

PREDICTION VALUE OF OXYGENATION INDEX AS PREDICTOR FOR POSTOPERATIVE PULMONARY COMPLICATIONS IN UROLOGIC SURGERY

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Abstract

Introduction: It is believed that pressure/flow (P/F) ratio (arterial oxygen to inspired oxygen fraction) does not give the best expression of oxygenation status in mechanically ventilated patients. Therefore, a new oxygenation index (OI) where the mean airway pressure (MAP) is incorporated ($\text{PaO}_2/\text{FiO}_2\text{MAP}$) is showed as superior to P/F in expression of the lung oxygenation status. In this article we wanted to assess the prediction value of OI calculated during urological surgeries as a predictive marker for developing postoperative pulmonary complications (PPC).

Material and methods: We evaluated all elective urologic patients operated in general endotracheal anesthesia, aged 18 to 65 years, without any known history of respiratory disease for the period from January till December 2017. We calculated the P/F ratio and the OI at three time points: after induction in general endotracheal anesthesia in the beginning of mechanical ventilation, 1 hour after induction in anesthesia, and at the end of the surgery before weaning the mechanical ventilation. The primary outcomes were PPC defined by European Society of Anesthesia. The second outcomes were: length of hospital stay, admission to intensive care unit (ICU) and mortality.

Results: A total of 240 patients who met the inclusion criteria were included in this evaluation and finally analyzed. PPC were diagnosed in 25% of patients and respectively 75% were without complications. Postoperative hospital stay was longer in PPC group no matter they were operated laparoscopically or with classic open surgery (PPC laparoscopy 4.9 ± 2.2 vs. non PPC laparoscopy 3.3 ± 1.7 , PPC laparotomy 6.8 ± 5.2 vs. non PPC 5.6 ± 2.1 laparotomy). Ten patients were admitted to ICU, 8 from PPC group and 2 from non PPC group. In PPC group patients were admitted to ICU for mean 3.7 ± 2.4 days, and in non PPC group patients were hospitalized in ICU only for 2 days. All evaluated patients were discharged from the hospital and no mortality was observed in the 30 postoperative days.

In the univariate and multivariate logistic regression analysis neither OI nor P/F were significantly associated with PPC.

Conclusion: This study does not offer a conclusive answer to the prediction value of OI for PPC. It would be fruitful to pursue further research about predictive variables for pulmonary complications.

Keywords: oxygenation index, pressure/flow ratio, mean airway pressure, postoperative pulmonary complications.

Introduction:

Postoperative pulmonary complications (PPC) are still one of the major cause of postoperative mortality. Incidences of PPC are reported as high in the elderly population requiring urological intervention due to increased preexisting comorbidities (1,2). Identifying patients with an increased risk of development of PPC can lead to improved preoperative evaluation, perioperative management and postoperative therapy. Risk factors for PPC can be classified into patients-related and surgery-related risk factors (3).

Ventilation specific parameters are also used to predict PPC. In the article of Chan *et al.* (4) plateau pressure is reported as an independent risk of hospital mortality. The pressure/flow (P/F) ratio known as arterial oxygen to inspired oxygen fraction is widely used to determine the prognostic outcome of patients with acute respiratory distress syndrome (ARDS) and acute lung injury (ALI)/ acute respiratory insufficiency (ARI). However, nowadays it is believed that P/F ratio does not give the best expression of oxygenation status and a new oxygenation index where the mean airway pressure (MAP) is incorporated ($\text{PaO}_2/\text{FiO}_2\text{MAP}$) and has been shown superior to P/F in mechanically ventilated (MV) patients, for expression of the intrapulmonary shunting and lung oxygenation status (5).

Oxygenation index (OI) is defined as reciprocal of the P/F ratio multiplied by the MAP. OI is widely used in ICU as an index for the gravity of lung injury in both children and adults (6). OI has been also evaluated in the thoracic surgery demanding one-lung ventilation (OLV) (7). However, we have not found any report in the literature for on evaluation of the OI as a predictive factor in the non-thoracic everyday surgical practice.

The aim of this study was to assess the prediction potency of OI calculated during urological surgeries as a predictive marker for developing PPC.

Material and methods

Data sources

We conducted this evaluation in the tertiary University Clinical Hospital “Mother Theresa” Skopje, at the Department of anesthesia, reanimation and intensive care and at the Urology department for the period from January till December 2017. All patients that underwent elective urological intervention under general endotracheal anesthesia, ASA I/II, aged 18 to 65 years, without any known history of respiratory disease were included in this evaluation. We excluded pregnant patients, patients with known respiratory disease, transplanted patients.

Investigated parameters in three phases

Investigated parameters were collected at three time points: after induction in general endotracheal anesthesia at the beginning of mechanical ventilation, 1 hour after induction in anesthesia, and at the end of the surgery before weaning the mechanical ventilation.

Parameter's determination

We evaluated demographic characteristics, operative diagnosis and parameters obtained from the arterial blood gases analyses (PaO_2 , PCO_2 , SaO_2); we calculated the P/F ratio and the OI at all three time points.

