Colombian Journal of Anesthesiology
REVISTA COLOMBIANA DE ANESTESIOLOGÍA

ORIGINAL ARTICLE

OPEN

Received: 19 May, 2020 ▸ Accepted: 24 January, 2021 ▸ Online first: 6 April, 2021

DOI: https://doi.org/10.5554/22562087.e981

Incidence of post-anesthetic respiratory complications in pediatrics. Observational, single-center study in Medellin, Colombia

Incidencia de complicaciones respiratorias postanestésicas en pacientes pediátricos. Estudio observacional en un hospital en Medellín, Colombia

Hugo Tolosa Pérez[a], Sebastián Gómez Santamaría[b], Laura Quintana Puerta[b], Miguel Andrés Bedoya López[b], Nicolás Echeverri Restrepo[b], Alejandra Gallo Parra[b], Leyla Margarita Redondo Morales[b], Clara Urrego[c], José Raúl Jaramillo[c], Carolina Franco Roldán[c], José Hugo Arias[d], Nury Isabel Socha[e]

[a] Clínica CES. Medellín Colombia.
[b] Anesthesiology, Universidad CES. Medellín. Colombia.
[c] Clínica Noel. Medellín, Colombia.
[d] Epidemiology area, School of Medicine, Universidad CES. Medellín, Colombia.
[e] Clínica Bolivariana. Medellín, Colombia.

Correspondence: Calle 28 Sur No. 27-100. Envigado, Colombia. **Email:** htolosa28@hotmail.com

What do we know about this topic?

· Post-anesthetic respiratory complications in pediatric patients are still a source of concern due to their high frequency.
· In the pediatric population, the incidence of any major complication is as high as 5%, and many of those complications are considered preventable.

What is the contribution of this study?

· Care by nursing staff trained in post-anesthetic recovery and airway management on extubation, with a 1:1 patient-nurse ratio, provided in the post-anesthesia care unit, shows a low frequency of respiratory complications.
· This information offers alternatives for the design of post-anesthesia recovery care models.

How to cite this article:

Tolosa Pérez H, Gómez Santamaría S, Quintana Puerta L, Bedoya López MA, Echeverri Restrepo N, Gallo Parra A, et al. Incidence of post-anesthetic respiratory complications in pediatrics. Observational, single-center study in Medellin, Colombia. Colombian Journal of Anesthesiology. 2021;49:e981.

Abstract

Introduction: Post-anesthetic complications, particularly respiratory complications, continue to be a source of concern due to their high frequency, particularly in pediatrics.

Objective: To describe the incidence of respiratory complications in the post-anesthesia care unit of an intermediate complexity center during a six-month period, and to explore the variables associated with major respiratory complications.

Materials and Methods: Retrospective cohort study based on clinical record reviews. The records of the post-anesthesia care unit of an intermediate complexity pediatric institution located in Medellin, Colombia, were reviewed. This center uses a nursing-based care model that includes patient extubation in the post-anesthesia care unit.

Results: The records of 1181 patients were analyzed. The cumulative incidences of major complications were bronchospasm 1.44%, laryngospasm 0.68% and respiratory depression 0.59%. There were no cases of cardiac arrest or acute pulmonary edema. A history of respiratory infection less than 15 days before the procedure, rhinitis and female sex were associated with major respiratory complications.

Conclusions: A low frequency of respiratory complications was found during care provided by nursing staff trained in anesthesia recovery and pediatric airway in the post-anesthesia care unit.

Keywords: Anesthesia; Bronchospasm; Child; Laryngospasm; Postoperative complications; Nursing.

Lea la versión en español de este artículo en www.revcolanest.com.co

Resumen

Introducción
Las complicaciones postanestésicas, especialmente las respiratorias, siguen siendo causa de preocupación por su alta frecuencia, en particular, en la población pediátrica.

Objetivo
Describir la incidencia de complicaciones respiratorias en la unidad de cuidados postanestésicos de una institución de mediana complejidad, en un período de seis meses y explorar las variables relacionadas con las complicaciones respiratorias mayores.

Materiales y métodos
Estudio de cohorte retrospectivo, basado en la valoración de historias clínicas. Se revisaron los registros de la unidad de cuidados postanestésicos de una institución pediátrica de mediana complejidad ubicada en Medellín. Esta institución utiliza un modelo de atención —basado en enfermería— que incluye la extubación del paciente en la unidad de cuidados postanestésicos.

