MHA MEDIHEALTH ACADEMY

Eurasian Journal of
Anesthesiology & Intensive Care

Original Article

doi
10.51271/EAJAIC-0062

Integrated Pulmonary Index in pediatric sedation for bronchoscopy, a prospective cohort study

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Cite this article: Kelleci Y, Abdullayev R. Integrated Pulmonary Index in pediatric sedation for bronchoscopy, a prospective cohort study. *Eur J Anesthesiol Intens Care.* 2026;3(4):101-107. doi:10.51271/EAJAIC-0062

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Received: 14/09/2026 ◆ **Accepted**: 14/11/2026 ◆ **Published**: 23/11/2026

ABSTRACT

Aims: To compare periprocedural Integrated Pulmonary Index (IPI) values in pediatric patients undergoing bronchoscopy under propofol- or ketamine-based sedation, and to evaluate associated physiological parameters, recovery time, and procedural satisfaction.

Methods: In this prospective cohort study, 60 children aged 1 month to 18 years undergoing elective diagnostic bronchoscopy were included. Patients received either propofol (group P) or ketamine (group K) at the discretion of the attending anesthetist. All patients received midazolam and remifentanil, and respiratory parameters were continuously monitored using an IPI monitor. End-tidal carbon dioxide ($ETCO_2$), respiratory rate (RR), peripheral oxygen saturation (SpO_2), pulse rate (PR), and IPI values were recorded at 3-minute intervals. Primary outcome was mean periprocedural IPI. Secondary outcomes included recovery time, airway interventions, bronchoscopist and anesthetist satisfactions.

Results: There was no statistically significant difference in mean IPI values between the groups (4.4±1.6 vs 4.5±1.1 in group P and group K, respectively; p=0.909). Group K had significantly lower RR and higher PR than group P (p=0.023 and p<0.001, respectively). Bag-mask ventilation was required more frequently in group K (p=0.029), and recovery time was significantly longer (p<0.001). Satisfaction scores did not differ significantly between groups. $ETCO_2$, RR, SpO_2, and PR differed significantly across low (1–3), medium (4–6), and high (7–10) IPI categories (all p<0.001).

Conclusion: Propofol and ketamine provided comparable periprocedural IPI values during pediatric diagnostic bronchoscopy despite differences in respiratory and cardiovascular profiles and recovery characteristics. IPI demonstrated consistent associations with standard physiological respiratory parameters and may provide a useful integrated measure for detecting changes in respiratory status during pediatric sedation.

Keywords: Child, ketamine, monitoring; physiologic, procedural sedation, propofol

INTRODUCTION

Respiratory depression and airway obstruction are the primary causes of morbidity and mortality during pediatric sedation.[1,2] While diagnostic bronchoscopy is essential for assessing airway pathologies, it is an invasive procedure that necessitates various sedo-analgesia methods to minimize anxiety and pain. Current clinical practice guidelines emphasize the continuous monitoring of a patient's hemodynamic and ventilatory status, as well as their state of consciousness, to facilitate the early recognition of adverse outcomes.[2]

Pulse oximetry remains the standard of care for detecting hypoxemia, yet it has significant limitations, including a delayed display of arterial deoxygenation and a lack of real-time information regarding ventilation. In the presence of supplemental oxygen, significant alveolar hypoventilation may go undetected by pulse oximetry alone.[3] In contrast, capnography has been found superior in detecting hypoventilation and airway obstruction, frequently identifying disordered respiration before the onset of measurable hypoxia. Guidelines now suggest that

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capnography should be used routinely, especially during deep sedation where verbal communication is interrupted.[4–6]

The Integrated Pulmonary Index (IPI) is a tool designed to simplify the assessment of respiratory status by utilizing a fuzzy logic mathematical model algorithm. It integrates four key physiological parameters—end-tidal carbon dioxide ($ETCO_2$), respiratory rate (RR), peripheral oxygen saturation (SpO_2), and pulse rate (PR)—into a single numerical value ranging from 1 to 10. An IPI score of 10 represents optimal status, while a score of 1–2 indicates the need for immediate emergency intervention (**Supplementary Table 1**). Studies have shown that IPI scores correlate well with clinical assessments, making the monitor a practical adjunct for clinicians in non-operating room settings.[1]

