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RIGHT HEART HAEMODYNAMICS AFTER LUNG RESECTION; THE ROLE OF THE TRANSTHORACIC ECHO-DOPPLER CARDIOGRAPHY

Jovev S.,[1] Tager S.,[2], Spirovski Z.,[1] Arsovski A.,[1] Trajkovska T.,[3] Proevska D.,[4] Kondov G.,[1] Colanceski R.,[1] Spirovska V.[4]

[1] Clinic for Thoracic and Vascular Surgery, Clinic for Cardiology, Clinical Centre, Medical Faculty, Ss. Cyril and Methodius University, Skopje, R. Macedonia
[2] Clinic for Cardiothoracic Surgery, Tel A Shomer, T. Aviv, Israel
[3] Caril, Clinical Centre, Medical Faculty, Ss. Cyril and Methodius University, Skopje, R. Macedonia
[4] Clinic for Cardiology, Clinical Centre, Medical Faculty, Ss. Cyril and Methodius University, Skopje, Macedonia

A b s t r a c t**:** We analyzed 80 patients with lung resections due to lung carcinoma operated at the Clinic for Thoracic Surgery. We performed lobectomy or bilobectomy in all cases, the patients were between 50 and 70 years old and the preoperative preparing was the same. The patients were divided in 2 groups; group A – the patients with anamnesis for myocardial infarction, arrhythmia, pulmonary hypertension or restrictive respiratory disease and group B – patients without such a history. Echo Doppler cardiography was performed in all cases to measure the main parameters that present the heart-lung hamodynamics. We found some changes even in group B (increased RVEDV, decreased EF, increased pulmonary systolic pressure) which can be a reason for cardiac complications after this type of surgery. The echo-Doppler cardiography is a sensitive and non-invasive method to obtain all valid parameters to present heart-lung haemodynamics.

Key words: lung resections, echo Doppler cardiography, heart-lung haemodynamics.

Introduction

The indications for lung surgery had suffered big changes during last years. The lung surgery nowadays is mainly focused on malign diseases. The patients operability depends on: extensibility of the disease, general condition, the risk from the operation and respiratory reserves [Bollinger, 4]. From the other side, the thoracotomy can cause some physiological changes.

The lung surgery has a repercussion on the vital organs function (hearth, lungs). The respiratory functional reserves and the lung vascular capacity should be sufficient to maintain good function postoperatively [Pate 5, Gross, 7]. The operation risk should be evaluated depending on the preoperative status and the predicted postoperative cardio respiratory function [Nitta, 6, Bollinger, 4].

The percentage of the postoperative nonfatal morbidity after pneumonecomies is variable and it varies up to 15% (athelectasis, arrhythmias and respiratory insuffitiention). In lobectomies it is at the same level but the mainly complications are athelectasis, excessive secretion and some level of respiratory insuffitiention which requests prolonged ventilation [Gross, 7]. The postoperative mortality after pneumonectomies is still high depending on the reason for resection and after lobectomies it is between 2% and 5% depending on the disease, but with a good cardiopulmonary estimation it shouldn't be bigger than 3% [Bernard, 8]. The clinical staging and adequate functional estimation is essential for the operative treatment for these patients.

On the other side the loss of the pulmonary vasculature due to the anatomical resection can increase the precapilary resistance and can cause pulmonary hypertension which can have an effect on the right heart. The disease and the lung resection have effects on the cardiopulmonary haemodynamics. Flanchbaum and ass. classify the patients depending on the haemodynamical anamnesis preoperatively (measuring the essential parameters which show the heart-lung haemodynamics and the estimated values postoperatively).

After the resection, the pressure in the pulmonary artery is mainly normal. But the toleration at exertion is lowering and the pressure in the pulmonary artery and pulmonary resistance increases. The cardiac output and the heart stroke volume are decreasing, the periphery arterial pressure and vascular resistance increases and the oxygen saturation at exertion decreases [Girard, 9]. The resection can result in an increase of the after-load of the right ventricle which can interfere with its emptying. The increasing of the after-load increases right ventricle end-systolic and end-diastolic volumes which can press the interventricular septum towards left and lowers the cardiac output [Oakada, 10]. The functional capacity depends on the expansion of the rest vascular bed. When the limit is outstripped a pulmonary hypertension and cor pulmonale occurs.

