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RESEARCH ARTICLE

INCIDENCE AND RISK FACTORS OF PERIOPERATIVE RESPIRATORY INCIDENTS IN PEDIATRIC ANESTHSIA: A PROSPECTIVE OBSERVATIONAL SINGLE-CENTER STUDY

Y. Hamdi, H. Darouich, K. El Fakhr, O. Aissaoui and S. Kalouch

1. Department of Anesthesiology and Critical Care, Abderrahim El Harrouchi Children's Hospital, CHU Ibn Rochd, Casablanca, Morocco.

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Abstract

Introduction/Objective: Perioperative respiratory incidents are a leading cause of morbidity in pediatric anesthesia. Few prospective studies from low- and middle-income countries have simultaneously evaluated patient-, surgery-, and anesthesia-related determinants of these events. This study aimed to determine their incidence and identify independent risk factors in a Moroccan pediatric surgical cohort.

Methods: A six-month prospective observational single-center study (April–September 2025) was conducted at Abderrahim El Harrouchi Children's Hospital, CHU Ibn Rochd, Casablanca. A total of 470 children undergoing surgery under general anesthesia were enrolled. Risk factors were identified by univariate analysis followed by binary logistic regression.

Results: The incidence of perioperative respiratory incidents was 26.8% (126/470). Desaturation (SpO_2< 90%) was the most common event (92.9%). On multivariate analysis, three independent risk factors were identified: upper airway obstruction (adjusted OR = 3.47; 95% CI [1.9–6.3]; $p < 0.001$), multiple intubation attempts (adjusted OR = 5.94; 95% CI [2.6–13.7]; $p < 0.001$), and agitation at induction (adjusted OR = 2.05; 95% CI [1.1–3.8]; $p = 0.04$).

Discussion: The incidence observed is consistent with comparable African settings and substantially higher than high-income country data, reflecting emergency case burden, comorbidities, and resource constraints. The three identified factors are all clinically modifiable and amenable to targeted prevention strategies.

Conclusion: Perioperative respiratory incidents are frequent in our setting. Systematic preoperative airway screening, structured difficult intubation protocols, and anxiolytic premedication are priority interventions for improving pediatric anesthetic safety.

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Corresponding Author:- Y. Hamdi
Address:-Department of Anesthesiology and Critical Care, Abderrahim El Harrouchi Children's Hospital, CHU Ibn Rochd, Casablanca, Morocco.

Introduction:-

Pediatric anesthetic safety is a major concern in anesthesiology. Children have unique anatomical and physiological characteristics — narrow airways, reduced thoracic compliance, elevated oxygen consumption, and rapid metabolism of anesthetic agents — that expose them to greater risk of perioperative respiratory incidents than adults [1,2]. Perioperative respiratory incidents (PRIs) include a spectrum of events: oxygen desaturation (SpO2< 90%), laryngospasm, bronchospasm, upper airway obstruction (UAO), apnea, and mask ventilation difficulty. Although usually reversible, these events may be life-threatening when not promptly recognized and managed [3,4]. The APRICOT study, conducted across more than 31,000 children in 261 European hospitals, reported a 5.2% incidence of severe critical respiratory events [4]. The rates seen in Europe cannot be projected onto middle income countries where the rates tend to be higher because there is a larger number of emergency procedures, and limited availability of specialized airway equipment, and limited available personnel [5,6]. In Morocco, epidemiological data specific to pediatric anesthesia remain scarce. Understanding the incidence and determinants of PRIs is therefore essential to guide local clinical practice and resource allocation. Therefore, the main objective of this study was to determine the incidence of PRIs in pediatric anesthesia at our institution. Secondary objectives were to identify independent risk factors and provide recommendations to prevent such occurrences.

Materials and Methods:-

Study design and setting:-

We conducted a prospective observational single-center study over six consecutive months, from April to September 2025, in the pediatric surgical operating rooms of Abderrahim El Harrouchi Children's Hospital, CHU Ibn Rochd, Casablanca, Morocco.

Study population:-

Inclusion criteria: all patients under 14 years of age undergoing surgery under general anesthesia during the study period.

Exclusion criteria: age ≥ 14 years; refusal of parental or legal guardian informed consent; incomplete anesthetic records.

Data collection:-

Data were collected prospectively using a standardized case report form (CRF) completed in the operating room by the attending anesthesiologist. Variables recorded included: (i) demographic data (age in months, sex); (ii) preoperative data (surgical specialty, elective vs. emergency status, ASA physical status score, history of allergy, Mallampati score, mouth opening, cervical spine mobility, signs of upper airway obstruction, simplified pediatric difficult intubation score, preoperative anxiety level); and (iii) intraoperative data (type of anesthetic induction, anesthetic agents, Cormack–Lehane grade, number of intubation attempts, agitation at induction, occurrence and type of respiratory incident, and surgical duration in hours).