Supplementary Table 1. Patient status definition according to different IPI scores

IPI	Patient status
1	Requires immediate intervention
2	Requires immediate intervention
3	Requires intervention
4	Requires intervention
5	Requires attention and may require intervention
6	Requires attention and may require intervention
7	Close to normal range; requires attention
8	Within normal range
9	Within normal range
10	Normal

IPI: Integrated Pulmonary Index

Propofol and ketamine are frequently used agents for pediatric endoscopy and bronchoscopy. Propofol is favored for its rapid onset and short half-life, which provides quick recovery; however, it is associated with a risk of dose-dependent respiratory depression, apnea, and hemodynamic instability. Ketamine, a dissociative anesthetic, generally preserves airway muscle tone and protective reflexes, causing less respiratory and hemodynamic suppression, though it may result in increased oral secretions and a prolonged recovery period.[7]

Despite the widespread use of these agents, their individual effects on IPI values in the pediatric population remain understudied. This prospective cohort study aimed to investigate and compare the periprocedural IPI values in pediatric patients sedated with either propofol or ketamine during diagnostic bronchoscopy. The primary outcome measure was average periprocedural IPI values. The secondary outcome measures were recovery time, bronchoscopist and anesthetist satisfactions. We hypothesized that patients sedated with ketamine would maintain higher IPI values due to the drug's more favorable respiratory profile.

METHODS

This study received approval from the Marmara University Faculty of Medicine Clinical Researches Ethics Committee (Date: 07.05.2021, Decision No: 09.2021.497) and was registered at ClinicalTrials.gov (No: NCT05137587). Pediatric patients who underwent elective bronchoscopy under sedation at our institution between September 2022 and February 2023 were enrolled in the study. Written informed consent was obtained from the patients' parents or legal guardians prior to participation. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Patients older than 1 month and younger than 18 years of age with an American Society of Anesthesiologists Physical Status Classification (ASA) score of I–III were included in the study. Patients were excluded if participation was declined by their guardians, if they had an ASA physical status of IV or higher, if they were not suitable candidates for non-operating room anesthesia, or if they had a known allergy to any of the sedative drugs used. In addition, patients who developed any of the following conditions after enrollment were excluded from further analysis: anaphylactic reactions related to the administered drugs, respiratory failure requiring endotracheal intubation, hemodynamic instability, or major bronchoscopy-related complications.

Participants were allocated into two groups according to the sedative agent administered. In the first group (group P), sedation was achieved using propofol, whereas ketamine was used in the second group (group K). No randomization was performed and the choice of the sedative agent was left to the discretion of the primary anesthetist. Patients were unaware of the group allocation and were blinded to the study design. The anesthetist responsible for drug administration and data collection was the same for all procedures and was not blinded. However, the pediatric bronchoscopist performing the bronchoscopy procedure was blinded to group allocation.

Upon arrival in the procedure room, routine monitoring was initiated, including pulse oximetry (SpO_2), three-lead electrocardiography (ECG), and non-invasive blood pressure (NIBP) monitoring. After peripheral intravenous access was obtained, a balanced crystalloid solution was infused at a rate of 10 ml/kg/h. Sedation and anxiolysis were initiated with intravenous midazolam at a dose of 0.05 mg/kg. For respiratory monitoring, a specialized nasal cannula (Smart CapnoLine Plus; Oridion Medical, Needham, MA, USA) capable of measuring IPI was placed and connected to a monitor (Capnostream 20; Oridion Medical, Needham, MA, USA). Oxygen was administered at a rate of 2 L/min through the nasal cannula.

