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Research Article

Effects of Pulmonary Vascular Resistance Index on Oxygen Saturation in Patients with Atrial Septal Defect

Pengaruh Pulmonary Vascular Resistance Index terhadap Saturasi Oksigen pada Pasien dengan Atrial Septal Defect

Supomo

Departement of Thorax and Cardiovascular Surgery RSUP Dr. Sardjito Yogyakarta

ABSTRACT

Atrial septal defect (ASD) is a congenital lesion in atrium septum. The lesion may cause pulmonary hypertension due to the high pressure in the right ventricle. This condition leads to cyanosis in ASD patient, but the pathophysiology of cyanosis in ASD patient is still unknown. This study aimed to identify the pathophysiology of cyanosis in ASD patients using the Pulmonary Vascular Resistance index (PVRi). The design of this study was retrospective cohort study. The data used in this study were the results of right heart catheterization procedure taken from forty ASD patient medical records at Dr. Sardjito general hospital. The exclusions criteria were the history of previous vasodilator administration and incomplete medical records. The median age of the patients was 30 (18-55) years old. The mean of the Qp/Qs ratio was 1.210 (0.57-6.33). Optimum oxygen saturation was found in vessel leaving the heart. The PVRi median is 61.98 (-15.58-676.64). The PVRi has a significant correlation with oxygen saturation, except in the right atrium. There is a significant correlation between PVRi and oxygen saturation in various heart chambers. Pathophysiology of cyanosis in ASD patients is central cyanosis.

Keywords: *Atrial septal defect, oxygen saturation, pulmonary hypertension, PVRi*

ABSTRAK

Atrial septal defect (ASD) adalah kelainan kongenital pada septum atrium jantung. Defek pada septum tersebut dapat mengakibatkan hipertensi pulmonal karena tekanan yang tinggi di ruang ventrikel kanan jantung. Kondisi ini memunculkan sianosis pada pasien ASD, namun patofisiologi dari sianosis pada pasien ASD belum diketahui. Penelitian ini bertujuan untuk mengetahui patofisiologi sianosis yang terjadi pada pasien ASD dengan menggunakan *Pulmonary Vascular Resistance Index* (PVRi). Desain penelitian yang digunakan adalah *retrospective observational study*. Data yang digunakan adalah hasil *right heart catheterization* dari rekam medis pasien ASD dewasa di RSUP Dr. Sardjito. Kriteria eksklusi pada penelitian ini adalah data yang tidak lengkap dan riwayat pengobatan vasodilator sebelumnya. Terdapat 40 data yang memenuhi kriteria. Median usia pasien adalah 30 tahun (18-55 tahun). Nilai Qp/Qs pada pasien 1.210 (0,57-6.33).Saturasi maksimal ditemukan pada darah yang meninggalkan jantung. PVRi adalah PVR/BSA (*body surface area*). Median nilai PVRi pada pasien adalah 61.98 (-15.58-676.64). Nilai PVRi memiliki hubungan yang signifikan dengan saturasi oksigen di berbagai ruang jantung kecuali atrium kanan. Patofisiologi sianosis yang terjadi pada pasien ASD adalah sianosis sentral. Terdapat hubungan yang signifikan antara saturasi oksigen di berbagai ruang jantung dan vasa dengan nilai PVRi.

Kata Kunci: Defek septum atrium, hipertensi pulmonal, PVRi, saturasi oksigen

Correspondence: Supomo. Departement of Thorax and Cardiovascular Surgery RSUP Dr. Sardjito Yogyakarta, Jl. Kesehatan Nomor 1, Sleman, Daerah Istimewa Yogyakarta 55281 Tel. 0816688047 Email: supomo.tkv@mail.ugm.ac.id

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INTRODUCTION

Atrial septal defect is a congenital heart disease which may cause pulmonary hypertension (1). Defect in atrium septum leads to high pressure in the right ventricle. This condition leads to pulmonary artery overload, which is a symptom of pulmonary hypertension (2). Patients with pulmonary hypertension have a poor outcome and have a high risk for ASD repair procedure (3), so vasodilator drugs are given to the patients(4).

ASD condition is correlated with cyanosis, but the mechanism of cyanosis in ASD patients is still unknown, whether central or peripheral cyanosis. Central cyanosis is caused by oxygen desaturation in vessels which leave the heart or hemoglobin problem that in chronic condition will lead into cognitive problems (5). In the peripheral cyanosis, an increase in oxygen demand or a decrease in oxygen perfusion rate occur (6). Both cyanosis types might happen in ASD patients, but there is no evidence yet. Administration of vasodilator will have an impact on peripheral cyanosis (7). Therapy with vasodilator agent has a positive effect on ASD condition with pulmonary hypertension (8). This finding leads to a question of whether central or peripheral cyanosis that can be found in ASD patients.

This study aimed to find the pathophysiology of the cyanosis condition through the Pulmonary Vascular Resistance index (PVRi) approach. PVRi is an index from Pulmonary Vascular Resistance (PVR) or Systemic Vascular Resistance (SVR) (2). PVRi measurement reflects the pressure occurred in pulmonary vessels in ASD condition. Correlation between PVRi and oxygen saturation from the heart chambers would show the cyanosis condition, whether it is central or peripheral cyanosis.