Definitions:-

Perioperative respiratory incident was defined as the occurrence of at least one of the following events from induction to end of surgery: oxygen desaturation (SpO2< 90%), laryngospasm, bronchospasm, mask ventilation difficulty, multiple or failed intubation attempts, apnea, perioperative bradycardia, or hypotension associated with a respiratory event [3,4]. A patient could present with more than one type of incident simultaneously. Upper airway obstruction (UAO): defined by preoperative clinical signs: snoring, stridor, mouth breathing, or documented adenotonsillar hypertrophy. Agitation at induction: any oppositional or agitated behavior preventing adequate peripheral venous access or face-mask placement. Multiple intubation attempts: two or more laryngoscopy attempts required for tracheal intubation.

Bias recognition:-

To minimize selection bias, standardized inclusion and exclusion criteria were applied prospectively. Information bias was reduced by using a structured, pre-defined case report form (CRF) completed at the bedside by the attending anesthesiologist throughout each procedure. Confounding was addressed through multivariate logistic regression, adjusting for all variables with $p < 0.20$ on univariate analysis. Observer bias was minimized by providing a written operational definition of each outcome variable to all data collectors prior to data collection.

Statistical analysis:-

Statistical analysis was performed using Jamovi version 2.6.44 (The Jamovi Project, Sydney, Australia). Continuous variables are expressed as median and interquartile range (IQR); categorical variables as absolute numbers and percentages. Univariate analysis was conducted for each candidate risk factor to preliminarily identify associations. Then variables with a p-value <0.20 in the univariate analysis were entered into a multivariable logistic regression model to control for confounding and identify independent predictors of complications. Adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were calculated to quantify the strength of association between risk factors and complications. Statistical significance was set at a p-value <0.05. 3.

Results:-

Study population:-

A total of 470 patients were enrolled. The most represented age group was 5–12 years (46.8%). The male-to-female ratio was 1.94. Orthopedic and trauma surgery was the leading surgical specialty (45.1%), followed by visceral surgery (28.9%) and urological and neurosurgical procedures (26.0%). Emergency procedures accounted for 44.0% of cases. ASA class I–II was recorded in 75.1% of patients and Mallampati score I–II in 63.0%. Signs of upper airway obstruction were present in 18.1% of patients. Demographic and intraoperative characteristics of the entire cohort are summarized in Table 1.

Table 1. Demographic and Intraoperative Characteristics of Patients (n = 470).

Variables	n (%)
Patient characteristics	
Gender M / F	310 (66.0%) / 160 (34.0%)
Age group	
• < 12 months	48 (10.2%)
• 1–5 years	117 (24.9%)
• 5–12 years	220 (46.8%)
• > 12 years	85 (18.1%)
ASA physical status I–II	353 (75.1%)
ASA physical status III–IV	117 (24.9%)
Mallampati score I–II	296 (63.0%)
Mallampati score III–IV	89 (18.9%)
Mallampati non-assessable	85 (18.1%)
Signs of upper airway obstruction	85 (18.1%)

Surgicalfactors	
Surgicalspecialty	
• Orthopedic / trauma	212 (45.1%)
• Visceralsurgery	136 (28.9%)
• Urological / neurosurgery	122 (26.0%)
Emergency procedure	207 (44.0%)
Surgical duration > 2 hours	98 (20.9%)
Anestheticfactors	
Type of anesthetic induction	
• Intravenous	308 (65.5%)
• Combined (IV + inhalational)	162 (34.5%)
Multiple intubation attempts (≥ 2)	70 (14.9%)
Agitation at induction	90 (19.1%)
Ketamine use	65 (13.8%)

Fig. 1. Distribution of perioperative respiratory incident types among affected patients (n = 126).
A patient may present with more than one type of incident simultaneously.

Factors associated with perioperative respiratory incidents — Univariate analysis:-
Univariate logistic regression identified nine significant risk factors for PRI (Table 2): age < 12 months (crude OR = 6.28; $p < 0.001$), upper airway obstruction (OR = 5.11; $p < 0.001$), multiple intubation attempts ≥ 2 (OR = 16.99; $p < 0.001$), Mallampati score III–IV (OR = 3.83; $p < 0.001$), combined induction (OR = 3.42; $p < 0.001$), agitation at induction (OR = 3.08; $p < 0.001$), ASA class III–IV (OR = 2.72; $p < 0.001$), surgical duration > 2 hours (OR = 2.04; $p = 0.004$), and emergency surgery (OR = 1.65; $p = 0.004$). Male sex (OR = 1.15; $p = 0.52$) and ketamine use (OR = 1.25; $p = 0.45$) were not significantly associated with PRI. All variables with $p < 0.20$ were retained for multivariate analysis.

