Airway interventions during intravenous anesthesia in children undergoing direct laryngoscopy for surgical procedures using high flow versus low flow nasal oxygen. Flowkid

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Abstract

Background: **Direct laryngoscopy in pediatric patients presents anesthetic challenges, particularly in maintaining airway patency and oxygenation. High-flow nasal oxygen therapy (Optiflow™) has been proposed as an alternative to conventional low-flow oxygen, potentially improving mucosal hydration and respiratory stability.**

Objectives: **This study compared airway responses and anesthetic interventions when using high-flow and low-flow oxygen in children undergoing direct laryngoscopy for supraglottoplasty. The impact of humidified, heated air on postoperative mucosal quality and surgical conditions was also assessed.**

Design and setting: **A prospective randomized controlled study conducted in the operating rooms of Antwerp University Hospital.**

Materials and methods: **The primary endpoint was a composite endpoint, namely airway responses and/or interventions (ARIN) and consisted of the incidence of airway responses, including desaturation (SpO_2 < 90% for >30 sec), bradycardia/tachycardia (≥30% change from baseline), and need for airway interventions (mask ventilation, nasopharyngeal airway, or intubation). Secondary endpoints included postoperative mucosal quality and surgeon satisfaction.**

Results: **ARIN occurred in 74% of patients, with no significant difference between groups (p=0.628). The number of ARIN per patient was higher in the low flow group (n=33 vs n=10), although not statistically significant (p=0.621). Sub analysis showed a slightly higher number of patients with desaturation in the low flow oxygen group (n=2 vs n=3), though total desaturation events were higher in the low-flow group (n=8 vs. n=2). Apnea occurred in 5 (55.6%) high-flow and 7 (70%) low-flow patients. Intubation was required in two (20%) low-flow patients but none in the high-flow group (p=0.167). Postprocedural mucosal quality was significantly better in high-flow patients (p<0.001). Surgeon satisfaction was slightly higher in the high-flow group (p=0.496).**

Conclusion: **While high-flow oxygen did not significantly reduce airway interventions, it improved mucosal hydration. Further studies with larger samples are needed to confirm these findings.**

Keywords: **Pediatric anesthesia, general anesthesia, oxygen inhalational therapy, airway management, airway surgery, supraglottoplasty, laryngomalacia.**

The Ethics Committee of the Antwerp University Hospital (Drie Eikenstraat 655, 2650 Edegem Belgium) and the chairman, Prof. dr. Peter Michielsen, provided approval for conduction of this study, with project ID 5561. Approval was dated 28/08/2023. The study was registered and the clinical trial number given was NCT06037915. Patients were included from November 1st, 2023, to January 31st, 2025. A written informed consent was obtained from a legal guardian or parent for every included subject.

Introduction

Laryngomalacia is a congenital condition where collapse of the supraglottic region occurs during inspiration due to softening of the laryngeal tissue. This dynamic collapse can exacerbate by feeding, agitation and supine positioning and can cause apnea or failure to thrive in the very young child. In most cases, this condition is self-limiting and will resolve by 12 to 18 months of age. Nevertheless, in about 10% of the cases the laryngomalacia is severe enough to necessitate surgical intervention[1].

Direct laryngoscopy is a crucial procedure for both diagnostic and therapeutic endoscopic interventions. When conducting invasive procedures, these are typically performed under general anesthesia with either spontaneous breathing or controlled ventilation. Spontaneous respiration anesthesia is often used for these procedures as it allows for the evaluation of vocal cord mobility, laryngeal reflexes, and dynamic assessment of neuromuscular abnormalities like laryngomalacia[1].

Therapeutic procedures, such as supraglottoplasty, pose significant challenges for both the surgeon and the anesthesiologist, particularly in pediatric cases. The primary anesthesia objectives include achieving sufficient sedation and analgesia while maintaining spontaneous respiration. The greatest challenge in these procedures lies in the problem of the shared airway. Anesthesiologists focus on achieving optimal sedation levels to prevent patient movements, while ensuring airway patency and maintaining oxygenation, while surgeons require unimpeded access to the airway[1,2]. Balancing sedation levels to prevent under or over-sedation, with careful titration of intravenous sedation according to patient needs, while preserving spontaneous ventilation presents a continuous challenge for the anesthesiologist[1,3]. Undersedation can lead to laryngospasm, bronchospasm or barotrauma with the need for muscle relaxation and intubation. Oversedation, on the other hand, might cause hypoventilation or apnea, resulting in hypoxemia and a possible need for bag mask ventilation or intubation and consequently interruption of the surgery[2].

