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Integrated Pulmonary Index (IPI) monitorization under sedation in cataract surgery with phacoemulsification technique

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Abstract

Purpose We aimed to investigate that change of IPI values after sedation of patients undergoing cataract surgery under sedation.

Methods We included 50 patients (ASA I–III) undergoing cataract surgery under sedation by phacoemulsification method in this prospective observational study. IPI, SpO_2, $ETCO_2$, respiratory rate (RR), peripheral pulse rate (PR), hemodynamic data and BIS values and perioperative complications were recorded.

Results Compared to baseline values, RR value at 5th min, RR, PR, IPI values at 10th min and RR, PR values at 15th min were significantly low and heart rate value at 15th min and arterial pressure, bispectral index (BIS) values at 5th min, 10th min, 15th min, 20th min, 25th min and 30th min were lower than baseline values.

Conclusions IPI monitoring will provide guidance during sedation of patients with comorbid diseases undergoing cataract surgery by phacoemulsification method.

Introduction

Cataract surgery is a common surgical procedure usually performed in the elderly population [1, 2]. In this patient group, the number of comorbidities, including hypertension, diabetes mellitus, angina, past myocardial infarction, also increases with increasing age. Tolerance to hypotension decreases in the elderly because of decreased elimination of or increased sensitivity to drugs or multiple diseases. Therefore, the risks of side effects that may arise particularly due to general anesthesia increase [1]. This is the reason why sedation is preferred to general anesthesia. Anesthetic drugs used in sedation are likely to cause cardiac and respiratory depression so rapid recognition and appropriate intervention will protect patients against risks such as brain damage and cardiac arrest [3].

The Integrated Pulmonary Index (IPI) is an algorithm that gives a single numerical value by combining four vital parameters: end-tidal carbon dioxide ($ETCO_2$), respiratory rate (RR), peripheral oxygen saturation (SpO_2) and heart rate (HR) (Fig. 1); the numerical value in the range of 1–10 allows rapid assessment of a patient's clinical condition and helps

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Fig. 1 The Integrated Pulmonary Index (IPI) monitorization

Table 1 Integrated Pulmonary Index (IPI) clinical assessment

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

determine whether he/she needs any intervention (Table 1) [4].

The aim of our study was to investigate that change of IPI values after sedation of patients undergoing cataract surgery under sedation.

Material and methods

After approval of the ethics committee of Fatih Sultan Mehmet Training and Research Hospital (FSMEAH-KAEK 2016/17) and patients' informed consent were obtained, 51 patients with anesthesia risk ASA I–III who would undergo cataract surgery by phacoemulsification (phaco) method were prospectively included to the study. The study was prospectively performed in the FSMEAH ophthalmic surgery room between March 1 and August 31, 2016. The cataract surgery performed under peribulbar anesthesia by ophtalmologist demographic characteristics and ASA values of the patients were recorded. After the patients were

taken to the operating room, bispectral index (BIS) monitoring and IPI monitoring were applied to all patients. After baseline values were obtained, with 5-min intervals throughout the operation, IPI, SpO$_2$, ETCO$_2$, respiratory rate (RR), peripheral pulse rate (PR), hemodynamic data (systolic arterial pressure (SAP), diastolic arterial pressure (DAP), mean arterial pressure (MAP), heart rate (HR)) and BIS values were recorded. Anesthetic drugs were administered in such a way as to obtain a sedation target level of 3–4 according to Ramsay sedation scale (Table 2). Duration of surgery and perioperative complications (bradycardia, tachycardia, apnea, etc.) were recorded.

Statistical analysis

IBM SPSS Statistics 22 (IBM SPSS, Turkey) software package was used for statistical analyses in order to asses data obtained from the study. While the study data were being assessed, normal distribution of parameters was examined by Shapiro–Wilk test. While evaluating study data, in addition to descriptive statistical methods (mean, standard deviation, frequency), in comparison with quantitative data, paired sample t test was used to assess variation at 5 min, 10 min, 15 min, 20 min, 25 min and 30 min with respect to baseline of parameters showing normal distribution and Wilcoxon signed-rank test was used to assess variation at 5 min, 10 min, 15 min, 20 min, 25 min and 30 min with respect to baseline of parameters not showing normal distribution. Significance was assessed at $p < 0.05$ level.

Table 2 Ramsay sedation scale

1 Point—awake, restless and/or agitated
2 Points—awake, calm, oriented
3 Points—sleepy but responsive to verbal stimuli
4 Points—sleepy but brisk response to glabellar tactile stimuli
5 Points—sleepy but sluggish response to glabellar tactile stimuli
6 Points—no response to stimuli

Findings

Sudden and unwanted movement was not observed in patients during the surgery. One patient developed apnea and required mask ventilation so he was excluded from the study. Demographic characteristics of the patients, ASA score distributions and comorbidities of the patients are given in Table 3.

The drugs administered, their amounts and duration of surgery are given in Table 4.

RR value at 5th min, IPI, RR, PR values at 10th min and RR, PR values at 15th min were significantly lower than baseline values (Table 5).