After confirmation that the bronchoscopy team was ready, remifentanil 0.5 µg/kg IV was administered. The patient was then positioned supine. Subsequently, propofol 0.5 mg/kg IV was administered in group P and ketamine 0.5 mg/kg IV in group K. When a sedation depth corresponding to a score of 5 or 6 on the Ramsay Sedation Scale (minimal or no response to glabellar tapping) was achieved, the patient was handed over to the bronchoscopy team to begin the procedure. Additional doses of remifentanil (0.5 µg/kg IV), propofol (0.5 mg/kg IV for group P), or ketamine (0.5 mg/kg IV for group K) were administered when necessary according to the anesthetist's clinical judgment.

All study data were recorded by the anesthetist performing the sedation. Demographic and anthropometric characteristics,

ASA physical status, drug doses administered, and procedure and recovery durations were documented. $ETCO_2$, RR, SpO_2, and PR values were recorded at three-minute intervals beginning from the induction of anesthesia.

The primary outcome of the study was the mean IPI value. Secondary outcomes included recovery time as well as bronchoscopist and anesthetist satisfactions. Satisfaction levels were evaluated using a Likert scale ranging from 1 to 10. The number of jaw-thrust maneuvers and bag-valve-mask assisted ventilations applied during the procedure were also documented. Furthermore, correlations between IPI values and $ETCO_2$, RR, SpO_2, and PR were analyzed. IPI values were categorized into three groups: Low IPI (1-3), Medium IPI (4-6), and High IPI (7-10). The $ETCO_2$, RR, SpO_2, and PR measurements were compared among these categories.

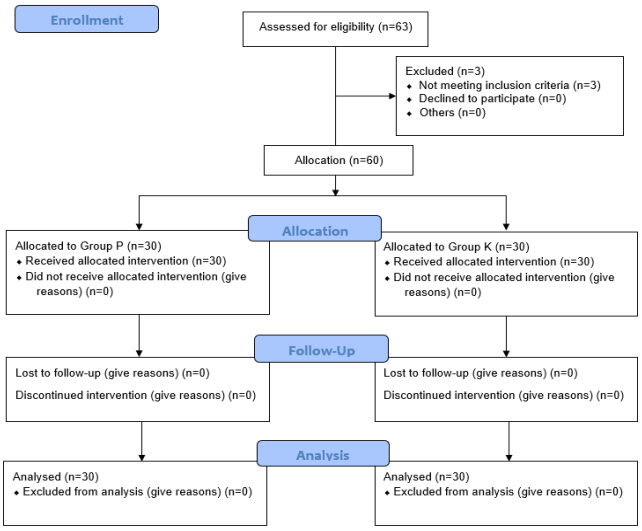

Figure 1. Study flow diagram

Statistical Analysis

The data were analyzed using jamovi statistical software (Version 2.3). Categorical variables were presented as frequencies and percentages, whereas continuous variables were expressed as mean±standard deviation for normally distributed data and median with interquartile range for non-normally distributed data. Normality was assessed using the Shapiro-Wilk test and histogram inspection. The Chi-squared or Fisher's exact test was used for the analysis of categorical variables. Continuous variables were analyzed using Student's or Welch's t-test for normally distributed data and the Mann-Whitney U test for non-normally distributed data. Comparisons of $ETCO_2$, RR, SpO_2, and PR values across IPI score categories were performed using the Kruskal-Wallis test, followed by pairwise comparisons with the Dwass-Steel-Critchlow-Fligner (DSCF) test. Independent variables in the study included age, gender, height, body weight, procedure duration, midazolam dose, remifentanil dose, sedative drug group, ASA score, intervention type, and the number of bag-valve-mask maneuvers. Dependent variables consisted of $ETCO_2$, RR, SpO_2, PR, IPI scores, and IPI score categories. Power analysis was conducted using G*Power (version 3.1). Based on the primary outcome (IPI score), assuming an alpha error of 5%, a study power of 80%, and an effect size of 0.75 derived from preliminary measurements obtained from eight patients, the required sample size was calculated as 58. A total of 60 patients in two groups was decided to be recruited.