The decision to perform a surgery depends on the potential risk and the benefit. The cardiac subsystem is very important for the thoracic patients where the cardiac complications are often especially arrhythmias, myocardial infarct and the congestive heart failure.

That is why the study of the heart-lung haemodinamics and the cardiac subsystem are essential for thoracic patients.

The aim of this work is to estimate the heart-lung haemodinamics after the lung resections, to discover the main parameters that are changing and to define the most often complications.

Materials and Methods

We have analyzed 80 patients operated at the Clinic for Thoracic and Vascular surgery at the Clinical Centre in Skopje. The study was prospective and we divided the patients in 2 groups:

Group A: patients with history of chronic arrhythmia, pulmonary hypertension or restrictive pulmonary disease and

Group B: patients without such a history.

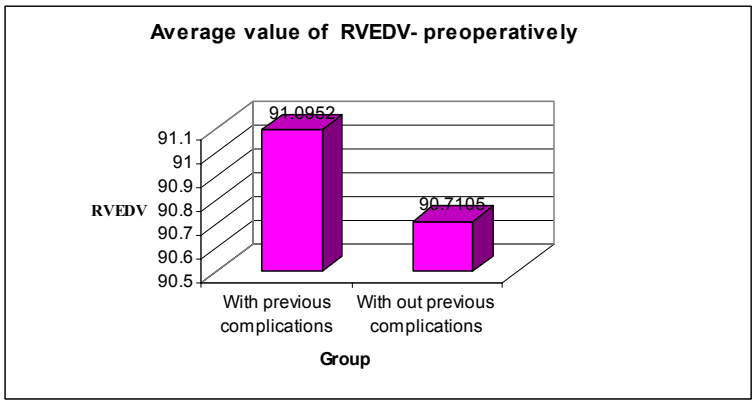
Both groups had 40 patients where a lobectomy or bilobectomy was performed. We measured with Doppler echocardiography: PAPs-pulmonary artery pressure(systolic) – using 2 methods for measurement: a) it was calculated as a sum from trans-tricuspid gradient and right atrial pressure and b) using peak velocity-pV and acceleration time-AT; RVEF-right ventricular ejection fraction; RVEDV-right ventricular end diastolic volume; HR-heart rate; RVD-right ventricular dimension, RVSW-right ventricular stroke work, FVC-forced vital capacity.

The cardiac output (CO) and the right ventricular volumes were indexed on the body surface area BSA in m^2. The relation between RVSW and RVEDV was used as index for the right ventricular contractility. The parameters were monitored: preoperatively, the second day postoperatively and 3 months after the intervention. We followed the complications intrahospitaly. The preoperative preparing was the same: antibiotics; bronchodilatators; in the treatment of the heart failure – adrenergic blocators, eventually diuretics, vasodilatators or ACE inhibitors preoperative physiotherapy and smoke prohibition. The postoperative treatment was also the same with if needed cardiological therapy. For statistical analyses we used linear regression (for estimation of the relation between RVSW and RVEDV), standard deviation, T-test and the coefficient of correlation.

Results

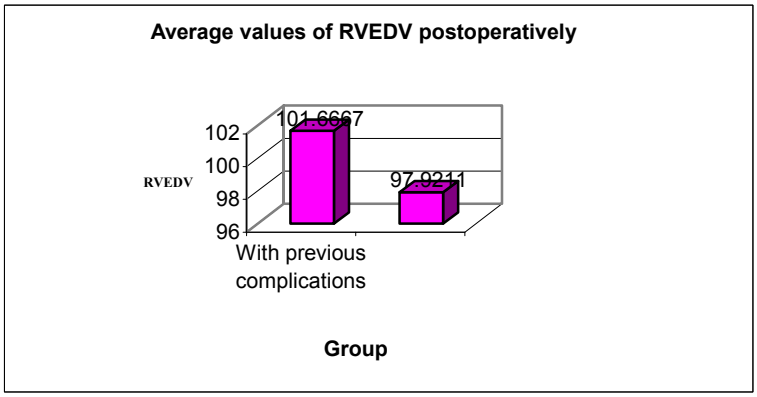
We had a very good presentation of the heart lung haemodynamics with Echo-Doppler cardiography. Trough the information about the right heart atrial and ventricular dimension, pressure, contractility, right ventricular systolic pressure and tricuspid regurgitation we evaluated the right heart disfunction and the pulmonary capillary pressure elevation.