Table 2. Univariate logistic regression analysis of factors associated with perioperative respiratory incidents (n = 470).

Variable	Crude OR	95% CI	p-value
Patient characteristics			
Male sex	1.15	[0.74–1.78]	0.52
Age < 12 months	6.28	[3.33–11.83]	< 0.001
ASA class III–IV	2.72	[1.74–4.25]	< 0.001
Mallampati score III–IV †	3.83	[2.30–6.38]	< 0.001
Upper airway obstruction	5.11	[3.11–8.38]	< 0.001
Surgical and anestheticfactors			
Emergency surgery	1.65	[1.10–2.50]	0.004
Surgical duration > 2 hours	2.04	[1.28–3.28]	0.004
Combined induction (IV + inhalational)	3.42	[2.24–5.24]	< 0.001
Multiple intubation attempts (≥ 2)	16.99	[9.09–31.77]	< 0.001
Agitation at induction	3.08	[1.91–4.98]	< 0.001
Ketamine use	1.25	[0.71–2.22]	0.45

OR: Crude Odds Ratio; CI: 95% Confidence Interval. Estimated by univariate binary logistic regression. p-values from Wald test. † Mallampati score assessed in 385/470 patients; uncooperative patients (n = 85) excluded from this analysis.

Independent risk factors — Multivariate logistic regression:-

All variables with $p < 0.20$ on univariate analysis were entered into a binary logistic regression model using a stepwise backward elimination strategy. After adjustment, three independent risk factors were identified (Table 3): upper airway obstruction (adjusted OR = 3.47; 95% CI [1.9–6.3]; $p < 0.001$), multiple intubation attempts ≥ 2 (adjusted OR = 5.94; 95% CI [2.6–13.7]; $p < 0.001$), and agitation at induction (adjusted OR = 2.05; 95% CI [1.1–3.8]; $p = 0.04$). Model goodness-of-fit was satisfactory (Hosmer–Lemeshow $p = 0.42$).

Table 3. Multivariate logistic regression — Independent predictors of perioperative respiratory incidents.

Clinicalrisk factor	Adjusted OR	95% CI	p-value
Upper airway obstruction	3.47	[1.9–6.3]	< 0.001
Multiple intubation attempts (≥ 2)	5.94	[2.6–13.7]	< 0.001
Agitation at induction	2.05	[1.1–3.8]	0.04

OR: Adjusted Odds Ratio; CI: 95% Confidence Interval. Hosmer–Lemeshow goodness-of-fit test: p = 0.42.

Discussion:-

Incidence of perioperative respiratory incidents:-

The incidence of PRIs in our series (26.8%) is consistent with prospective data from comparable African settings. Wudineh et al. reported a prevalence of 26.2% in a prospective study of 210 pediatric surgical patients in Northwest Ethiopia [7], and Hordofa et al. similarly identified an incidence of 29.8% in a 2024 prospective study of 205 pediatric patients in southern Ethiopia [18], further confirming the elevated burden of perioperative respiratory events in sub-Saharan African contexts. In contrast, Tay et al. found a 2.97% critical incident rate (77.4% of which were respiratory events) in Singapore [8]. These figures contrast markedly with high-income country data: the APRICOT study reported a 5.2% incidence of severe critical respiratory events across 261 European hospitals [4], while the NECTARINE study documented that one third of neonates and young infants undergoing anaesthesia across 31 European countries required an intervention for a severe critical event [19]. In the ambulatory setting, Subramanyam et al. reported 3.1% in a large US cohort [9]. These disparities are largely attributable to the high proportion of emergency surgeries in our cohort (44%), the greater prevalence of nutritional and respiratory comorbidities, and resource constraints limiting access to advanced airway management equipment.

Upper airway obstruction:-

UAO was the most prevalent independent risk factor in our model (adjusted OR = 3.47). Adenotonsillar hypertrophy is the leading etiology of UAO in children, generating bronchial hyperreactivity and airway lability that predispose to laryngospasm and bronchospasm under general anesthesia [10,11]. These findings are aligned with the established literature demonstrating that children with UAO have a threefold to fivefold elevated risk of perioperative respiratory complications. Notably, a pre-existing pulmonary disorder appears as one of the 11 predictors of the recently validated SPORC-C score, reinforcing the importance of systematic preoperative airway assessment [20]. Combined (IV + inhalational) induction was also significantly associated with PRIs on univariate analysis, consistent with data showing that inhalational agents increase airway reactivity in children with underlying bronchial hyperresponsiveness. Ramgolam et al. demonstrated in a randomized controlled trial that intravenous induction significantly reduced the risk of respiratory adverse events compared to inhalational or combined induction in high-risk children [10].