During the surgery, continuous oxygen supplementation is essential to maintain sufficient oxygenation, especially in pediatric populations. It is well-documented that small children experience rapid desaturation in the absence of supplemental oxygen during apneic episodes. This is due to their increased oxygen consumption, reduced functional residual capacity (FRC), and higher closing capacity leading to airway collapse compared to adults[4-6].

In adults, studies showed that the reported safe apnea time can be prolonged with the use of high-flow nasal oxygen. In children there are few data about the effects of high flow oxygen on safe apnea time. One case report by Riva et al. showed a prolonged apnea time during bronchoscopy and airway surgery when using high flow oxygen compared to no supplemental oxygen[7]. Most studies show that the time to desaturation is not prolonged when using high-flow oxygen compared to low-flow 100% oxygen via nasal cannula. Another study by Klotz et al. did not prove superiority of high flow oxygen compared to low flow oxygen in maintaining respiratory stability during procedural sedation in children[8]. However, a potential drawback of low-flow oxygen is the lack of humidification, which could potentially damage the mucociliary layer[4,5,9].

Methodology

Study design and study population

The Ethics Committee of the Antwerp University Hospital (UZA) and the chairman, Prof. dr. Peter Michielsen (Drie Eikenstraat 655, 2650 Edegem Belgium), provided approval for conduction of this study, with project ID 5561. Approval was dated 28/08/2023. The study was registered and the clinical trial number given was NCT06037915. This study was set up as a prospective randomized controlled study. Patients were included from November 1st, 2023, to January 31st, 2025. All children between the age of 1 month and 10 years old, scheduled to undergo an elective direct laryngoscopy with surgical intervention were evaluated for eligibility for this study. Patients were recruited preoperatively at the ward. Inclusion required written consent from parents or legal guardians. Children who were able to read or understand the study procedures were provided with a tailored consent form. Exclusion criteria included refusal of consent and a known allergy to dexmedetomidine or remifentanil. Additionally, if a child’s pulse oxygen saturation (SaO_2) at the beginning of anesthesia was below 85% or if the child was already on high flow oxygen treatment, the child was excluded from participation in the study. Patients who did not complete the study after inclusion and randomization because of medical reasons were included in the statistical analysis.

Sample size and assignment method

A power analysis was conducted to determine the sample size needed to investigate our hypothesis that high flow oxygen therapy reduces the occurrence of ARIN compared to low flow oxygen therapy in children undergoing direct laryngoscopy for supraglottoplasty. Based on previous experience we estimated an occurence of ARIN of 60% when using low flow oxygen compared to 25% when using high flow oxygen. Given the fact that this study was set up as part of a master thesis with a limited inclusion period, alfa was set at 0,1. The power was set to 80%. This led to a calculated sample size of 48 patients.

All included patients were randomized in two groups: low flow oxygen versus high flow nasal therapy. Allocation was based on the REDCap randomization module.

Intervention

Anesthesia provider and setting

The study was conducted under supervision of the Head of department Anesthesiology at the UZA. The intervention was performed by trained anesthesiologists from the study team with supervision from the board-certified staff anesthesiologist responsible for patient care. The intervention was performed during surgery under general anesthesia in the operating theatres at the UZA. In the hours following the study, patients remained under supervision of trained personnel at PACU or ICU at the UZA.

Materials

To carry out this study, the OptiflowTM Nasal High Flow (NHF) therapy system by Fisher and Paykel Healthcare – Auckland New Zealand, was used. This is a form of non-invasive respiratory therapy (Fig. 1) that can deliver high levels of oxygen (FiO_2 21% up to 100%) at high flow rates. The high flow rates lead to decreased dead space and generate dynamic positive airway pressure, both of which enhance alveolar ventilation. A key feature of NHF therapy is airway hydration, achieved through heated humidification. Heating and humidification of the air not only enhances patient comfort with high gas flows but also prevents airway epithelium dryness and supports and improves mucociliary clearance.

For neonates, infants and children on NHF therapy, the Fischer and Paykel Healthcare Optiflow Junior 2 nasal interface is a sealing nasal interface specifically designed for the flow requirements and anatomical features of these small children. In this study, the Optiflow™ system was set at a flow rate of 2l/kg/min with 100% oxygen concentration.