RESULTS

Among the 63 patients assessed for eligibility, 60 were ultimately included in the final analysis. The study flow diagram is shown in Figure 1. Of the included participants, 33 (55%) were male. The median age of the cohort was 9 years (25th-75th percentiles: 3-13.5). The demographic and clinical characteristics of the patients are summarized in Table 1.

Patients in group P had significantly greater age, height, and body weight compared with those in group K (p=0.020, p=0.038, and p=0.030, respectively; Mann-Whitney U test). No significant differences were observed between the groups regarding gender distribution and ASA physical status. Doses of midazolam and remifentanil administered per kilogram basis were significantly higher in group K (p values 0.023 and 0.043, respectively). There was no statistically significant difference in mean IPI values between the groups (4.4±1.6 in group P vs 4.5±1.1 in group K; median difference -0.04, 95% CI: -0.73 to 0.66, p=0.909, Welch's t-test).

Atropine administration was significantly more frequent in group K (p<0.001, Chi-squared test). The number of jaw-thrust maneuvers did not differ significantly between the groups (p=0.181, Mann-Whitney U test). However, the number of bag-mask ventilations was higher in group K (p=0.029, Mann-Whitney U test). Although procedure duration was comparable between the groups, recovery time was significantly longer in group K (p<0.001, Mann-Whitney U test). Bronchoscopist and anesthetist satisfaction scores were also similar between the groups.

Regarding physiological parameters, the average SpO_2 and $ETCO_2$ values were comparable between the groups. PR was significantly higher in group K than in group P (p<0.001, Welch's t-test), whereas RR was significantly lower in group K compared with group P (p=0.023, Mann-Whitney U test).

Descriptive statistics of the IPI values together with their associated physiological parameters are presented in Figure 2 and Supplementary Table 2. The comparison of physiological parameters ($ETCO_2$, RR, SpO_2, and PR) among the low, medium, and high IPI categories is shown in Table 2. Significant differences were identified among the three IPI groups for $ETCO_2$, RR, SpO_2, and PR (p<0.001, Kruskal-Wallis test). Pairwise comparisons demonstrated that $ETCO_2$ values in the medium IPI group were significantly higher than those in both the low and high IPI groups (p<0.001 and p=0.004, DSCF test). RR differed significantly among all three IPI groups (p<0.001, DSCF test). Similarly, SpO_2 values were significantly different across the three groups (p<0.001, DSCF test). In addition, PR values in the low IPI group were significantly higher than those observed in the medium and high IPI groups (p=0.042 and p<0.001, DSCF test).

No complications directly related to the bronchoscopy procedure were observed in any of the patients.