After the lung resection in all patients we registered a change in the following 2 parameters: RVEDV – the volume of the right ventricle at the end of diastole (RVEDVI-right ventricular right heart volume index) (Figure 1, 2) and restricted ejection fraction (EF) (Figure 3, 4, 5, 6).



*RVEDV (right ventricular end diastolic volume) – (desno komoren krajno dijastolen volumen)

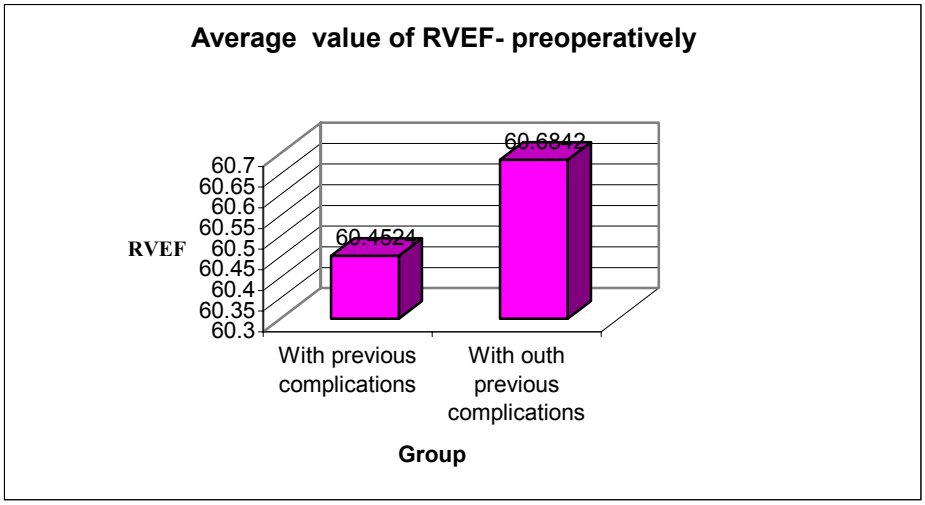
Figure 1 – Average value of RVEDV – preoperatively
Slika 1 – Prose~na vrednost na RVEDV – predoperativno



*RVEF (right ventricular ejection fraction) ‡ (desno ventrikularna ejekciona frakcija)

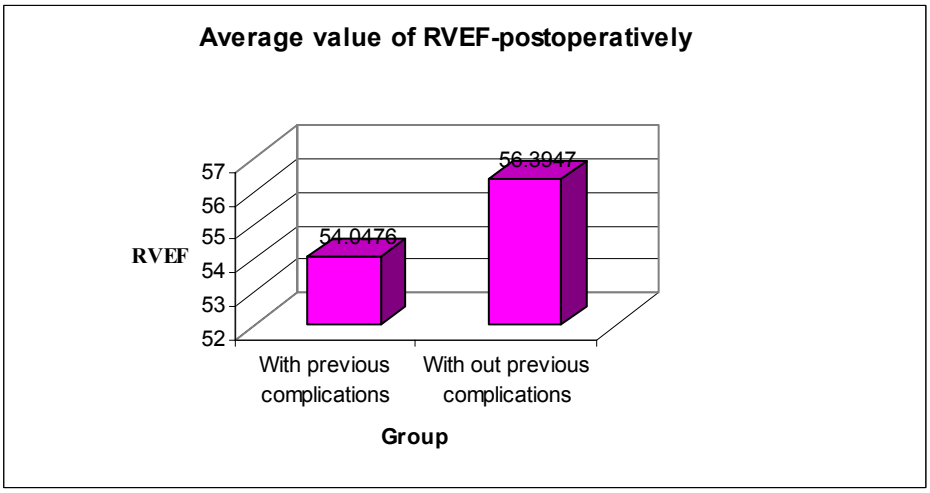
Figure 2 – Average values of RVEDV – postoperatively

