressure and MAC were recorded during intubation in shorter time intervals to assess cardiovascular stability. All recorded data were printed at the end of the surgery.

**Haemodynamics**

To assess cardiovascular responses to intubation, heart rate and non-invasive arterial pressure measurements were recorded and reported as baseline, prior intubation and after intubation. Baseline data were those recorded after the insertion of an i.v. cannula but before to the application of induction agents. Prior to intubation the data were recorded immediately before the insertion of laryngoscope. After intubation the data were recorded after the placement of the orotracheal tube into trachea but before surgical incision. Haemodynamic changes $>20\%$ were considered as clinically not acceptable.

**Intubation conditions**

To access the intubation conditions, we used the Copenhagen Scoring System (28). Ease of intubation was assessed on the basis of the scoring system described by Helbo-Hansen et al. (29). Intubation criteria include four variables: jaw relaxation and resistance to laryngoscopy blade, the position and movement of vocal cords, the movement of the limbs, and coughing. Each of these variables was rated as excellent (=1), good (=2), poor (=3). The intubation conditions were considered clinically acceptable when all scores were 2 or less, whereas, if any variable was scored 3, the intubation conditions were considered as not acceptable.

| Table 1. Patients’ characteristics in R-group (alfentanil/propofol/rocuronium) and C-group (alfentanil/propofol) presented as mean ±SD and range or numbers |
|-----------------------------|-----------------------------|
| **R-group (n=118)** | **C-group (n=90)** |
| Age (years) | 6.46 ± 2.56 | 5.6 ± 2.31 |
| (2-12) | (2-12) |
| Weight (kg) | 26.14 ± 11.54 | 21.8 ± 10.31 |
| (13-65) | (11-60) |
| Gender (M/F) | 68/50 | 60/30 |
| ASA* I/II | 105/ 13 | 75/15 |
| Duration of surgical procedure (min) | 27.43 ± 9.65 | 12 ± 4.28† |
| (10-50) | (10-30) |
| Duration of anaesthesia (min) | 40.86 ± 10.25 | 23.33 ± 5.14† |
| (20-65) | (15-40) |

*ASA, American Society of Anaesthesiologists score; †significant difference between the groups (<0.05)
Statistical analysis

Data were expressed as mean ± standard deviation (SD). Categorical data were expressed as frequencies and percentages. Unpaired $t$ test was used for differences in systolic, diastolic and mean arterial pressures, MAC or heart rate between groups. Paired $t$ test was used for intra-group differences in systolic, diastolic and mean arterial pressures, MAC or heart rate. Association of categorical variables was assessed with $\chi^2$ test. $P < 0.05$ was considered statistically significant. Statistical analysis was performed with SPSS software for Windows, version 11.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Patients’ characteristics are presented in Table 1. The groups were similar in age ($p=0.493$), weight ($p=0.135$), gender ($p=0.093$) and ASA ($p=0.542$) distribution. There was a significant difference in duration of surgical procedures and anaesthesia between the groups ($p<0.001$).

Haemodynamics

Table 2. shows mean (±SD) changes in heart rate (HR), systolic arterial pressure (SAP), diastolic arterial pressure (DAP), mean arterial pressure (MAP) and minimal alveolar concentrations (MAC) in R-group and C-group.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Prior intubation</th>
<th>After intubation</th>
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<tbody>
<tr>
<td><strong>HR b/min$^{-1}$</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group R</strong></td>
<td>96.94 ± 3.03</td>
<td>95.26 ± 20.31</td>
<td>102.6 ± 18.25**†</td>
</tr>
<tr>
<td><strong>Group C</strong></td>
<td>105.9 ± 27.34</td>
<td>97.83 ± 20.63</td>
<td>106 ± 19.95†</td>
</tr>
<tr>
<td><strong>SAP mmHg</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group R</strong></td>
<td>99.57 ± 18.41</td>
<td>95.96 ± 21.59</td>
<td>103.57 ± 17.24**†</td>
</tr>
<tr>
<td><strong>Group C</strong></td>
<td>96.33 ± 16.74</td>
<td>87.43 ± 26.39</td>
<td>100.97 ± 18.92*</td>
</tr>
<tr>
<td><strong>DAP mmHg</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group R</strong></td>
<td>54.69 ± 17.68</td>
<td>51.77 ± 18.19</td>
<td>58.23 ± 16.27**†</td>
</tr>
<tr>
<td><strong>Group C</strong></td>
<td>53.1 ± 5.71</td>
<td>47.67 ± 16.64</td>
<td>56.23 ± 18.92*</td>
</tr>
<tr>
<td><strong>MAP mmHg</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group R</strong></td>
<td>71.48 ± 22.93</td>
<td>70.97 ± 18.17</td>
<td>77.23 ± 20.87†</td>
</tr>
<tr>
<td><strong>Group C</strong></td>
<td>72.73 ± 15.24</td>
<td>69.3 ± 15.07</td>
<td>69.13 ± 27.05</td>
</tr>
<tr>
<td><strong>MAC</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Group R</strong></td>
<td>2.15 ±0.47</td>
<td>0.8 ± 0.49†</td>
<td>0.59 ± 0.19*</td>
</tr>
<tr>
<td><strong>Group C</strong></td>
<td>2.38 ±0.68</td>
<td>1.12 ± 0.79†</td>
<td>0.79 ± 0.29**</td>
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</tbody>
</table>