Table 1. Demographic and clinical characteristics of patients

		Group P (n=30)	Group K (n=30)	p
Age (years)		12 (5.5-15.8)	5 (2-11.5)	0.020*[m]
Gender	Female	16 (53.3)	11 (36.7)	0.194[c]
	Male	14 (46.7)	19 (63.3)	
Height (cm)		150 (112.5-160)	118 (100-147.5)	0.038*[m]
Body weight (kg)		43 (21.5-50)	21.5 (11.3-43.5)	0.030*[m]
BMI (kg/m^2)		18.8±4.6	17.8±5.0	0.511[t]
ASA	I	11 (36.7)	12 (40)	0.580[f]
	II	14 (46.7)	16 (53.3)	
	III	5 (16.7)	2 (6.7)	
Midazolam amount (mg/kg)		0.04 (0.04-0.05)	0.05 (0.04-0.05)	0.023*[m]
Remifentanil amount (µg/kg)		0.94 (0.67-1.00)	1.11 (0.85-1.48)	0.043*[m]
Propofol/ketamine amount (mg/kg)		2.04 (1.94-2.85)	1.86 (1.00-2.00)	NA
IPI		4.4±1.6	4.5±1.1	0.909[w]
Atropine use		9 (30)	24 (80)	<0.001*[c]
Jaw-thrust maneuver (number)		1 (0-2) (0-3)	1 (1-2.8) (0-5)	0.181[m]
	0	10 (33.3)	6 (20)	0.493[c]
	1	9 (30)	10 (33.3)	
	≥2	11 (36.7)	14 (46.7)	
Bag mask ventilation (number)		0 (0-0)	0 (0-1)	0.029*[m]
	0	27 (90)	20 (66.7)	NA
	1	2 (6.7)	6 (20)	
	≥2	1 (3.3)	4 (13.3)	
Procedure duration (min)		10 (7.3-11)	9.5 (8-13)	0.583[m]
Recovery duration (min)		10 (8-12.8)	19.5 (15-25)	<0.001*[m]
Bronchoscopist satisfaction (1–10-point Likert scale)		10.0 (10-10)	10.0 (8.3-10)	0.126[m]
	≤6	1	2	NA
	7-9	3	7	
	10	26	21	
Anesthetist satisfaction (1–10-point Likert Scale)		9 (7.3-10)	7 (5-10)	0.074[m]
	≤6	3	12	NA
	7-9	18	9	
	10	9	9	
SpO_2 (%)		89.7 (84.8-93)	88.4 (80.6-93.2)	0.460[m]
PR (beats/min)		123.9±23.2	145.7±15.7	<0.001*[w]
RR (breaths/min)		14.1 (11.6-18)	11.6 (8.8-15.7)	0.023*[m]
$ETCO_2$ (mmHg)		38.9±9.6	36.8±9.1	0.391[t]

Continuous variables are given as median (25th–75th percentiles) or mean±standard deviation. Categorical variables are given as number (percentage). For jaw-thrust maneuvers minimum-maximum values are given in the separate parentheses as well. group P, propofol group; group K, ketamine group; [c]Chi-squared test; [f]Fisher's exact test; [m]Mann-Whitney U test; [t]Student's t test; [w]Welch's t test; NA, not assessed. *p<0.05. BMI: Body-mass index, ASA: American Society of Anesthesiologists physical status, IPI: Integrated Pulmonary Index, SpO_2: Peripheral oxygen saturation (%), PR: Pulse rate (beats/min), RR: Respiratory rate (breaths/min), $ETCO_2$: End-tidal carbon dioxide (mmHg), min: Minute