Multiple intubation attempts:-

Multiple intubation attempts were the strongest independent predictor in our model (adjusted OR = 5.94). Each additional laryngoscopy attempt causes mucosal trauma, laryngeal edema, and increased airway reactivity, cumulatively raising the risk of desaturation, bronchospasm, and laryngospasm [12,13]. The rate of multiple intubation attempts in our series (14.9%) likely reflects limited access to pediatric videolaryngoscopy and flexible fiberscopic equipment, and the absence of formally implemented difficult airway management algorithms. Konrad et al. demonstrated that structured training protocols significantly reduced the number of intubation attempts and associated complications [14]. Implementation of such protocols, combined with appropriate equipment availability, constitutes a high-priority safety intervention in our setting.

Agitation at induction:-

Agitation at induction was an independent risk factor in our series (adjusted OR = 2.05), with 19.1% of children affected. Agitation impairs adequate face-mask placement and preoxygenation, significantly increasing the risk of early desaturation. Preoperative anxiety is a well-established precipitant, particularly in children under 3 years and in

those undergoing inhalational induction [15]. Oral midazolam premedication and intramuscular ketamine are validated strategies to reduce induction agitation [16,17]. A recent systematic review and meta-analysis of 7 categories of prophylactic pharmacological interventions in children undergoing noncardiac surgery confirmed the efficacy of several agents in reducing overall PRAEs and their subtypes including laryngospasm, bronchospasm, and oxygen desaturation [21]. Of interest, ketamine showed no significant association with PRI in univariate analysis (crude OR = 1.25; p = 0.45), though this does not exclude a clinically meaningful effect given the limited number of exposed patients (n = 65). Its bronchodilatory properties and capacity to preserve upper airway reflexes remain a plausible mechanistic rationale [16]. The limited number of exposed patients (n = 65) precluded a definitive conclusion, and this hypothesis warrants investigation in a dedicated randomized controlled trial.

Other associated factors:-
Young age, elevated ASA score, and emergency surgery were strongly associated with PRIs on univariate analysis, reflecting findings from prior literature. Infants under 12 months had a particularly high incidence (64.6%), attributable to anatomophysiological specificities including a relatively large occiput, high laryngeal position, reduced thoracic compliance, and predisposition to obstructive apneas [1,2]. These factors were not retained in the final multivariate model, likely due to collinearity with the variables that were retained.

Limitations:-
This study has several limitations. Its single-center monocentric design limits generalizability to the national level. Prospective observational data collection may have been subject to variable detection bias across operators. Missing Mallampati scores in uncooperative patients (18.1%) may have influenced the analyses. The composite endpoint groups events of variable clinical severity, which limits the interpretation of certain associations. Finally, potential confounders such as recent upper respiratory tract infection and passive tobacco smoke exposure were not systematically recorded and may have contributed to residual confounding.

Conclusion:-
This prospective observational study demonstrates that perioperative respiratory incidents remain frequent in pediatric anesthesia at a Moroccan referral center, with an incidence of 26.8%. Upper airway obstruction, multiple intubation attempts, and agitation at induction were identified as the three independent risk factors. These findings support systematic preoperative airway assessment including active UAO screening, implementation of structured difficult airway algorithms with appropriate equipment availability, and targeted anxiolytic premedication strategies as priority measures to improve pediatric anesthetic safety. Multicenter national studies are needed to confirm these results, identify regional disparities, and evaluate the impact of educational and organizational interventions on perioperative respiratory safety in pediatric anesthesia.

List of Abbreviations:- ASA: American Society of Anesthesiologists; CI: Confidence Interval; IQR: Interquartile Range; OR: Odds Ratio; PRI: Perioperative Respiratory Incident; SpO2: Peripheral Oxygen Saturation; STROBE: Strengthening the Reporting of Observational Studies in Epidemiology; UAO: Upper Airway Obstruction.

Ethics Approval and Consent to Participate :-This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Informed consent was obtained from the parents or legal guardians of each patient prior to inclusion. Patient data were anonymized prior to analysis.

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Conflict of Interest:- The author(s) confirm(s) that there is no conflict of interest related to this manuscript.

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