

Right ventricular systolic pressure as a predictive factor for postoperative pneumonia in patients with valvular heart disease

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Introduction Hospital-acquired pneumonia is one of the complications in patients undergoing heart valve surgery.¹ The definition of hospital-acquired pneumonia includes inflammation that develops 48 hours after admission to the hospital. Risk factors for hospital-acquired pneumonia include the postoperative use of a nasogastric tube, prolonged intubation, transfusion of packed red blood cells, older age, chronic obstructive pulmonary disease, steroid use, lower hemoglobin levels, or heart transplants.²⁻⁵ Knowledge of predictors of postoperative pneumonia enables the implementation of an appropriate perioperative strategy, which in turn allows to improve treatment outcomes in patients with valvular heart disease.⁶ Therefore, the aim of the present study was to assess the usefulness of preoperative measurement of right ventricular systolic pressure (RVSP) by means of transthoracic echocardiography for hospital-acquired pneumonia in the postoperative period in patients undergoing heart valve surgery.

Methods This was a prospective study in a group of consecutive patients with hemodynamically significant valvular heart disease (aortic valve stenosis, aortic regurgitation, mitral stenosis, and mitral regurgitation) undergoing valve surgery at the Institute of Cardiology in Warsaw, Poland. The exclusion criteria were: age under 18 years, lack of consent to participate in the study, massive tricuspid regurgitation, active malignant diseases, autoimmune diseases, active endocarditis, and significant atherosclerotic lesions in the coronary arteries.

Plasma levels of C-reactive protein (CRP) were measured by the cardiac C-reactive protein test (Roche, Mannheim, Germany). The estimation of RVSP with transthoracic echocardiography using the continuous wave doppler method was based on the measurement of the peak tricuspid valve regurgitation jet velocity, according to the simplified Bernoulli equation and taking into account right atrial pressure. All treatments were performed through median sternotomy under general anesthesia and normothermic conditions. The primary endpoint at the in-hospital follow-up was the postoperative diagnosis of pneumonia. Pneumonia was diagnosed based on new typical clinical symptoms (such as cough, fever, chills, malaise, sweating, chest pain, dyspnea), auscultatory changes located over a certain chest area, changes in radiological image of the thorax such as increased compaction in the lung fields, and increase in inflammation parameters in laboratory tests such as leukocytosis and CRP concentration. Patients were followed for 30 days. In the case of prolonged hospitalization, the follow-up lasted until the end of stay. The study protocol was approved by the institutional ethics committee (approval no. 1705).

Statistical analysis All analyses were performed using the SAS software, version 9.2 (SAS Institute Inc., Cary, North Carolina, United States). Data are presented as mean (SD) and frequency (percentage). Logistic regression was used to assess relationships between variables. Significant determinants ($P < 0.05$) identified on the basis of univariate analysis

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Received: July 19, 2019.

Revision accepted:

August 26, 2019.

Published online: August 27, 2019.

Kardiol Pol. 2019; 77 (10): 969-971

doi:10.33963/KP.14940

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were subsequently introduced into multivariate models. The Spearman rank correlation analysis was used to search for associations between the preoperative value of CRP level and RVSP. The cut-off point for the RVSP value, which fulfilled the criterion of maximum sensitivity and specificity for postoperative hemodynamic instability, was determined based on the Youden index.

Results and discussion The present study included 631 patients undergoing heart valve surgery. The mean (SD) age in the study population was 62 (12) years. Chronic obstructive pulmonary disease was present in 49 patients (7%). The mean (SD) preoperative RVSP level was 44 (17) mm Hg. Postoperative pneumonia occurred in 24 patients. The mean (SD) time to the diagnosis of pneumonia was 3.5 (2) days after surgery. Each patient with pneumonia received empiric antibiotic therapy. Due to the lack of improvement in clinical status, antibiotic therapy was switched in 5 patients, including 3 patients with positive microbiological test result. Significant predictors of postoperative hospital-acquired pneumonia at univariate analysis are presented in TABLE 1. At multivariate analysis only RVSP (odds ratio, 1.043; 95% confidence interval, 1.018–1.067; $P = 0.004$) remained an independent predictor of the primary endpoint. The optimal cut-off point for primary endpoint was calculated at 46 mm Hg. The area under receiver operator characteristic curve for postoperative pneumonia for RVSP was 0.781 (95% confidence interval, 0.747–0.813). A positive correlation was found between the level of CRP and RVSP ($r = 0.31$; $P = 0.001$). Out of the patients who had postoperative hospital-acquired pneumonia, 6 patients died due to increased cardiorespiratory failure.