Resultados
Se analizaron los registros de 1181 pacientes. La incidencia acumulada de complicaciones mayores fue: broncoespasmo 1,44 %, laringoespasmo 0,68 % y depresión respiratoria 0,59 %. No se presentaron casos de paro cardiaco ni de edema agudo de pulmón. El antecedente de infección respiratoria menor a 15 días, rinitis y sexo femenino se asociaron con complicaciones respiratorias mayores.

Conclusiones
Durante la atención en la unidad de cuidados postanestésicos por parte del personal de enfermería entrenado en la recuperación de la anestesia y de la vía aérea de los pacientes pediátricos, se encontró una baja frecuencia de complicaciones respiratorias.

Palabras clave
Anestesia; Broncoespasmo; Niño; Laringoespasmo; Complicaciones postoperatorias; Enfermería.

INTRODUCTION

Morbidity and mortality associated with pediatric anesthesia has dropped dramatically over the past decade (1,2). However, post-anesthetic respiratory complications continue to be a source of concern due to their high frequency (3). Major complications — critical or serious events requiring immediate intervention — are a priority, given that they can result in disability or death (4,5).

Risk factors for major complications which can be identified during the pre-anesthesia assessment have been described (6) and include patient characteristics, surgery-related characteristics and, finally, the experience of the anesthetist or of the post-anesthesia care unit (PACU) staff (3).

In pediatrics, the incidence of any major complication is described to be as high as 5.2% (5); however an important proportion is considered preventable (7). Most perioperartive complications in the pediatric population have been observed during anesthesia induction and in the PACU (6). Knowledge of the risk factors for major respiratory complications during PACU stay is highly relevant.

In pediatric patients, care for the airway in the PACU has been entrusted to trained nurses in several institutions throughout the world, with results that show that this is an efficient strategy when complications and length of stay are measured (8).

The objective of this study is to describe the incidence of respiratory complications during a six-month period in the PACU of an intermediate complexity center with a nursing-based recovery model, exploring the variables associated with major respiratory complications.

METHODS

Retrospective, historical cohort study. Data were taken from PACU records of an intermediate complexity pediatric center located in Medellín, Colombia, between April and October, 2017.

Fundación Clínica Noel is an intermediate complexity center that serves the pediatric population in Medellín, Colombia. A model of nursing-based patient care in the PACU has been developed over the past few years. Care is provided by licensed practical nurses (LPN) who receive intensive training in airway management and anesthesia emergence in pediatric patients, with a 1:1 nurse-to-patient ratio. LPNs are responsible for removing the airway device used during the surgical procedure and to respond to any complication, with the continuous support of the anesthetist who provided the anesthesia.

The clinical records of all patients under 16 years of age who were taken to surgery and received post-anesthesia care in the institution during the study period were reviewed.

The primary outcome was major respiratory complications in the PACU (laryngospasm, bronchospasm, respiratory depression, cardiac arrest and acute pulmonary edema) (5). Minor respiratory complications were also reviewed: stridor, persistent loud coughing, presence of pharyngeal plug at the end of the procedure, airway bleeding and residual muscle relaxation. Demographic characteristics, patient background history and intra-operative variables such as surgery type and airway management were assessed.

STATISTICAL ANALYSIS

Frequency and percentages were used for categorical variables and medians and inter-quartile ranges (IQR) for quantitative variables for the descriptive analysis of patient characteristics and surgical and anesthetic management. The cumulative incidence of major and minor complications is reported.

A binary logistic regression model was used for the exploratory analysis of factors associated with complications. Estimates adjusted by OR and 95% CI are described. A value of $p \leq 0.05$ was established as significant.

To add to the analysis, taking into account lengths of stay in the PACU, incidence rates of major complications were estimated and associations were calculated using a generalized linear regression with Poisson family and logarithmic link. Crude and adjusted estimates are presented using incidence rate ratios with 95% CI.

The Stata® versión 12 (StataCorp) software was used for the analysis.

RESULTS

Overall, 1314 patients under 16 years of age admitted to the PACU were included. Of them, 133 were excluded because of more than 20% missing data. Records of 1181 patients were analyzed. Median age was 4 years (IQR 2-8); 69.09% were males (Table 1).

TABLE 1. Characteristics of the study population.