OI was calculated as reciprocal of the P/F ratio multiplied by MAP. The PaO_2 obtained by the arterial gas analyses, fraction of inspired oxygen concentration and ventilator determinate MAP were used to calculate the OI.

Outcome definitions

The primary outcomes were PPC defined by European Society of Anesthesia (8): persistent coughing >15 seconds, new detection of respiratory wheezing treated with bronchodilators, pulmonary embolism, re-intubation, respiratory insufficiency, atelectasis, pneumothorax, aspiration pneumonia, pneumonia, pleural effusion, bronchospasm, laryngospasm, acute respiratory distress syndrome (ARDS). PPC were assessed within the first 30 days postoperatively in post-anesthesia care unit and in the ward during the entire time of patients' hospitalization. The second outcomes were: length of hospital stay, admission to ICU and mortality.

Statistical analysis

A computer database was created and analysis was performed with IBM SPSS (20.0) program. Descriptive and analytical standard methods were used. The odds relations, measures of the central tendency or proportions were used for analysis of the numerical and attributive data. They were reported as median and ranges and categorical variables were expressed in percentage. Statistical significance was indicated

when p was <0.05 tested with analysis of variance and difference.

Results

Between January and December 2017, a total of 1517 cases were evaluate in the tertiary University Clinical Hospital "Mother Theresa" Skopje, at the Department for anesthesia, reanimation and intensive care and at the Urology department. A total of 1017 of them received regional or local anesthesia and were excluded from the evaluation. 175 patients did not meet the inclusion criteria. Forty-five patients were excluded from the evaluation since arterial blood gas analysis during surgery was not performed. Additionally 40 cases were excluded due to missing data.

A total of 240 patients who met the inclusion criteria were included in this evaluation and analyzed. Sixty-six of them underwent prostatectomy, 90 patients underwent nephrectomy, 11 patients underwent renal cyst removal, 15 patients had suprarenal gland removal, 14 patients had varicocele and 44 patients underwent Bricker procedure (urinary ileostomy).

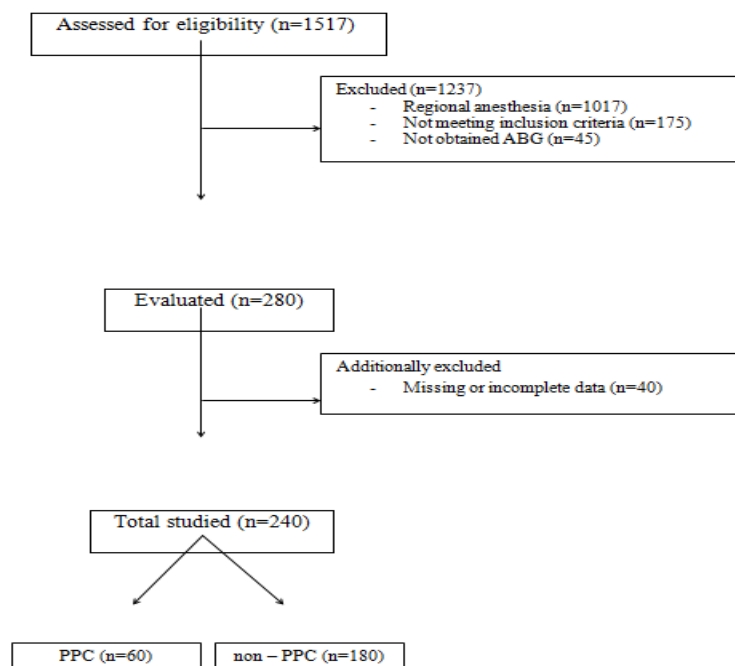


Figure 1: Study participants flow diagram

Table 1: Patients and surgery characteristics

Variables	PPC	non-PPC
Age (y)	50.2 ± 12.84	49.93 ± 13.99
Sex M/F	58/12	120/60
ASA I/II	10/50	70/110
BMI	25.84 ± 3.5	25.92 ± 2.76
Surgery Open / Laparoscopic	35/25	77/103
Anesthesia time	215±86,54	233±80.00
Surgery time	176.8±77.24	193.2±76.30

Data presented as mean and SD, ASA - physical status classification system, BMI – body mass index, PPC –postoperative pulmonary complications.

PPC were diagnosed in 25% of patients and respectively 75% were without complications. There were 185 measurements of OI in PPC group and 550 in non PPC group. Postoperative hospital stay was longer in PPC group no matter they were operated laparoscopically or with classic open surgery (PPC laparoscopy 4.9 ± 2.2

vs. non PPC laparoscopy 3.3 ± 1.7 , PPC laparotomy 6.8 ± 5.2 vs. non PPC 5.6 ± 2.1 laparotomy) ($p < 0.005$). Ten patients were admitted to ICU 10, 8 from PPC group and 2 from non PPC group. In PPC group patients were admitted to ICU for mean 3.7 ± 2.4 days, and in non PPC group patients were hospitalized in ICU for 2 days. All evaluated patients were discharged from the hospital and no mortality was observed in the 30 postoperative days.