HR value at 15th min and SAP, DAP, MAP, BIS values at 5th min, 10th min, 15th min, 20th min, 25th min and 30th min were lower than baseline values (Table 6).

Discussion

In our study, we observed that IPI monitoring was effective in monitoring respiratory parameters in patients undergoing cataract surgery by phacoemulsification method under sedation. Previous studies in the literature reported that IPI monitoring has been utilized in a wide range of areas and procedures (operating room, intensive care, and non-operating anesthesia, etc.) [5–8].

Sabbatani et al. [9] applied conscious sedation to 45 patients with atrial fibrillation receiving cardioversion. No adverse event occurred in respiratory parameters of the patients monitored by $ETCO_2$ and IPI analysis so the authors concluded that midazolam was effective in conscious sedation during cardioversion applications to patients with atrial fibrillation. However, in that case, we think that no adverse event occurred because deep sedation was not applied [9].

In a pilot study conducted by Vaessen et al. [10] on 20 ASA I and II patients, who received propofol and

Table 3 Distribution of demographic data, ASA scores and comorbidities of the patients

Demographic	Min–max	Mean ± SD
Age (years)	38–85	67.08 ± 10.11
BMI	17.94–44.44	28.85 ± 5.51
Gender n (%)		
Male	21	42
Female	29	58
ASA score n (%)		
1	4	8
2	23	46
3	23	46
Comorbid diseases n (%)		
Hypertension	35	70
Tricuspid insufficiency	1	2
Diabetes mellitus	15	30
Goiter	8	16
Coronary artery diseases	11	22
Hypercholesterolemia	3	6
Arrhythmia	1	2
COPD	3	6
Asthma	3	6
Heart failure	1	2
BPH	1	2
Venous insufficiency	1	2
Multiple myeloma	1	2
Alzheimer's disease	1	2
Aorta insufficiency	1	2
CRF	1	2
Depression	1	2

BPH benign prostatic hyperplasia, *CRF* chronic renal failure

alfentanil for moderate-to-deep sedation before upper gastrointestinal system endoscopies, in 15 of 100 measurement points, IPI values were less than 7, which, according to the authors, was not consistent with the patients' actual clinical conditions and was

Table 4 Drugs administered and duration of surgery

	Min–max	Mean ± SD
Drugs administered		
MIDAZOLAM*	1–3	1.63 ± 0.69
FENTANYL**	50–100	54.17 ± 13.7
Duration of surgery (min)	8–40	21.64 ± 7.46

*mg, **mcg

ascribed to increased $ETCO_2$ value of leakage of CO_2, insufflated throughout endoscopy and accordingly they did not recommend the use of IPI in upper endoscopic gastrointestinal procedures where CO_2 insufflation is used [10]. In addition, Garah et al. [11] obtained 124 measurements from 109 pediatric patients who underwent endoscopic procedures and found low IPI levels for patients from younger age-groups when propofol alone or high-dose midazolam was used for sedation or in the presence of an anesthesiologist during sedation procedure. They concluded that although the number of patients in propofol-only patient group was low, the use of the combination of propofol with low-dose midazolam and/or fentanyl decreased IPI values to a lesser extent than the use of propofol alone and that the use of a combination of medications for sedation has an improving effect on sedation outcome [11]. In GIS endoscopies, the use of propofol alone as a sedative agent for sedation carries a greater risk of cardiopulmonary complications than its use in combination with conventional agents. Combined use of propofol with other agents also reduces the total dose of propofol. This risk exists even in long lasting cases [12]. We used midazolam and fentanyl as sedative agents in our study. We believe that avoiding propofol use in sedation is effective in avoiding unwanted respiratory complications secondary to sedation. The other factor could be that we did not apply deep sedation. In our study, IPI value at 10 min and respiratory rate at 5, 10, 15 min and pulse rate at 10, 15 min were significantly lower than baseline values, however, SpO_2 and $ETCO_2$ values did not decrease. Apnea was observed only a patient in our study, but as indicated by Vargo et al. [13], the appearance of instantaneous real-time respiratory waves alerts us earlier than SpO_2. The patient excluded from the study because of the mask ventilation that is necessity of interference with the

Table 5 Assessment of IPI, SPO_2, $ETCO_2$, RR, PR levels at 5 min, 10 min, 15 min, 20 min, 25 min and 30 min with respect to baseline