Age Me (IQR)	4	(2-8)
Sex n (%)		
Male	816	69.09
Female	365	30.91
Background history		
None	888	75.19
Asthma	167	14.14
Atopy	31	2.62
ARI <15 days	41	3.47
ARI >15 days	23	1.95
Rhinitis	28	2.37
Passive smoking	3	0.25
SpO2 on admission Me (IQR)	99	(99-100)
HR on admission Me (IQR)	105	(91-120)
Characteristics of the procedure		
Specialty		
Pediatric surgery	527	44.62
Orthopedics	282	23.88
Dentistry	169	14.31
Otolaryngology	97	8.21
Plastic surgery	76	6.44
Dermatology	20	1.69
Gastroenterology	10	0.85
Airway management		
Orotracheal intubation	909	79.32
Nasotracheal intubation	118	10.3
Laryngeal mask	78	6.81
Oropharyngeal cannual	41	3.58
Type of endotracheal tube		
Cuffed	672	58.64
Uncuffed	355	30.98
Ventilation on admission to the PACU		
Spontaneous	864	73.66
Assisted	309	26.34
Length of the surgery in minutes Me (IQR)	60	(45-90)
Time in the PACU	40	(35 - 55)

ARI = Acute respiratory infection; HR= Heart rate; IQR = Interquartile range; Me = median; PACU = Post-anesthesia Care Unit.

SOURCE: Authors.

Surgical and anesthetic management

The most frequently performed surgical procedures were specialized pediatric procedures (44.62%) and orthopedics (23.88%). The device most frequently used for airway management during the surgery was the endotracheal tube (TET) (89.62%; n= 1027), 58.64% cuffed (Table 1). Airway devices were removed by the nursing staff in 93.56% of patients (orotracheal tube [OTT], nasotracheal tube [NTT] or laryngeal mask [LM]) in the PACU.

Incidence of respiratory complications

Bronchospasm was the most frequent major complication (1.44%), followed by laryngospasm and respiratory depression (0.68% and 0.59%, respectively). There were no cases of cardiac arrest or pulmonary edema (Table 2). The incidence of bronchospasm was 15.8 for every 1000 hours-person (95% CI [9.8-24.4]) while it was 7.4/1000 hours-person for laryngospasm (95% CI [3.7-14.8]) and 6.5/1000 hours-person for respiratory depression (95% CI [3.1-13.6]).

Minor respiratory complications, in order of frequency, were dysphonia (8.47%), airway bleeding (6.27%), persistent loud coughing (5.08%), stridor 0.59%, pharyngeal plug not removed in surgery (0.59%) and residual neuromuscular relaxation (0.17%) (Table 2).

Table 2. Frequency of respiratory complications in the post-anesthesia care unit.

Major complications	*n*	%
Bronchospasm	17	1.44
Laryngspasm	8	0.68
Respiratory depression	7	0.59
Minor complications		
Dysphonia	100	8.47
Airway bleeding	74	6.27
Persistence loud coughing	60	5.08
Stridor	7	0.59
Pharyngeal plug	7	0.59
Residual relaxation	2	0.17

Source: Authors.

Table 3. Factors associated with bronchospasm in the post-anesthesia care unit.

Variable	Crude IRR	p	95% CI	Adjusted IRR	p	95% CI
Background history						
Asthma	1.6	0.478	[0.44-5.8]	2.57	0.166	[0.68-9.75]
ARI <15 days	6.5	0.004	[1.79-23.6]	6.14	0.007	[1.64-22.96]
ARI >15 days	3.86	0.198	[0.49-30.17]	4.67	0.146	[0.58-37.44]
None	1			1		
Categorical age						
Under 1 year	3.49	0.028	[1.14-10.66]	3.06	0.067	[0.93-10.15]
<6 years	0.68	0.559	[0.18-2.52]	0.53	0.367	[0.13-2.11]
Remaining	1					
Sex						
Female	1.98	0.158	[0.77-5.15]	2.68	0.048	[1.01-7.13]
Male	1			1		
Device type						
Cuffed	0.53	0.233	[0.19-1.51]	0.36	0.142	[0.09-1.41]
Uncuffed	1				1	

ARI = Acute respiratory infection; CI= Confidence interval; IRR= Incidence rate ratio.

Source: Authors.