For administration of low flow oxygen therapy, a Portex cuffless tube (Smith medical) or a Shiley cuffless (Covidien) tubes, was placed through the nose, with the tip of the tube just above the glottis. This tube was connected to our anesthesia machine

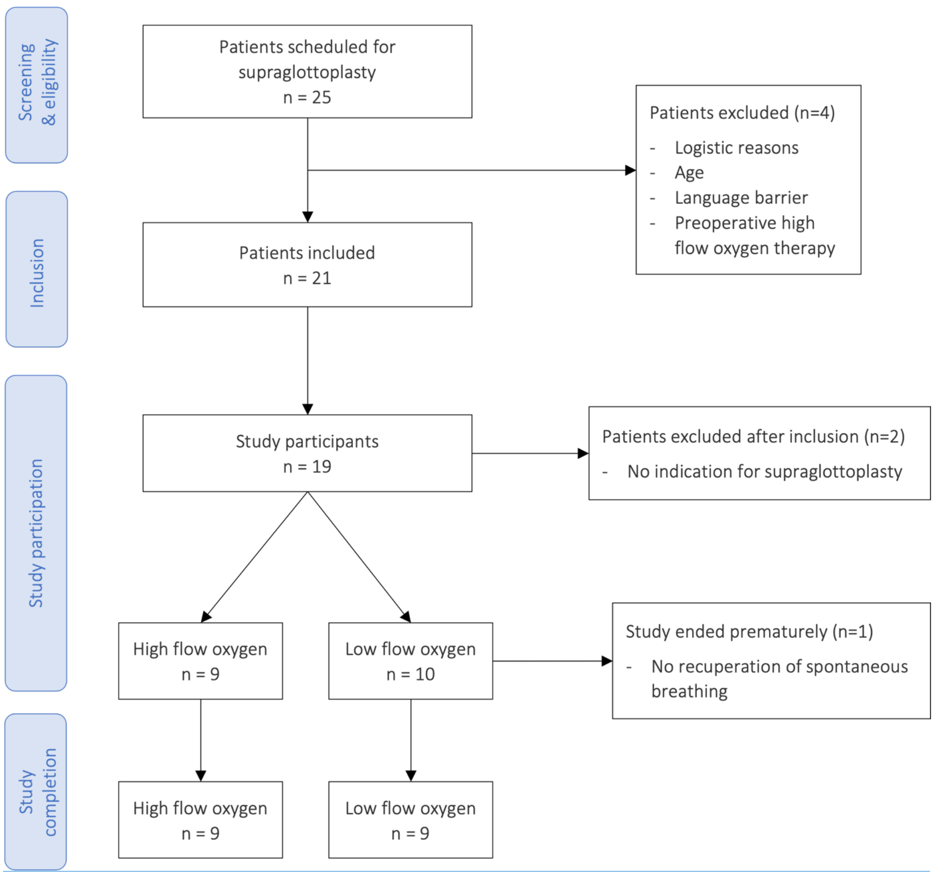

Fig. 1 — Flowchart of patient inclusion.

and 100% oxygen with a fresh gas flow of 6l/min was administered. This method provided unheated and dry oxygen.

Protocol

All patients received standard anesthesia care for therapeutic direct laryngoscopy according to the local protocol of the UZA (Tables I & II). This standard protocol consists of an inhalation induction and maintenance of anesthesia with preservation of spontaneous respiration.

All children included were medicated with intravenous midazolam 0.05 mg/kg. Standard continuous monitoring and recording was provided with a 3-lead electrocardiography, non-invasive blood pressure measurement, peripheral pulse-oximetry, respiratory rate evaluation and rectal temperature measurement. The NeuroSENSE® monitor was installed prior to induction of anesthesia to monitor the depth of sedation. For this purpose, two electrodes were placed at the right and left hemisphere of every child. At the end of anesthesia these electrodes were removed.

Induction of anesthesia was carried out through mask induction and inhalation of sevoflurane at a concentration of 8%. After induction of anesthesia a 24 Gauge intravenous catheter was placed in a peripheral vein and a bolus of dexmedetomidine 4µg/kg was administered. At this point, heart rate and blood pressure were noted as baseline parameters, defined as T0. Based on the randomization patients would either receive Optiflow nasal prongs or a nasal pharyngeal tube for oxygen supplementation. High flow oxygen (heated at 37°C, and humidified) was provided using the Fisher and Paykel Optilow Airvo 2 system at a rate of 2 l/kg/minute. For fow flow oxygen (unheated and dry) a nasal canula was used to supply 100% oxygen from the anesthesia machine at a rate of 6l/min.

Maintenance of anesthesia was provided with dexmedetomidine infused at 2µg/kg/h and adjusted to clinical needs with top up rate dexmedetomedine of 0.5 µg/kg/h. Remifentanil was infused at 0.3 µg/kg/min and adjusted to clinical needs to 0.5 µg/kg/min. The attending anesthesiologist was instructed to guide the titration of dexmedetomidine and remifentanil according to clinical signs, which is standard of care. Before commencing surgery, upon visualizing the vocal cords, a single spray of 10% Lidocaine is administered to anesthetize the vocal cords. The purpose was to maintain spontaneous respiration throughout the procedure, with oxygen supplementation through the OptiflowTM system or through a nasal canula according to randomization. In case of laryngospasm and desaturation, propofol was used as rescue medication. After surgery, all children

Table I. — Baseline demographics and clinical characteristics.