METHODS

This study has been approved by the Medical and Health Research Ethics Committee, Faculty of Medicine, Public Health, and Nursing Universitas Gadjah Mada - Dr. Sardjito General Hospital with ethical number KE/FK/768/EC. Retrospective observational study design was used in this study. Right heart catheterization (RHC) data were taken from medical records of patients with ASD. The RHC data used in this study were the patient's first examination results related to the diagnosis of ASD condition. The subjects of this study were adult ASD patients at Dr. Sardjito general hospital. Patients with incomplete medical records and history of previous vasodilator therapy were exclude from the study. Statistical analysis was performed using Medcalc 2016 software.

RESULT

Forty patients were included in the study with the median age of the subject was 30 (18-55) years old. The median Qp/Qs ratio was 1.210 (0.57-6.33) while the average of Mean Pulmonary Artery Pressure (mPAP) of all subject was 28.69 ±11.49 (Table 1).

Table 1. Subjects characteristics

Variable	Mean	Median
Age (years)		30 (18-55)
Qp/Qs		1.21 (0.57-6.33)
mPAP (mmHg)	28.69 ± 11.49	
BSA (m^2)	1.47 ± 0.16	
6 MWT (m)	352.91 ± 87.03	
PVR (Woods unit)		94.5 (-24 – 927)
PVRi (Wood unit/m^2)		61.99 (-15.58 – 676.64)

Note: Qp/Qs: pulmonary to systemic flow ratio; mPAP: mean pulmonary arterial pressure; BSA: body surface area; 6MWT: six minute walking test; PVR: pulmonary vascular resistance; PVRi: pulmonary vascular resistance index.

There were decreases in oxygen saturation in various heart chambers before transferred to the pulmonary circulation. Increase in oxygen saturation could be found in the heart chambers that receive blood from the pulmonary circulation. Meanwhile, the optimum oxygen saturation was found in vessels which leave the heart (Table 2).

Table 2. Oxygen saturation in heart chambers

Location	Mean of Oxygen Saturation (%)
Aorta	94.37 ± 2.76
Inferior Vena Cava	77.12 ± 7.64
Superior Vena Cava	65.45 ± 7.34
Left Atrium	94.39 ± 2.20
Pulmonary Artery	86.81 ± 6.53
Right Atrium	82.35 ± 5.7
Right Ventricle	86.9 ± 5.19
Pulmonary Vein	94.13 ± 3.24

PVRi was calculated from Pulmonary Vascular Resistance/Body Surface Area. The median of subjects PVRi is 61.98(-15.58-676.64). The correlation analysis showed a significant correlation between PVRi and oxygen saturation in the right ventricle, but not significant correlation was also found in the right atrium (Table 3).

Table 3. Correlation between Pulmonary Vascular Resistance Index (PVRi) and oxygen saturation

Oxygen Saturation Test Site	Correlation coefficient	P
Aorta	-0.7120	P<0.0001
Inferior Vena Cava	-0.6141	P<0.0001
Superior Vena Cava	-0.3007	P=0.0530
Left Atrium	-0.5379	P=0.0003
Pulmonary Artery	-0.4840	P=0.0012
Right Atrium	-0.3174	P=0.0459
Right Ventricle	-0.6155	P<0.0001
Pulmonary Vein	0.04400	P=0.7875

DISCUSSION

Our study noted that the oxygen saturation is increases in various heart chambers and pulmonary vein, which receive blood from the pulmonary circulation. This finding is consistent with the pulmonary circulation flow direction. However, there is a slight decrease in oxygen saturation in

the aorta, compared to the left atrium, though it is not a significant difference.

The statistical analysis showed significant correlations between some oxygen saturation parameters and PVRi, supporting previous study, which showed positive response (increase in oxygen saturation) to oxygen administration in pulmonary hypertension patients (9). However, patients with advanced pulmonary hypertension showed no improvement in spite of oxygen administration (10,11). Increase in PVRi is often associated with the outcome of surgery (2). Some studies showed a significant correlation between PVRi and 5-year mortality rate after surgery –(2,12,13) since PVRi might be a reflection of heart condition, especially for the right side of the heart. Prior study found that an increase in PVRi is associated with right ventricle enlargement (14) that may contribute to the decrease of oxygen saturation in the right ventricle in this study.

Another finding in this study is that PVRi is significantly correlated with oxygen saturation in various heart chambers. This result suggests that central cyanosis is caused by structural changes of the heart, thus contribute to an ischemic state in the heart (12). Furthermore, this discussion may give an insight of chronic heart failure risk, which may be a mechanism of mortality beside Eisenmenger syndrome, in ASD patient with pulmonary hypertension (15). It can be concluded that the pathophysiology of cyanosis in ASD patient is central cyanosis, which is caused by structural changes of the heart which lead to pulmonary hypertension.

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