Factors associated with major respiratory complications

After adjusting for other variables in a logistic regression model, the variables found to be associated with bronchospasm were: a history of acute respiratory infection (ARI) less than 15 days before the procedure (OR 7.16; 95% CI [1.76-29.13]), female sex (OR 3.38; 95% CI [1.20-9.46]), as well as age under one year (OR 4.94; 95% CI [1.45-16.75]). Arriving at the PACU with an ETT was associated with a lower frequency of bronchospasm (OR 0.18; 95% CI [0.05-0.73]) (Table 3).

As for respiratory depression, an association was found between a history of ARI more than 15 days before (OR 20.47; 95% CI [1.86-225.24]) and a history of rhinitis (OR 14.47; 95% CI [1.35-155.55]) (Table 4)

None of the studied factors was associated with the presence of laryngospasm (Table 5).

DISCUSSION

Extubation in the PACU by trained nursing staff is not new. The Michigan Children's

Table 4. Factors associated with the onset of respiratory depression in the post-anesthesia care unit.

Variable	Crude IRR	p	95% CI	Adjusted IRR	p	95% CI
Background history						
Asthma	3.54	0.166	[0.59-21.21]	4.2	0.132	[0.65-27.25]
ARI >15 days	12.87	0.027		18.57	0.013	[1.86-185.16]
Rhinitis	10.57	0.041	[1.10-101.63]	13.46	0.027	[1.34-134.88]
None	1					
Categorical age						
Under 1 year	2.18	0.436	[0.31-15.48]	4.15	0.167	[0.55-31.21]
<6 years	1.27	0.795	[0.21-7.59]	1.98	0.473	[0.31-12.80]
Remaining	1			1		
Sex						
Female	0.89	0.894	[0.17-4.61]	0.99	0.99	[0.18-5.45]
Male	1			1		
Device type						
Cuffed	3.17	0.286	[0.38-26.33]	5.27	0.142	[0.57-48.46]
Uncuffed	1			1		

ARI = Acute respiratory infection; CI= Confidence interval; IRR= Incidence rate ratio.
Source: Authors.

Table 5. Factors associated with the onset of laryngospasm in the post-anesthesia care unit.

Variable	Crude IRR	p	95% CI	Adjusted IRR	p	95% CI
Background history						
Astma	0.76	0.797	[0.09-6.17]	0.89	0.917	[0.10-7.62]
None	1			1		
Categorical age						
Under 1 year	6.54	0.104	[0.68-62.88]	8.03	0.074	[0.81-79.11]
<6 years	3.38	0.276	[0.38-30.24]	3.69	0.264	[0.37-36.38]
Remaining				1		
Device type						
Cuffed	2.64	0.375	[0.31-22.6]	3.67	0.24	[0.42-32.2]
Uncuffed						

CI= Confidence interval; IRR= Incidence rate ratio.
Source: Authors.

Hospital has 30 years of experience using a model in which registered nurses with a minimum experience of two years in the pediatric intensive care unit and two months of training under the supervision of experienced nurses and anesthetists provide care in the PACU, including extubation, without compromising patient safety and with more efficient time management (9).

At Clínica Noel, the nursing staff receives specific training for recovery care and they have more than 20 years of experience in post-anesthesia care (including airway device removal) of pediatric patients. One of the biggest strengths of these models is the 1:1 nurse-to-patient ratio in the PACU. There are no reports in the literature regarding the frequency of complications with this care model, although there are reports of variation in terms of the type of training of the staff and the level of autonomy in the PACU.

One of the benefits of extubation in the PACU is a more efficient turnaround time in the operating room (8). Kako et al. compared total time in the operating room of pediatric patients extubated in the room, as compared to those who were extubated in the PACU, and found an average reduction of 17 minutes in the latter, showing increased efficiency (10).

This study found that despite not being a method commonly used in our setting, the total frequency of major respiratory complications was 2.7%. When compared to a conventional care model like the one described in the APRICOT trial (bronchospasm 4.0% and laryngospasm 3.2%), there was no increase in the frequency of major respiratory complications (5).

The study by Mamie, also involving a traditional model, reported a 12.8% incidence of respiratory complications, although less complication categories were evaluated. The study concluded that respiratory complications had more to do with anesthetic than with patient background history (11).