N	19
Age (days; IQR)	613 (1133)
Gender (male/female; %, number of patients)	53/47 (10/9)
Group (high flow/ low flow; %, number of patients)	47/53 (9/10)
History (%, number of patients)	
ASA 2	68 (13)
ASA 3	32 (6)
Cardiac history	67 (4)
Pulmonary history	50 (3)
Syndromic background	67 (4)

Table II. — Patient characteristics and adverse events per group.

	High flow group	Low flow group
N (%)	9 (47)	10 (53)
Age (days; IQR)	662 (1905)	393 (1258)
Gender (male/female: %, number of patients)	55/44 (5/4)	50/50 (5/5)
History (%, number of patients)		
ASA 2	66.7 (6)	70 (7)
ASA 3	33.3 (3)	30 (3)
Cardiac history	66.7 (2)	66.7 (2)
Pulmonary history	66.7 (2)	33.3 (1)
Syndromal background	66.7 (2)	66.7 (2)

were monitored on the PACU (post anesthetic care unit) or the intensive care unit of the UZA, as standard of care.

Outcomes

Demographics

The following demographic patient details were obtained from the digital patient record EPD Powerchart Cerner Millenium (Cerner Corporation, Houston, USA): age, gender, weight, length ASA status and medical history.

Primary endpoint

Primary outcome was to evaluate a possible difference in airway responses and/or interventions during the procedure when comparing the two oxygenation methods (low flow oxygen versus nasal high flow therapy). The primary endpoint was a composite endpoint, consisting of clinical signs of airway responses and/or interventions (ARIN), namely:

1. Desaturation, defined as SpO2 lower than 90% for more than 30 seconds
2. Bradycardia of tachycardia, defined as a change of 30% from the baseline heart rate
3. The incidence of airway interventions, defined as the need to interrupt the surgical procedure in order to maintain adequate oxygenation of the child. Possible interventions were:
   a. Mask ventilation
   b. Introduction of a nasopharyngeal airway
   c. Intubation with endotracheal tube

Perioperative parameters were obtained and recorded automatically and continuously in the digital patient record EPD Powerchart Cerner Millenium anesthesia chart, as well as manually at different intervals by our study nurse in the parameter form specifically made for this study. These perioperative parameters were heart rate, non-invasive blood pressure measurements, pulse oxygen saturation and respiratory rate. Furthermore, time of induction (=T0), neurowave values, anesthetic events and airway interventions, surgical events, adverse events and awakening time were recorded at different times.

Secondary endpoint

The secondary endpoint was focused on assessing the quality of the oropharyngeal mucosa and the surgical conditions when using both oxygenation methods. Surgery satisfaction was assessed using the following scoring system: 1= extremely dissatisfied; 2= not satisfied but able to manage; 3= extremely satisfied. Comparison of the oropharyngeal mucosa before and after the procedure was assessed using score 1= good quality, humid mucosa; 2= acceptable quality; 3= dry mucosa.

Interpretation and statistical analyses

All data was entered or uploaded to eCRF's in a locally hosted instance of REDCap. Statistical analyses were carried out in Statistical Package for the Social Sciences (SPSS, version 29.0) for Mac in collaboration with the Statistic Department at UZA. A p-value of <0.05 was considered statistically significant.

Given the low number of subjects included in the study, no statements can be made about the normality of the data. These continuous variables are expressed as median and interquartile range (IQR). Data for categorical variables were presented as a number and percentage.

Not normally distributed continuous variables were compared using the independent samples Mann-Whitney U test. Differences between two categorical variables were compared using the Fisher exact test.

Results

Study population and intervention

During the inclusion period from November 1st, 2023, to January 31st, 2025, a total of 25 patients who were scheduled to undergo a supraglottoplasty were screened for eligibility in the Antwerp University hospital. One patient was excluded because of logistic reasons and one patient did not meet inclusion criteria for age. One patient was not able to give consent due to a language problem and one patient was preoperatively already receiving high flow oxygen treatment and was therefore excluded from the study. A total of 21 patients were included in our research. For all patients included, informed consent was obtained from a parent or a legal guardian of the child. Of the 21 included patients, two did not complete the study because there was no indication for supraglottoplasty after sleep endoscopy was carried out. Patient flow for inclusion is depicted in Figure 1.