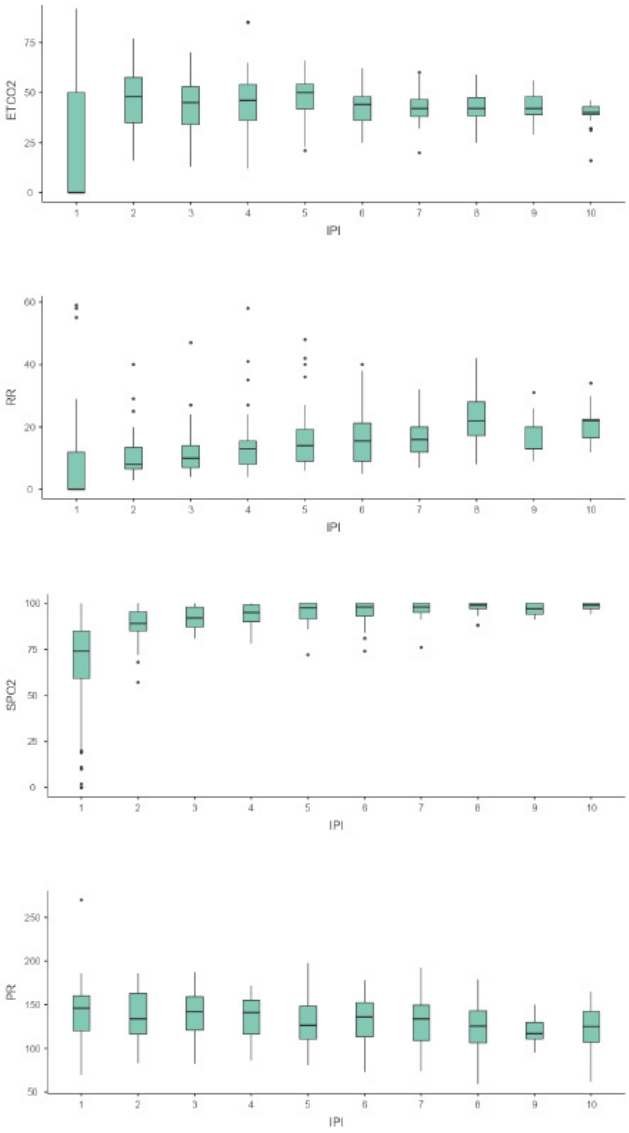

Figure 2. Distribution of physiological variables with different IPI values

Please note that IPI is determined by the combination of all the four parameters using the fuzzy logic principle (see text). IPI: Integrated Pulmonary Index, $ETCO_2$: End-tidal carbon dioxide, RR: Respiratory rate, SpO_2: Peripheral oxygen saturation, PR: Pulse rate

DISCUSSION

The primary finding of this prospective cohort study was that pediatric patients undergoing diagnostic bronchoscopy exhibited comparable periprocedural IPI scores when sedated with either propofol or ketamine. Specifically, the average IPI scores were 4.4±1.6 in the propofol group and 4.5±1.1 in the ketamine group. These results suggest that while the two agents possess distinct pharmacological profiles, they provide a similar level of respiratory status during invasive airway procedures when managed by a dedicated anesthesia team. Interestingly, the average IPI values in our study were lower than those reported in recent pediatric gastrointestinal endoscopy literature, such as the median values of 6.3–6.8 observed by Abdullayev et al.[1] This discrepancy likely reflects the more stimulating and invasive nature of bronchoscopy, which involves direct manipulation of the airway and a higher inherent risk of respiratory interference.[8]

Although IPI scores were similar, significant physiological differences were observed between the groups. The RR was significantly lower in the ketamine group compared to the propofol group, while the PR was significantly higher in the ketamine group. The higher PR in group K is consistent with ketamine's known sympathomimetic effects, which typically result in increased heart rate and blood pressure. Conversely, propofol is often associated with dose-dependent respiratory depression and hemodynamic instability, including bradycardia and hypotension.[9]

Supplementary Table 2. Distribution of physiological variables with different IPI values

IPI	Number of measurements	$ETCO_2$ (mmHg)	RR (breaths/min)	SpO_2 (%)	PR (beats/min)
1	126	0 (0–50)	0 (0–12)	74 (59.25–85)	146 (120–160)
2	35	48 (35–57.5)	8 (6.5–13.5)	89 (85–95.5)	134 (116.5–163)
3	49	45 (34–53)	10 (7–14)	92 (87–98)	142 (121–159)
4	31	46 (36–54)	13 (8–15.5)	95 (90–99)	141 (116.5–155)
5	36	50 (41.75–54.3)	14 (9–19.3)	97.5 (91.5–100)	126.5 (110.75–148.5)
6	48	44 (36–48)	15.5 (9–21.3)	98 (93–100)	136 (113.25–152.5)
7	39	42 (38–46.5)	16 (12–20)	98 (95–100)	134 (109–149.5)
8	54	42 (38.25–47.5)	22 (17.25–28)	99 (97–100)	125.5 (106.5–143.3)
9	9	42 (39–48)	13 (13–20)	97 (94–100)	117 (111–130)
10	31	40 (39–43)	22 (16.5–22.5)	99 (97–100)	125 (107.5–142.5)
Total	458	42 (32–50)	13 (7–20)	94.5 (85–99)	137 (114–155)

Variables are given as median (25th–75th percentiles). IPI: Integrated Pulmonary Index, ETCO2: End-tidal carbon dioxide, RR: Respiratory rate, SpO2: Peripheral oxygen saturation; PR: Pulse rate.