The low frequency of respiratory complications in patients taken to the PACU with the endotracheal tube in place could be explained by the lower need for rushing awakening in order to comply with the operating room schedule. This allows to have an adequate emergence plane at the time of removing the device (12).

Recovery of airway reflexes is aided by sympathetic nervous system activation during awakening after anesthesia. This is one of the physiological basis for extubating once the patients are fully awake (13,14). Likewise, transfer to the PACU with the patient on an airway device should occur while the patient is in one of the planes previously mentioned (15).

On the other hand, staff experienced in pediatric care and a 1:1 care model ensure safe care. Several authors have emphasized that training in pediatric anesthesia is critical for the correct development of surgical procedures and perioperative care (16-18).

In Colombia, Echeverry highlighted the importance of having highly competent and qualified staff and providing ongoing training for the development not only of psychomotor skills but also of soft skills such as teamwork, in order to ensure comprehensive care to pediatric patients in accordance with good quality and safety standards (19).

The search for factors associated with respiratory complications showed that bronchospasm is associated with a history of ARI less than 15 days before the procedure, age under 1 year and female sex. These results support the decision to cancel procedures on the grounds of recent ARI (20). They are also consistent with other studies that show an association between age and the development of bronchospasm (21).

Respiratory depression was associated with a history of rhinitis, which has been found to be a risk factor for obstructive sleep apnea. This mechanism could explain airway obstruction and depression in pediatric patients, although further studies that clarify that relationship are needed (22).

Although there were no significant differences in the risk of respiratory complications with the use of cuffed or uncuffed OTT, evidence shows that the use of the former did not increase the risk of post-extubation stridor and, on the contrary, it reduced the number of device exchanges when compared with the uncuffed OTT (23). Shi et al. are currently conducting a meta-analysis to compare post-extubation morbidity with the use of cuffed or uncuffed OTT, which may provide relevant information regarding this issue (24).

The study by Shi et al. did not show a relationship between any of the variables analyzed and the development of laryngospasm. However, the literature suggests that this complication is associated with a superficial anesthetic plane and tachycardia. In terms of the placement of airway devices, a meta-analysis published by Luce et al. concluded that the use of LM in pediatric anesthesia reduces the incidence of this complication (24-26).

A trend towards a higher risk of respiratory complications in the PACU was found in patients with a prior history of disease conditions. This is consistent with the findings in a retrospective cohort of 1547 patients with a history of asthma of a 1.3% incidence of bronchospasm and a 0.13% incidence of laryngospasm, and no patients with respiratory depression (27).

A model of care in the PACU like the one described in this paper highlights the importance of adequate staffing for perioperative care, both in terms of numbers but also in terms of skills and experience. In such a model, the anesthetist plays a key role as the person responsible for supervised care management in a setting traditionally considered as prone to the occurrence of adverse events. The information derived from this study is relevant and timely at a time when patient safety is even more relevant.

This research includes a substantial number of patients, particularly when compared to other studies. The associations described correspond to an exploratory but not a causal analysis given that this was not its main objective and a sample size for that purpose was not calculated. Estimates must be taken with caution, bearing in mind that intraoperative variables such as drugs, which can be related to complications in the PACU, were not included. The historical nature of the research creates certain limitations derived from the quality of the entries in the clinical record; however, original records were assessed for completeness of the information, with 10.1% of the records being excluded because of missing data. The researchers believe that, in view of the paucity of information regarding this topic, a historial design provides relevant information that can serve as a basis for future prospective studies.

The frequencies of the complications described correspond to an intermediate complexity center; the operation of this PACU care model in other settings such as emergency or high complexity procedures, could differ. Further studies are required in those settings in which demands may result in different requirements for care in the PACU.

CONCLUSION

In this cohort of pediatric patients, care provided by nursing staff trained in anesthesia recovery and pediatric airway management resulted in a low frequency of respiratory complications in the PACU. This strategy could be implemented in other similar centers in the country with the aim of optimizing operating room time and resources without compromising patient safety. Likewise, improvement of psychomotor skills and continuing education must be the responsibility of all the people working in services where pediatric procedures are performed. It is important to insist on the need to identify preventable factors that could result in postoperative respiratory complications.

Ethical disclosures

The authors declare that they participated in the preparation of this article and that the procedures that were followed are in compliance with the current ethical standards. The study was approved by the Ethics Committee of Clinica Noel as stated in Minutes No. 4, and by the Research and Innovation Committee of CES University as stated in Minutes No. 232 of March 10, 2020.