All patients included received the same medication for induction and maintenance of anesthesia during the procedure. There were six deviations from protocol. In one case, the study was ended prematurely because there was no recuperation of spontaneous breathing, for which the child was eventually intubated. This was noted as a deviation from research protocol. This patient was nonetheless included in the analysis. Secondly, two patients underwent a sleep endoscopy prior to the supraglottoplasty, while spontaneously breathing with sevoflurane. Finally, in three cases a sleep endoscopy with IV propofol 9mg/kg/h was performed before the supraglottoplasty was carried out.

Demographics and patient characteristics

The baseline demographics and clinical characteristics of the studied population are listed in Table I. In total, 19 patients were included in the study. There were 9 (47%) patients in the high flow oxygen group and 10 (53%) patients in the low flow group. The median age was 613 days (1133), with a large spreading of ages. 53% of patients (n=10) was male and 47% of patients (n=9) were female. Most patients (n=13; 68%) of the included subjects had an ASA status of 2. The other patients (n= 6; 32%) had ASA status of 3. Of the ASA 3 patients, 67% (n=4) had a history of cardiac diseases and 50% (n=3) had a history of pulmonary diseases. 67% of the included patients with ASA status 3 had a syndromic background, of which three children were known with trisomy 21 and one child suffered from generalized hypotonia.

For further analysis, the patient population was divided according to randomization, in a high flow oxygen group and a low flow oxygen group. The high flow oxygen group contained 9 patients, and the low flow group had 10 patients. Both groups were similar for sex, ASA status and medical history (p=1.0). There was no statistically significant difference between both groups for age, despite observation of a large spreading of age, with a lot of small children in the low flow group (Figure 2). Patient characteristics and baseline demographics of both groups are presented in Table II.

Airway responses and/or interventions (ARIN)

During the procedure, 14 patients (74%) out of 19 patients experienced one or more ARIN, whereof 8 of patients (57%) were in the low flow group and 6 patients (43%) were in the high flow group. In the low flow group, 8 patients (80%) had one or more ARIN, compared to 6 patients (67%) in the high flow group. This difference was not statistically significant (p=0.628).

The total number of ARIN in the study was 43, of which 23% (n=10) occurred in the high flow group and 77% (n=33) in the low flow group. This difference in number of ARIN per person was not statistically significant (p=0.261) (Figure 3A).

Difference in airway responses during the procedure

Altogether, 14 patients (74%) experienced one or more adverse events, 57% (n=8) of these patients were in the low flow group and 43% (n=6) in the high flow group. This difference in occurrence of adverse events was found not statistically different (p=0.628).
Two patients had more than one adverse event. In toto, 34 adverse events took place during our study, of which 32.4% (n=11) were in the high flow group and 67.6% (n=23) in the low flow group. The number of adverse events per patient was not significantly different in both groups (p=0.271).

Desaturation and apnea

In the high flow oxygen group (n=9), 2 patients (22,2%) desaturated during the supraglottoplasty. In the low flow oxygen group (n=10), desaturation occurred in 3 patients (30%). Notably, the total number of desaturations was higher in the low

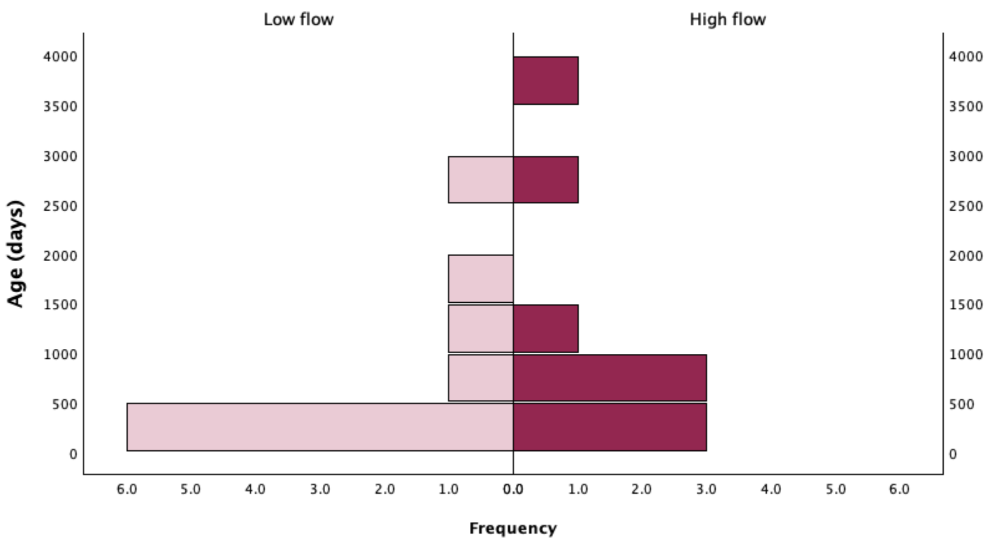

Fig. 2 — Distribution of age in both groups.