*significant difference after intubation v. baseline <0.05; †significant difference after intubation v. prior intubation <0.05; ‡significant difference prior intubation v. baseline intubation <0.05; there was no significant difference between the groups

MAC values were similar between the two groups at the three measuring points. There was no statistical difference in baseline MAC ($p=0.332$), MAC prior intubation ($p=0.115$) or MAC after intubation ($p=0.227$) between the two groups. However, in R-group there was a significant decrease in MAC values prior intubation compared to baseline ($p<0.001$) and in MAC values after intubation compared to baseline ($p<0.001$). There was no significant difference between MAC values prior and after intubation ($p=0.08$) in R-group. In C-group there was a significant decrease in MAC values prior intubation compared to baseline ($p=0.00$, in MAC values after intubation compared to baseline ($p=0.013$) and in MAC values after intubation compared to prior intubation ($p<0.001$).

There was no statistical difference in baseline HR, SAP, DAP and MAP nor in HR, SAP, DAP and MAP prior and after intubation between the two groups.

However, there was a significant increase in HR value in R-group after intubation compared to baseline ($p=0.002$) and compared to values prior intubation ($p=0.001$). There was a significant increase in HR in C-group after intubation compared to HR prior intubation ($p=0.003$), but not compared to baseline ($p=0.527$).

In R-group SAP increased after intubation. This increase was significant when compared to baseline ($p<0.001$) and to SAP prior intubation ($p=0.001$). Similarly there was a significant in-
crease in SAP after intubation compared to baseline values (p=0.027) in C group. A significant increase in DAP occurred in both groups after intubation compared with baseline (p=0.002 in both groups). A small fall in MAP occurred in R – group after induction but prior intubation (p=0.052 vs baseline) and a consequent significant increase in MAP after intubation only in R-group when compared to values prior intubation (p=0.001). However, this MAP values were not significantly higher when compared with baseline (p=0.121).

There was no case of severe hypotension, bradycardia, hypoxemia or other recorded complication during the studied period.

**Intubation conditions**

Intubation was possible in all patients. Table 3. shows clinically acceptable (excellent or good) and not acceptable (poor) intubation conditions in both groups. The overall intubation conditions were scored excellent in 72.3%, good in 21.5% and poor in 6.2% patients. There were no significant differences in the intubation conditions between the two groups (p=0.244).

**DISCUSSION**

In this study we compared two induction anaesthetic regiments with or without use of muscle relaxants in children undergoing ear-nose-throat surgery. The results of our study show that the anaesthetic induction regimen that includes the combination of alfentanil-propofol-rocuronium is similar to the anaesthetic induction regimen that includes the combination of alfentanil-propofol in children. Intubation conditions were scored excellent or good in majority of the studied children in both groups, so we have concluded that both anaesthetic regiments provided clinically acceptable intubation conditions. In addition, in both groups we have recorded small but statistically significant haemodynamic changes. However, all these changes were less than 20% and did not require any treatment, which makes them clinically unimportant. Thus, we have concluded that both studied anaesthetic induction regiments provide clinically acceptable haemodynamics.

Several studies showed that tracheal intubation can be facilitated safely and effectively after induction anaesthesia with a hypnotic, propofol, and an opioid, alfentanil or remifentanil, without use of muscle relaxant in adults (5-16) and children (17-23). Most studies report adequate tracheal intubation conditions without significant haemodynamic changes. Such a technique is additionally advantageous in cases where muscle relaxants have to be avoided because of known allergic reactions (24) or myopathia (25). Moreover, it is useful in short surgical procedures where there is no need for muscle relaxation to facilitate surgical access (4) but there is a potential risk for postoperative residual paralysis (26).

On contrary, there are studies that have shown that this technique does not provide reliable intubation conditions in all circumstances (27,28). In addition, relaxant- sparing approach requires higher doses of propofol and opioids that result in higher incidence of postinduction arterial hypotensia and bradycardia (9,11,12).

A recent study compared two anaesthetic induction protocols similar to ours in adults and found that omitting a muscle relaxant before tracheal intubation makes tracheal intubation more difficult and is associated with more events of hypotensia and bradycardia requiring treatment (29). We have not found similar results in our study. However, the patient groups in these two studies are so different that it is not surprising that the results are different. Secondly, although we used the same drugs, the doses in our studies were not equal that makes the complete comparative analysis difficult. We used a fixed induction dose of alfentanil (0.02 mg kg⁻¹) with a higher dose of propofol (3 mg kg⁻¹) when a muscle re-

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**Table 3. Intubation conditions according to the Copenhagen score in R-group (alfentanil/propofol/rocuronium) and C-group (alfentanil/propofol) (numbers and percentage)***