Data confidentiality and right to privacy

The authors state that they followed the protocols of their center for the disclosure of patient data, in compliance with the Personal Data Protection regulations (Statutory Law 1581 of 2012).

ACKNOWLEDGEMENTS

Authors' contributions

HT, CU, JJ, CF and NS: Study planning, data collection.
SG, LQ, MB, NE, AG, LR and JA: Interpretation of the results and drafting of the manuscript.

Assistance for the study

None declared.

Funding and sponsorship

Researchers' own resources. No external funding was received.

Conflict of interest

None of the authors have disclosures to make.

Presentations

None declared.

Appreciation

We are grateful to Universidad CES and the members of the School of Medicine. To the leadership, the Department of Anesthesiology and Nurses of Fundación Clínica Noel.

REFERENCES

1. Tay C, Tan G, Ng S. Critical incidents in paediatric anaesthesia: an audit of 10 000 anaesthetics in Singapore. Pediatr Anesth. 2001;11(6):711-8. doi: http://www.doi.org/10.1046/j.1460-9592.2001.00767.x

2. Murat I, Constant I, Maud'huy H. Perioperative anaesthetic morbidity in children: a database of 24 165 anaesthetics over a 30-month period. Pediatr Anesth. 2004;14(2):158-66. doi: http://www.doi.org/10.1111/j.1460-9592.2004.01167.x

3. von Ungern-Sternberg BS, Boda K, Chambers NA, Rebmann C, Johnson C, Sly PD, et al. Risk assessment for respiratory complications in paediatric anaesthesia: a prospective cohort study. The Lancet. 2010;376(9743):773-83. doi: http://www.doi.org/10.1016/S0140-6736(10)61193-2

4. Paterson N, Waterhouse P. Risk in pediatric anesthesia. Pediatr Anesth. 2011;21(8):848-57. doi: http://www.doi.org/10.1111/j.1460-9592.2010.03366.x

5. Habre W, Disma N, Virag K, Becke K, Hansen TG, Jöhr M, et al. Incidence of severe critical events in paediatric anaesthesia (APRICOT): a prospective multicentre observational study in 261 hospitals in Europe. Lancet Respir Med. 2017;5(5):412-25. doi: http://www.doi.org/10.1016/S2213-2600(17)30116-9

6. von Ungern-Sternberg BS. Respiratory complications in the pediatric postanesthesia care unit. Anesthesiol Clin. 2014;32(1):45-61. doi: http://www.doi.org/10.1016/j.anclin.2013.10.004

7. Erb TO, Trachsel D, Ungern-Sternberg BS. Laryngeal reflex responses in pediatric anesthesia. Pediatr Anesth. 2020;30(3):353-61. doi: http://www.doi.org/10.1111/pan.13807

8. Sonneborn O, Robers G. Nurse-led extubation in the post-anaesthesia care unit. J Perioper Pract. 2018;28(12):362-5. doi: http://www.doi.org/10.1177/1750458918793366

9. Lucier MM, Brisson D. Extubation of pediatric patients by PACU nurses. J Perianesth Nurs. 2003;18(2):91-5. doi: http://www.doi.org/10.1053/jpan.2003.50011

10. Kako H, Corridore M, Seo S, Elmaraghy C, Lind M, Tobias JD. Tracheal extubation practices following adenotonsillectomy in children: effects on operating room efficiency between two institutions. Pediatr Anesth. 2017;27(6):591-5. doi: http://www.doi.org/10.1111/pan.13100

11. Mamie C, Habre W, Delhumeau C, Barazzone Argiroffo C, Morabia A. Incidence and risk factors of perioperative respiratory adverse events in children undergoing elective surgery. Pediatr Anesth. 2004;14(3):218-24. doi: http://www.doi.org/10.1111/j.1460-9592.2004.01169.x

12. Hagberg CA, Artime CA. Extubación del paciente perioperatorio con una vía aérea difícil. Colombian Journal of Anesthesiology. 2014;42(4):295-301. doi: http://dx.doi.org/10.1016/j.rca.2014.05.005

13. Arai Y-CP, Kandatsu N, Ito H, Sato J, Ushida T, Suetomi K, et al. Behavior of children emerging from general anesthesia correlates with their heart rate variability. J Anesth. 2010;24(2):317-8. doi: https://doi.org/10.1007/s00540-010-0887-4