In the present study conducted on a group of 631 patients undergoing heart valve surgery, RVSP was an independent predictor of postoperative pneumonia. Pulmonary hypertension often complicates the course of cardiovascular disease. The gold standard for the measurement of pulmonary artery pressure is right heart catheterization.⁷ It is, however, an expensive,

time-consuming, invasive, and limited-access procedure. Therefore, a noninvasive diagnostic tool evaluating RVSP, such as echocardiography, despite limitations, is very helpful in assessing the likelihood of pulmonary hypertension.^{8,9}

Pneumonia is one of the complications that may occur in the early postoperative period in patients undergoing heart valve surgery. Moreover, it is burdened by a risk of prolonged hospitalization, respiratory failure, reintubation, and death.¹⁰ The natural defense mechanisms of the respiratory system ensure that the lower respiratory tracts are physiologically sterile. Microbes most often enter the lower respiratory tract with aspiration. Bacteria are usually killed by the immune cells in the lungs. However, under favorable conditions, the bacteria are able to survive, which stimulates the body to defend.

A significant valve defect in the left part of the heart is one of the causes of elevated pulmonary artery pressure,^{11,12} and persistently high pressure in pulmonary circulation vessels are associated with various pathophysiological mechanisms. Persistent elevated resistance in pulmonary vessels may lead to pulmonary vascular endothelial dysfunction, which in turn leads to a reduced production of antiproliferative substances, for example, nitric oxide and prostacyclin. Vascular endothelial dysfunction is also accompanied by overexpression of vasoconstrictive and proliferative compounds, for example, thromboxane A2 and endothelin 1. Many of these abnormalities increase vascular tone and promote vascular remodeling involving the proliferation of endothelial cells, smooth muscle cells, and fibroblasts. In addition, there is increased production of the collagen, elastin, fibronectin, and tenascin range in the extracellular matrix, as well as increased accumulation of inflammatory cells.^{13,14} It seems, therefore, that the pathophysiological processes occurring in the lungs with, among others, a chronic enhanced inflammatory state (one of the exponents of the inflammation is CRP) in patients with elevated pressure in the pulmonary circulation vessels (which confirms the correlation between RVSP and CRP demonstrated in the present study) make the patients more susceptible to infections that may occur in the early postoperative period.¹⁵

The results of the present study indicate that patients with higher preoperative RVSP may be prone to postoperative pneumonia and worse long-term outcomes. Knowledge of the predictors of postoperative pneumonia is extremely important because it allows the implementation of an appropriate perioperative strategy, including maintaining rigorous aseptic principles, which in turn can improve treatment outcomes in patients with valvular heart disease.

TABLE 1 Univariate analysis of predictive factors for the occurrence of the composite endpoint

Variable	OR	95% CI	P value
RVSP, mm Hg	1.030	1.013–1.048	<0.001
CRP, mg/dl	1.396	1.058–1.843	0.01
Hemoglobin, g/dl	0.690	0.551–0.862	0.001
NYHA classes	2.024	1.040–3.936	0.03

Abbreviations: CRP, C-reactive protein; NYHA, New York Heart Association; OR, odds ratio; RVSP, right ventricular systolic pressure

ARTICLE INFORMATION

CONFLICT OF INTEREST None declared.

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HOW TO CITE Duchnowski P, Hryniewiecki T, Kuśmierczyk M, Szymański P. Right ventricular systolic pressure as a predictive factor for postoperative pneumonia in patients with valvular heart disease. *Kardiol Pol.* 2019; 77: 969-971. doi:10.33963/KP.14940

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