<table>
<thead>
<tr>
<th></th>
<th>Excellent</th>
<th>Good</th>
<th>Poor</th>
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<tbody>
<tr>
<td>Group R</td>
<td>85 (71%)</td>
<td>30 (26%)</td>
<td>3 (3%)</td>
</tr>
<tr>
<td>Group C</td>
<td>60 (67%)</td>
<td>27 (30%)</td>
<td>3 (3%)</td>
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*There was no significant difference between the groups.
laxant was decided not to be used and a lower dose of propofol (2 mg kg⁻¹) when a muscle relaxant rocuronium in dose of 0.45 mg kg⁻¹ was used. Combes et al. used a 0.015 mg kg⁻¹ of alfentanil, 2.5 mg kg⁻¹ of propofol and 0.6 mg kg⁻¹ of rocuronium for the muscle relaxant group and 2.5 mg kg⁻¹ of propofol and 0.040 mg kg⁻¹ of alfentanil for the controlled group.

Propofol, a hypnotic used in our and their study, has cardiovascular depressant effect that is attributed to direct myocardial depression, decreased systemic vascular resistance. In addition, it alters the baroreflex mechanism, resulting in a smaller increase in HR for a given decrease in arterial pressure (2). Children differ to adults in anaesthetic pharmacodynamic requirements and in haemodynamic response to a given propofol. It is well known that they have higher propofol requirement and that they tolerate the decrease in MAP and HR following the propofol better (2). This may explain why no patient in our study developed hypotension or bradycardia.

As mentioned above, it is very difficult to establish which combination and doses are equipotent for the specific population when the study designs differ. In addition, in recent years there is a trend in paediatric anaesthesia to obviate the need for muscle relaxants, so there are many reported studies that compare the different combination of hypnotics and opioids without having a controlled group with a muscle relaxant. Klemola et al. compared intubation conditions after different doses of remifentanil followed with 3.5 mg kg⁻¹ propofol and two doses of muscle relaxant rocuronium (0.2 mg kg⁻¹ and 0.4 mg kg⁻¹) in children (21). According to their study the best intubation conditions without causing undue cardiovascular depression were produced by the combination of 0.004 mg kg⁻¹ remifentanil and 3.5 mg kg⁻¹ propofol. Batra et al. compared intubation conditions after the induction with 3 mg kg⁻¹ propofol and two doses of remifentanil (0.002 mg kg⁻¹ and 0.003 mg kg⁻¹). Their study protocol did not include a muscle relaxant, but included atropine for premedication. Our study protocol did not include atropine for premedication. The conclusion of Batra et al. was that the combination of 0.003 mg kg⁻¹ and 3 mg kg⁻¹ propofol provides better intubation conditions in healthy pre-medicated children with favourable airway anatomy (20). Bartolek et al. studied the optimal paediatric dose of propofol (2 mg kg⁻¹ vs 2.5 mg kg⁻¹ vs 3 mg kg⁻¹) that by means of alfentanil (0.02 mg kg⁻¹) and reduced dose of rocuronium (0.45 mg kg⁻¹) with respect to the intubation conditions. They showed that the average mean arterial pressure was significantly lower only after induction dose of 3 mg kg⁻¹ propofol (30). Thus, it is not clear why they concluded that the optimal dose was 2.5 mg kg⁻¹ of propofol in their study, although the dose of 2 mg kg⁻¹ provided also clinically acceptable intubation conditions and no haemodynamic disturbances.

The main limitation of our study is its design without proper randomisation and masking. The decision of using or not using a muscle relaxant was based on the type of operation and its duration. As expected, our study groups differed in duration of surgical operation and duration of anaesthesia. However, except these two parameters, patients’ characteristics in the study groups were similar and comparable with respect to age, weight, gender and ASA physical status. We find that the duration of surgical procedure and anaesthesia were not important parameters for this study, because the study period focused only on the period during tracheal intubation before surgical incision.

As an another disadvantage, we would like to mention that though our primary aim was to compare two anaesthetic induction protocols that included only intravenous drugs, the fact is that we used sevoflurane, a volatile anaesthetics, for a short period before an insertion of i.v. cannula. All volatile anaesthetics have cardiac depressant effect that may interfere with the haemodynamic stability. According to MAC values measured in our study, the potential cardiac influence of sevoflurane was most at the baseline measuring point with a significant decrease at other two measuring points. In other words, baseline haemodynamic values in our study had already
been depressed under the influence of sevoflurane. The influence of sevoflurane decreased prior and after intubation, so in these two points haemodynamics was the reflection of the studied intravenous anaesthetic agents.

The possible advantage of our study is that it offers an insight into our current practice and brings full real data.

In conclusion, our study has shown that anaesthetic induction protocol which includes the combination of 2 mg kg⁻¹ of propofol, 0.02 mg kg⁻¹ of alfentanil and 0.45 mg kg⁻¹ of rocuronium provided clinically acceptable haemodynamics and intubation conditions in children when compared to the combination of 3 mg kg⁻¹ of propofol and 0.02 mg kg⁻¹ of alfentanil.

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