Table 2. Distribution of physiological parameters according to low, medium, and high IPI groups

	Low IPI (1-3) (n=210)	Medium IPI (4-6) (n=115)	High IPI (7-10) (n=133)	p
$ETCO_2$ (mmHg)	36.5 (0-52)	46 (37.5-52.5)[a]	41 (38-46)	<0.001*
RR (breaths/min)	7 (0-13)[b]	14 (9-19.5)[b]	20 (14-24)[b]	<0.001*
SpO_2 (%)	84 (70-92)[c]	97 (92-100)[c]	99 (97-100)[c]	<0.001*
PR (beats/min)	143 (119-160)[d]	137 (114-154)	126 (106-146)	<0.001*

Variables are given as median (25th–75th percentiles). *p<0.05. Kruskal-Wallis test was used. [a]Significant difference compared to the low and high IPI groups (p<0.001 and 0.004, respectively, Dwass-Steel-Critchlow-Fligner (DSCF) test). [b]Significant difference between all the IPI groups (p<0.001, DSCF test). [c]Significant difference between all the IPI groups (p≤0.001, DSCF test). [d]Significant difference compared to the medium and high IPI groups (p=0.042 and<0.001, respectively, DSCF test). IPI: Integrated Pulmonary Index, $ETCO_2$: End-tidal carbon dioxide, mmHg: Millimeters of mercury, RR: Respiratory rate, SpO_2: Peripheral oxygen saturation, PR: Pulse rate, Min: Minute

Even though the midazolam and remifentanil doses administered per kilogram basis were statistically different between the groups, being higher in group K, this difference was too low to have clinical significance.

A notable clinical finding was that bag-mask ventilation was required significantly more often in the ketamine group. While ketamine is generally recognized for preserving spontaneous respiration and protective airway reflexes, it can also cause increased oral secretions and, in rare instances, laryngospasm.[10,11] These factors can compromise the airway even if the patient's drive to breathe remains intact, necessitating assisted ventilation to restore normoventilation. In our study, this was further evidenced by the significantly higher use of atropine in the ketamine group, likely administered to manage secretions or potential bradyarrhythmias, though the latter is less common with ketamine.[12,13] As the PR is one of the four parameters incorporated into the IPI calculation, administration of ketamine might have influenced the composite IPI score. Interpretation of IPI in patients in whom ketamine was administered as part of the regimen should be made in this context.

Our results showed that recovery time was significantly longer in the ketamine group compared to the propofol group, which aligns with established pharmacological data. Propofol is favored for its rapid onset and short half-life, leading to quick awakening and shorter recovery periods. Ketamine, despite its benefits in preserving hemodynamics, is associated with a more prolonged recovery and the potential for unpleasant emergence reactions. Despite the differences in recovery dynamics and the need for more frequent airway interventions in the ketamine group, bronchoscopist satisfaction scores were comparable between the two groups. This indicates that both agents provide adequate procedural conditions for diagnostic bronchoscopy.[9] Even though not statistically significant, a trend towards lower satisfaction scores were noted in the ketamine group. This might have been attributed to increased secretions, as noted by higher rate of atropine administration, and bag-mask ventilation need in this group. As this was not the primary endpoint of the study, this needs further investigation.