Table 2: OI and P/F ratio

	OI	P/F
PPC	5.9 ± 1.31 (min 4.4/max 9.02)	170.9 ± 13.70 (min 139/ max 202)
non PPC	4.7 ± 1.06 (min 3.3/ max 7.4)	190 ± 14.12 (min 154/max 210)
P value	$P < 0.005$	$P < 0.05$

Data presented as mean and SD, min – minimum, max – maximum, OI –oxygenation index, P/F partial pressure of oxygen/inspired oxygen fraction.

In the univariate and multivariate logistic regression analysis neither OI nor P/F were

significantly associated with PPC. However, according to Spearman Rank Order Correlations test we registered a statistically significantly moderate positive correlation between P/F ratio and PPC, and a strong statistically significantly negative correlation between OI and PPC.

Table 3: Ventilation parameters

Variables	PPC	non-PPC	P value
MV (L/min)	5 ± 1	5 ± 1	$p > 0.05$
PPEP	5 ± 1	5 ± 1	$p > 0.05$
Vt (ml)	400 ± 65	415 ± 76	$p > 0.05$
Peak pressure	19 ± 10	18 ± 9	$p > 0.05$
Plato pressure (cmH ₂ O)	15 ± 5	15 ± 4	$p > 0.05$
EtCO ₂ (cmH ₂ O)	40 ± 7	39 ± 7	$P > 0.05$

Data presented as mean and SD, MV –minute ventilation, PPC –postoperative pulmonary complications, Vt – tidal volume, PEEP - positive end expiratory pressure, EtCO₂ - end tidal carbon dioxide.

Discussion

We believe that P/F ratio might not be the most excellent impression of oxygenation status in MV patients. Therefore, we wanted to evaluate the prediction value of OI where MAP shows better reflection in the oxygenation status for identification of patients who are at risk of developing PPC. By incorporating MAP in P/F equation we can have superior impression of the lung functional status. In this evaluation we found no significant association of OI with the development of PPC. A slightly decreased OI was observed in PPC group (non PPC 4.7 ± 1.06 vs. PPC 5.9 ± 1.31), however, there was no statistically significant difference between non PPC and PPC group ($p > 0.05$).

We assume that maybe due to the fact that our patients were elective cases with relatively brief duration of mechanical ventilation, we did not identify OI as a predictor for PPC. However, some studies in the literature, such as the cohort study of 259 patients analyzed by Monchi *et al.* reported OI to be a valuable predictor for mortality in ARDS patients (9). Another derivation cohort from Go *et al.*, analyzed data from 3 ARDSNet studies, ARMA, FACTT, and ALVEOLI, as well as data from the ARDS et Curarisation Systematique (ACURASYS) study and although they did not demonstrate the usefulness of OI in individual patients with ARDS, they presented the importance of OI in distinguishing patients with and without response to intervention (10). Modified OI with age for predicting mortality in patients with ARDS was developed by Dechert *et al.* using the ARDSNet database. They detected that OI modified with age had AUC of 0.70 to 0.74 for the first four days of predicting mortality. Seeley *et al.* (11) in their univariate and multivariate analysis identified OI as a superior independent predictor of mortality compared to P/F; they assumed that maybe due to the integrated MAP and oxygenation into a distinct variable, OI was the determinant that stayed significant for mortality prediction.

Development of OI was associated with extracorporeal membrane oxygenation (ECMO), and higher OI correlated with greater need for ECMO in the study of Bayrakci *et al.* (12). Another study enrolled pediatric patients with respiratory failure aged 1 month to 18 years, and identified higher OI as independently associated with mortality without extubation (6).

Despite the fact that P/F remains essential for diagnosis of ADRS, according to the American European Consensus Conference, value of < 300 P/F has been defined as an acute lung injury. Revised in the Berlin definition, PEEP has been included in P/F ratio for graduating the severity of ARDS (13), however OI still has a superior predictive value.

OI is a composite index that indicates gas exchange of the lungs and compliance of the lungs (14). Another study that evaluated OI in everyday clinical practice had comprised patients who underwent thoracic surgery demanding OLV (7). The authors evaluated and analyzed 296 patients and did not isolate OI as a predictor for PPC. However, they used a non-controlled mode of ventilation which may have impact on the parameters incorporated in the OI equation.

The limitations of our study are the retrospective and single center design as well as the relatively small sample size. The relatively healthy patients ASA I/II, leave the OI unanswered in more complicated patients. On the other hand, we used mean data rather than worst OI which can lead to underestimation of the severity of the lung injury.

Conclusion

While this study does not offer a conclusive answer to the prediction value of OI, it does open the door to further prospective researches including larger cohort of patients in order to determine OI as a predictor for PPC and to determine the predictive variables for pulmonary complications.

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