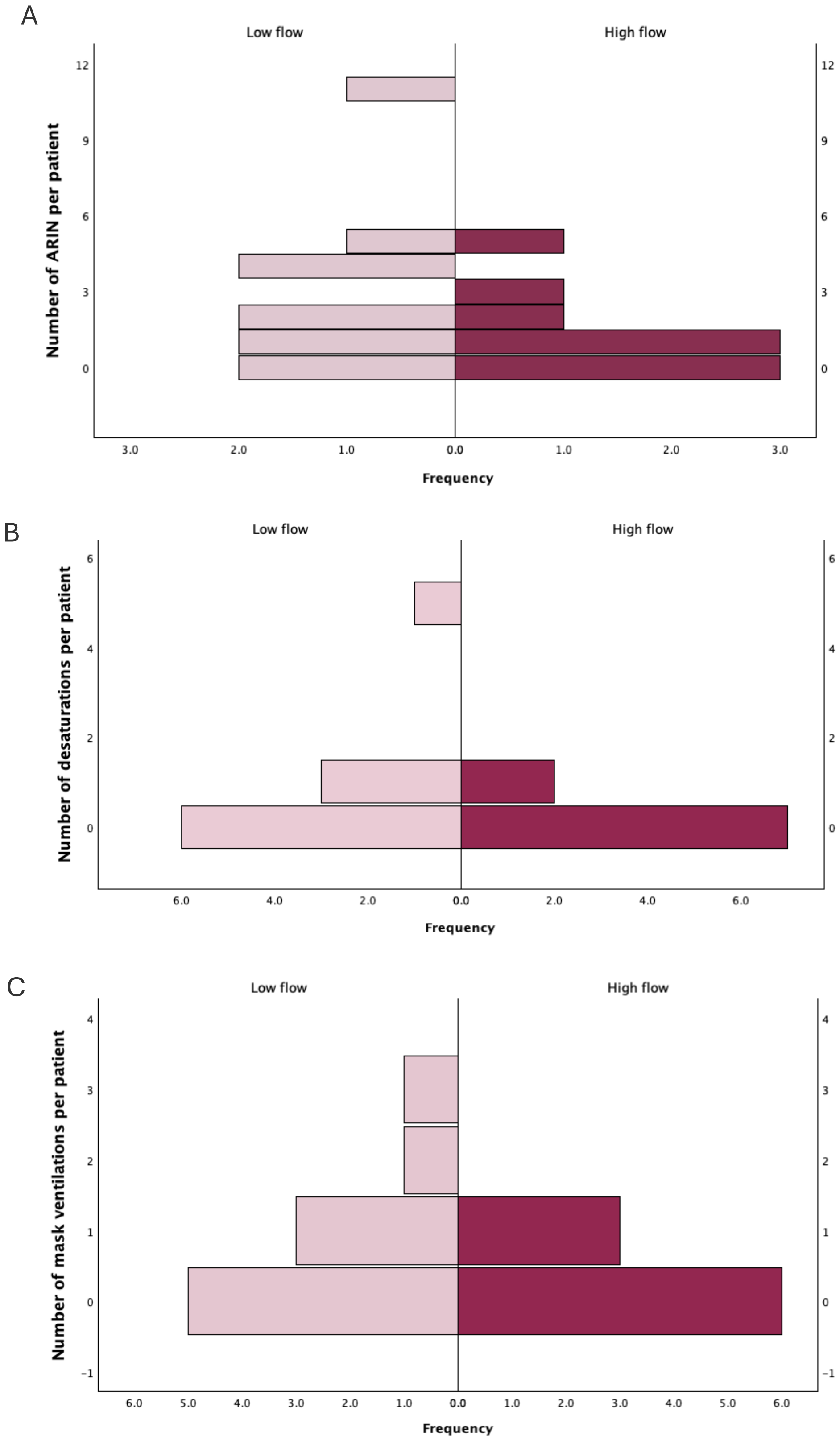

Fig. 3 — 3A: Number of ARIN per patient according to randomisation. Figure 3B: Number of desaturations per patient according to randomisation. Figure 3C: Number of mask ventilations per patient according to randomisation.

flow group (n=8) compared to the high flow group (n=2). This difference occurred due to malplacement of the nasal cannula in one patient in the low flow group, which caused the child to desaturate five times during the procedure. There was no significant difference in the number of desaturations between the two groups (p=0.367). The number desaturations per patient according to randomization is depicted in Figure 3B.