The study demonstrated a strong and consistent correlation between IPI scores and standard physiological parameters ($ETCO_2$, RR, SpO_2, and PR). IPI can be a simplified and practical tool for real-time respiratory monitoring in the pediatric population. Our analysis showed that low IPI scores (1–3 points) were significantly associated with the lowest values for RR and SpO_2. Interestingly, the PR was significantly higher in the low IPI group compared to the medium and high groups, likely reflecting a compensatory tachycardic response to respiratory distress or the inherent "fuzzy logic" algorithm of the IPI monitor which incorporates PR into its calculation.[2,14,15]

Pairwise comparisons using the DSCF test revealed that $ETCO_2$ was significantly higher in the medium IPI group compared to both the low and high groups. High $ETCO_2$ is often a sign of hypoventilation or hypercapnia during sedation, which would naturally lower the IPI score from 'normal' (8–10) to 'requires attention' (4–7).[1,2,13] However, the very low $ETCO_2$ values observed in the low IPI group (1–3) likely indicate apnea or complete airway obstruction, where CO2 fails to reach the sampling line entirely. These findings support previous research suggesting that IPI monitoring is superior to pulse oximetry alone because it captures ventilatory changes—such as apnea or hypopnea—long before measurable desaturation occurs.

The use of IPI is particularly valuable in non-operating room anesthesia settings, such as bronchoscopy suites, where the risk of cardiopulmonary complications remains a significant concern.[16,17] Current guidelines emphasize that capnography should be used routinely during deep sedation when verbal

communication is interrupted, as pulse oximetry can be a lagging indicator of respiratory failure, especially when supplemental oxygen is provided. In our study, IPI served as an important numerical surrogate that allowed the anesthesia team to identify respiratory trends quickly. Studies by Peveling-Oberhag et al.[4] and others have shown that capnography-based tools can detect respiratory compromise 83–99 seconds earlier than standard monitoring, providing a vital window for intervention.[8,18]

Limitations

Several limitations to this study must be addressed. First, there were significant demographic differences between the groups, as patients in group P were older than those in group K. A significant bias in selecting patients for group K might have contributed, as the drug protocol choice was left to the discretion of the primary anesthetist. Taking into consideration physiological development, patient age is an important factor in the pattern of respiratory depression. Younger age has been identified as a factor associated with lower IPI scores and a higher risk of respiratory complications, which may have confounded the comparison. Further studies in this regard should take this fact into consideration, and homogeneous groups particularly the patient age should be considered. Second, we did not utilize objective measures for sedation depth, such as processed electroencephalography. While clinical scales like the Ramsay Sedation Scale are common, objective monitoring could have ensured greater group homogeneity regarding the level of sedation provided. Future studies in this regard should consider objective monitors of depth of anesthesia, like Bispectral Index. Third, the anesthetist performing the sedation was also responsible for recording the IPI scores, which introduces the possibility of observation bias. Finally, the single-center design may limit the generalizability of these findings to broader pediatric populations.

CONCLUSION

As a result, the IPI can be a valuable monitor for pediatric patients undergoing diagnostic bronchoscopy. Our study demonstrates that propofol and ketamine result in comparable IPI scores, although they exhibit different physiological and recovery profiles. While ketamine resulted in a longer recovery time, it remains a clinically acceptable option with high satisfaction among the medical team. The strong correlation between IPI values and physiological data may provide a comprehensive and accurate summary of a patient's respiratory status. We recommend that clinicians utilize IPI monitoring to enhance patient safety during pediatric sedation, particularly in high-risk airway procedures where early detection of hypoventilation is critical. Future studies should aim for more balanced demographics and the inclusion of objective sedation depth monitoring to further refine these comparisons.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study received approval from the Marmara University Faculty of Medicine Clinical Researches Ethics Committee (Date: 07.05.2021, Decision No: 09.2021.497).

Informed Consent

Informed consent was obtained from a parent or legal guardian. Where appropriate, age-adjusted assent was also obtained from the child. The inclusion of vulnerable populations in this study adhered to national and international ethical guidelines. Extra care was taken to ensure voluntary participation, understanding, and protection of participant dignity and autonomy.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

The authors received no financial support for the conduct or publication of this research.

Author Contributions

Concept: YK, RA; Design: YK, RA; Consultation: YK, RA; Data Collection and/or Processing: YK, RA; Analysis and/or Interpretation: YK, RA; Literature Review: YK, RA; Manuscript Preparation: YK, RA; Critical Review: YK, RA.

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