14. Guignard B. Monitoring analgesia. Best Pract Res Clin Anaesthesiol. 2006;20(1):161-80. doi: http://www.doi.org/10.1016/j.bpa.2005.09.002

15. Naraghi L, Peev MP, Esteve R, Chang Y, Berger DL, Thayer SP, et al. The influence of anesthesia on heart rate complexity during elective and urgent surgery in 128 patients. J Crit Care. 2015;30(1):145-9. doi: http://www.doi.org/10.1016/j.jcrc.2014.08.008

16. Morray JP, Geiduschek JM, Ramamoorthy C, Haberkern CM, Hackel A, Caplan RA, et al. Anesthesia-related cardiac arrest in children: initial findings of the pediatric perioperative cardiac arrest (POCA) registry. Anesthesiol J Am Soc Anesthesiol. 2000;93(1):6-14. doi: http://www.doi.org/10.1213/01.ane.0000268712.00756.dd

17. Bhananker SM, Ramamoorthy C, Geiduschek JM, Posner KL, Domino KB, Haberkern CM, et al. Anesthesia-related cardiac arrest in children: Update from the pediatric perioperative cardiac arrest registry. Anesth Analg. 2007;105(2). doi: http://www.doi.org/10.1213/01.ane.0000268712.00756.dd

18. Auroy Y, Ecoffey C, Messiah A, Rouvier B. Relationship between complications of pediatric anesthesia and volume of pediatric anesthetics. Anesth Analg. 1997;84(1):234-5. doi: http://www.doi.org/10.1097/00000539-199701000-00060

19. Echeverry Marín PC. Los nuevos retos de la

anestesia pediátrica en Colombia. Colombian Journal of Anesthesiology. 2017;45(1):5-7. doi: http://www.doi.org/10.1016/j.rca.2016.10.003

20. Regli A, Becke K, von Ungern-Sternberg BS. An update on the perioperative management of children with upper respiratory tract infections: Curr Opin Anaesthesiol. 2017;30(3):362-7. doi: http://www.doi.org/10.1097/aco.0000000000000460

21. Virag K, Sabourdin N, Thomas M, Veyckemans F, Habre W. Epidemiology and incidence of severe respiratory critical events in ear, nose and throat surgery in children in Europe: A prospective multicentre observational study. Eur J Anaesthesiol. 2019;36(3):185-93. doi: http://www.doi.org/10.1097/EJA.0000000000000951

22. Zheng M, Wang X, Zhang L. Association between allergic and nonallergic rhinitis and obstructive sleep apnea. Curr Opin Allergy Clin Immunol. 2018;18(1):16-25. doi: http://www.doi.org/10.1097/ACI.0000000000000414

23. Weiss M, Dullenkopf A, Fischer JE, Keller C, Gerber AC, European, et al. Prospective randomized controlled multi-centre trial of cuffed or uncuffed endotracheal tubes in small children. Br J Anaesth. 2009;103(6):867-73. doi: http://www.doi.org/10.1093/bja/aep290

24. Shi F, Xiao Y, Xiong W, Zhou Q, Huang X. Cuffed versus uncuffed endotracheal tubes in children: a meta-analysis. J Anesth. 2016;30(1):3-11. doi: http://www.doi.org/10.1007/s00540-015-2062-4

25. Elwood T, Cecchin F, Low JI, Bradford HM, Goldstein B. Pilot study of preoperative heart rate variability and adverse events in children emerging from anesthesia. Pediatr Crit Care Med. 2005;6(1):54-7. doi: http://www.doi.org/10.1097/01.PCC.0000149316.36372.2A

26. Luce V, Harkouk H, Brasher C, Michelet D, Hilly J, Maesani M, et al. Supraglottic airway devices vs tracheal intubation in children: a quantitative meta-analysis of respiratory complications. Pediatr Anesth. 2014;24(10):1088-98. doi: http://www.doi.org/10.1111/pan.12495

27. Warner DO, Warner MA, Barnes RD, Offord KP, Schroeder DR, Gray DT, et al. Perioperative respiratory complications in patients with asthma. Anesthesiol J Am Soc Anesthesiol. 1996;85(3):460-7. doi: http://www.doi.org/10.1097/00000542-199609000-00003