Apnea took place in 5 patients (55.6%) in the high flow oxygen group (n=9) and in 7 patients (70%) in the low flow oxygen group (n=10). In the high flow oxygen group, apnea occurred 5 times, where each of the five children desaturated one time. In the low flow group, however, there was an occurrence of 9 apneas, where two children had two apneas. This group also contains the child who did not regain spontaneous breathing after apnea and did not complete the study after intubation. There was no statistically significant difference in the number of apneas when comparing the two groups (p=0.295).

Bradycardia or tachycardia

Bradycardia occurred in 2 patients (22.2%) of the high flow group (n=9) and in 2 patients (20%) of low flow group (n=10). Statistical analysis showed no significant difference between the groups (p=1.000).

Tachycardia occurred in 1 patient (11%) in the high flow group. There was no occurrence in the low flow group. There was no significant difference between the groups (p=1.000).

Difference in airway interventions during the procedure

Mask ventilation

Mask ventilation was needed in three (33.3%) patients in the high flow group (n=9). Each patient had one adverse event where mask ventilation was needed. In the low flow group (n=10), five (50%) patients needed one or more interventions of mask ventilation. The total occurrence of mask ventilation was 8 times in this group. The difference in number of mask ventilations per patient was found not statistically significant (p=0.331). The number of mask ventilations per patient according to randomization is displayed in Figure 3C.

Introduction of nasal canula

Aside from protocol in the low flow oxygen group, there were no other instances where a nasal cannula was placed to secure the airway.

Intubation

There were two patients (20%) in the low flow group (n=10) that had to be intubated to secure the airway and to maintain oxygenation. These two patients were the one child who had a misplaced nasal canula and desaturated five times during the study and the child who did not regain spontaneous breathing after apnea in the beginning of the procedure. In the high flow group, there was no need for intubation. This difference was not statistically significant (p=0.167).

Secondary endpoints

Difference in quality of oropharyngeal mucosa before and after the procedure

All children in the high flow oxygen (n=9), as well as all children in the low flow group (n=9) had a good quality of oropharyngeal mucosa before the surgery. Data for evaluation of the mucosa at the end of surgery were missing for the one patient in the low flow group who ended the study prematurely.

After the procedure, a good quality of oropharyngeal mucosa was found in all of the children in the high flow oxygen group (n=9). In the low flow oxygen group (n= 10) one child (10%) showed mucosa of good quality, four children (40%) showed acceptable quality, and four children (40%) had dry mucosa. Data were missing for the one patient in the low flow group who ended the study prematurely. Statistical analysis showed a significant difference in quality of the mucosa at the end of the study between both groups (p<0.001) (Figure 4).

Surgery satisfaction score

Surgery satisfaction score was recorded at the end of the procedure. In the high flow group (n=9), in 8 cases (88.9%) a high surgery satisfaction score was noted, in one case (11.1%) a medium score and no low scores. In the low flow group (n=10), there was a high satisfaction in 7 cases (70%), a medium score in one case (10%) and a low score in one case (10%) and a missing value for the patient who ended the study prematurely (10%). This difference was not statistically significant (p=0.496).

Discussion

Patients undergoing supraglottoplasty for laryngomalacia

Direct laryngoscopy for therapeutic interventions poses significant challenges for the anesthesiologist, where the patient must be sufficiently sedated, while maintaining spontaneous respiration. Undersedation can cause laryngospasm, bronchospasm or coughing, while oversedation can lead to apnea, hypopnea and subsequent desaturation. In this prospective randomized controlled pilot study, we studied 19 scheduled patients who underwent a supraglottoplasty.

There was a statistically similar distribution of age, gender, ASA status and medical history. For age, however, there was a large spreading, with a range from 2 months to 10.3 years. The median age was also not similar in both groups, with a median age of 1.83 years in the high flow oxygen group