	IPI Mean ± SD† (median)	p+	SPO2 Mean ± SD† (median)	p+	ETCO2 Mean ± SD† (median)	p+	RR Mean ± SD**	p+	PR Mean ± SD**	p+
Baseline	8.84 ± 1.86 (10)		97.6 ± 1.43 (98)		31.68 ± 6.61 (33)		16.28 ± 4.13		71.02 ± 12.82	
5 min	8.1 ± 2.48 (9)	0.060	97.12 + 2.47 (98)	0.142	31.14 ± 8.68 (33.5)	0.727	13.88 ± 4.44	0.001*	69.92 ± 11.48	0.158
10 min	7.73 ± 2.5 (8)	0.009*	97.2 ± 2.35 (98)	0.205	31.43 ± 7.95 (34)	0.991	14.08 ± 4.56	0.006*	67.92 ± 14.55	0.049*
15 min	8.26 ± 2.6 (10)	0.143	97.26 ± 2.27 (98)	0.356	31.76 ± 7.51 (34)	0.876	14.26 ± 4.64	0.012*	68.22 ± 10.63	0.004*
20.dk	8.31 ± 2.18 (9)	0.342	97.37 ± 2.04 (98)	0.628	31.83 ± 8.1 (35)	0.732	15.09 ± 4.42	0.137	67.94 ± 10.38	0.068
25 min	8.23 ± 2.11 (8.5)	0.833	97.27 ± 2.07 (97.5)	0.792	30.45 ± 9.27 (35)	0.794	15.82 ± 4.87	0.766	69.5 ± 11.18	0.135
30.dk	8.9 ± 1.1 (9)	0.461	97.7 ± 1.77 (98)	0.420	31.3 ± 6.53 (30.5)	0.889	15.4 ± 4.62	0.867	66.5 ± 12.91	0.769

IPI Integrated Pulmonary Index, RR respiratory rate, PR pulse rate

† Wilcoxon sign test, **Paired samples test, † Changes according to baseline, *$p < 0.05$

Table 6 Assessment of SAP, DAP, MAP and BIS levels at 5 min, 10 min, 15 min, 20 min, 25 min and 30 min with respect to baseline

	SAP Mean ± SD	p^{+}	DAP Mean ± SD	p^{+}	MAP Mean ± SD	p^{+}	HR Mean ± SD	p^{+}	BIS Mean ± SD	p^{+}
Baseline	167.3 ± 27.3		93.1 ± 13.03		122.4 ± 18.34		71.94 ± 12.99		94.18 ± 3.85	
5 min	150.88 ± 24.44	0.001*	85.62 ± 10.75	0.001*	110.68 ± 14.43	0.001*	71.08 ± 12.56	0.425	83.82 ± 7.81	0.001*
10 min	145.96 ± 22.55	0.001*	83.69 ± 10.97	0.001*	107.1 ± 14.05	0.001*	70.88 ± 11.56	0.418	81.22 ± 7.86	0.001*
15 min	145.57 ± 21.04	0.001*	82.5 ± 11.34	0.001*	107.28 ± 14.39	0.001*	68.93 ± 10.4	0.002*	83.72 ± 5.42	0.001*
20 min	146.29 ± 17.62	0.001*	83.8 ± 10.51	0.001*	105.89 ± 12.81	0.001*	68.94 ± 11.61	0.127	84.89 ± 6.53	0.001*
25.dk	148.68 ± 18.38	0.001*	84.14 ± 12	0.001*	108.18 ± 12.66	0.001*	69.67 ± 11.62	0.257	86.82 ± 5.95	0.001*
30.dk	159.1 ± 19.3	0.019*	90.3 ± 11.49	0.013*	117 ± 13.94	0.073	66.9 ± 11.44	0.963	87.7 ± 5.23	0.042*

SAP systolic arterial pressure, *DAP* diastolic arterial pressure, *MAP* mean arterial pressure, *HR* heart rate, *BIS* bispectral index

Paired samples test, $^{+}$Changes with respect to baseline, $*p < 0.05$

airway. This is important in operations requiring anesthesia team to stay away from the airway, such as cataract surgery. Garah et al. [11] ascribed lower IPI scores obtained in the presence of an anesthesiologist to the fact that anesthesiologists in their unit administer anesthesia only to children in the younger age-groups or to patients with high ASA scores and that anesthesiologists tend to be more aggressive in sedation. Riphaus et al. [14] compared the control group with the IPI group in 170 endoscopy patients who underwent deep sedation with midazolam and propofol, and noted that there was no apparent clinical advantage in these patients but IPI was effective in reducing the frequency of apnea episodes.

Berkenstadt et al. [7] found 113 events requiring attention in 51 patients undergoing moderate sedation (midazolam + meperidine) in colonoscopy. The IPI values in these events were 53.1% high (7–10), 32.1% moderate (4–6), 14.2% low (1–3). There was no difference between these IPI groups in respiratory rate, SpO_2 and heart rate, while high $ETCO_2$ values were obtained for high IPI group. They concluded that according to the data, there was limited agreement between respiratory physiological parameters and the IPI.

Fot et al. [15] investigated diagnostic and predictive value of IPI in a study of 40 patients undergoing off-pump coronary artery bypass graft surgery. They noted that IPI provides important information about respiratory and hemodynamic status, especially during the extubation period, of patients undergoing cardiac surgery and may predict postoperative complications during the discontinuation from mechanical ventilation and cardiac output changes. The limitations of their study were relatively small sample size and that all patients received bisoprolol postoperatively, which might have influenced heart rate as well as IPI values.

The limitations of our study are as follows. In our study, sedation was applied moderately depending on the nature of the cataract surgery. The rate of detection of respiratory insufficiency due to sedation may be high in deeper sedation levels. The changes in IPI value in deep sedation might have been more noticeable. The second limitation of our work is that our case count is low.

As a result, changes in IPI value after sedation in cataract surgery applied with sedation in geriatric patients may be indicative of respiratory monitoring.

Compliance with ethical standards

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