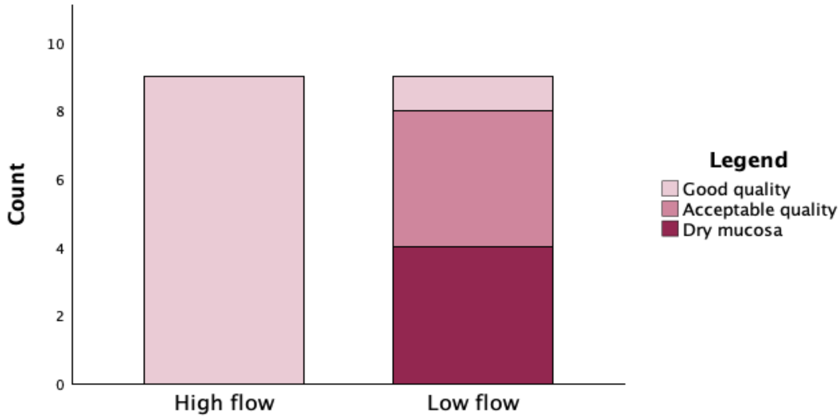

Fig. 4 — Evaluation of the mucosa at the end of the procedure.

and a median of 1.08 years in the low flow group. There were a lot of young children in the low flow group. Given that age might affect the incidence of airway responses during this procedure, where it might be more difficult to maintain an open airway in smaller children, this is an important observation to interpret these results.

Airway responses and interventions during the procedure

In current literature, there is few data about possible better outcomes when using high flow oxygen in children compared to low flow oxygen, but data suggest that time to desaturation is not prolonged[4,5,8,9]. Furthermore, randomized controlled trial (RCT) by Klotz et al. suggests that respiratory stability is not improved with high flow oxygen therapy[8].

This pilot study aimed at exploring difference in airway in airway responses and airway interventions when using high flow oxygen therapy, compared to low flow oxygen therapy. Although time to desaturation was not measured nor investigated, there was no statistically significant difference in incidence of airway response, nor in incidence of airway interventions. There was, however, a remarkable observation that one subject in the low flow oxygen group desaturated five times during the supraglottoplasty because of a malplacement of the nasal cannula. It is important to note this because this problem cannot arise when using the Optiflow™ Nasal High Flow (NHF) therapy system. This subject was eventually intubated to maintain a safe airway. Furthermore, there was another subject in the low flow oxygen group that was intubated early in the procedure and ended the study early. This makes for two intubations in the low flow oxygen group, compared to none in the high flow oxygen group, which was not statistically significant, but might be clinically significant.

Moreover, it is important to notice the medical and syndromic background in this study population. Pulmonary medical history, such as bronchopulmonary dysplasia impacts the oxygen reserve and can cause accelerated desaturations. As mentioned above, three children were known to have trisomy 21 and one child suffered from generalized hypotonia, two conditions that can complicate airway management due to inherent features of the syndromes.

Lastly, there were some deviations from protocol, which included three patients undergoing a sleep endoscopy under propofol TCI (Target Controlled Infusion) prior to the supraglottoplasty. The administration of propofol might precipitate apnea and subsequent desaturation, although this was not apparent in our studied population, probably due to a small sample size.

Quality of oropharyngeal mucosa

A possible advantage of the OptiflowTM Nasal High Flow (NHF) therapy system is the humidification of the administered air, with possibly beneficial effects on the airway mucosa of patients[4,5,8,9]. This study investigated whether the quality of the airway mucosa was better in patients who had received high flow oxygen, compared to those who received low flow oxygen. The statistical analysis showed a significant difference in quality of the airway mucosa, where the high flow oxygen was superior.

Limitations

The aim of this study was to be a pilot study and to evaluate possible advantages of disadvantages from high flow oxygen compared to low flow oxygen. The study was terminated early as surgeons reported a clear and major improvement in surgical conditions in the high flow group, resulting in better clinical outcomes for patients. The warm and humidified air led to a better quality of oropharyngeal mucosa, which facilitated surgical mucosal manipulation and led to a higher level of patient comfort. It was therefore considered unethical to continue further allocation to the low flow group. The early termination of the study lead to a low number of inclusions, which constitutes a major limitation. Due to the small sample size, a couple of considerations need to be taken. First, the statistical power was insufficient to detect significant differences. Differences had to be enormous to be statistically significant. Next, the small sample size makes it impossible to correct for possible confounders, such as age, syndromic background, pulmonary comorbidities and prior administration of propofol.

Conclusion

In conclusion, 19 patients undergoing supra-glottoplasty under general anesthesia while maintaining spontaneous respiration were included in this study. No statistically significant difference could be detected in the primary endpoint, ARIN, nor in the number of airway responses or airway interventions by the anesthetist. There was, however, a statistically significant difference in the quality of the mucosa, where humidified and heated high flow oxygen proved superior compared to dry and unheated low flow oxygen. The improved surgical and clinical conditions lead to an early termination of the study, with consequently an underpowering of the primary endpoint. Nonetheless, it seems that high flow oxygen is superior to low flow oxygen because of the effects on the oropharyngeal mucosa in upper airway surgery. More research on this topic is necessary.

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