Slika 2 ‡ Prose~na vrednost na RVEDV ‡ postoperativno



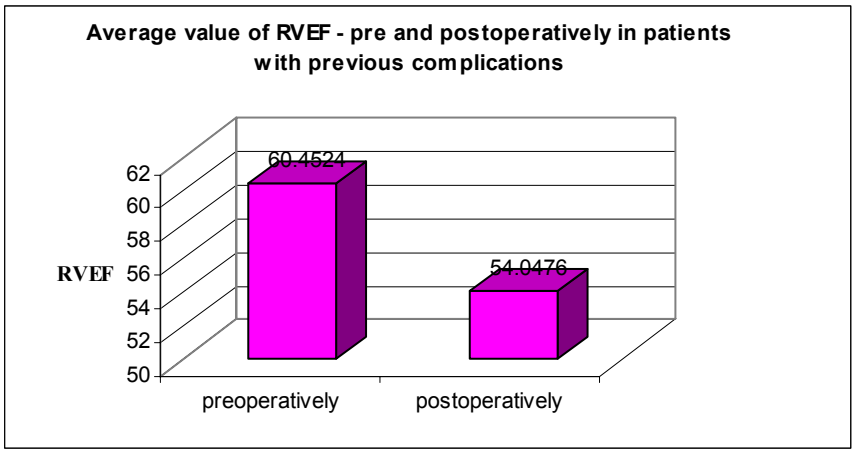
*RVEF (right ventricular ejection fraction) ‡ (desno ventrikularna ejekciona frakcija)

Figure 3 – Average value of RVEF – preoperatively
Slika 3 ‡ Prose~na vrednost na RVEF ‡ predoperativno



*RVEF (right ventricular ejection fraction) ‡ (desno ventrikularna ejekciona frakcija)

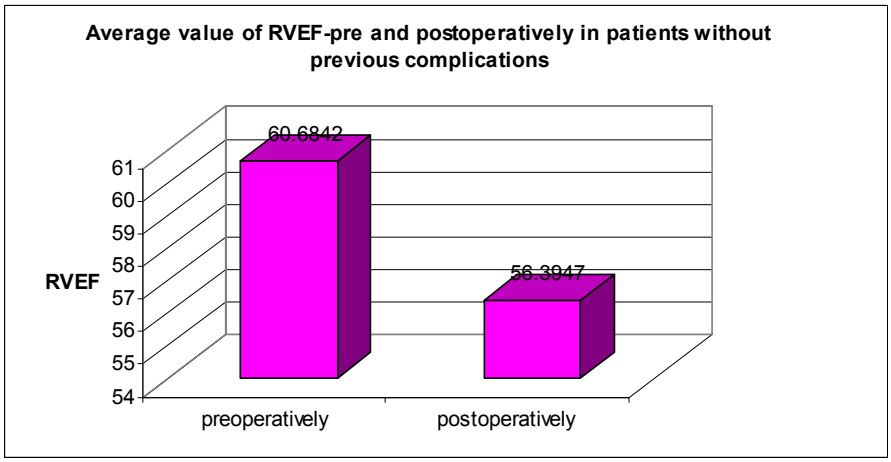
Figure 4 – Average value of RVEF – postoperatively
Slika 4 ‡ Prose~na vrednost na RVEF – postoperativno



*RVEF (right ventricular ejection fraction) ‡ (desno ventrikularna ejekciona frakcija)

Figure 5 – Average value of RVEF – pre and postoperatively in patients with previous complications

Slika 5 ‡ Prose~na vrednost na RVEF ‡ pred i postoperativno kaj pacienti so prethodni komplikacii

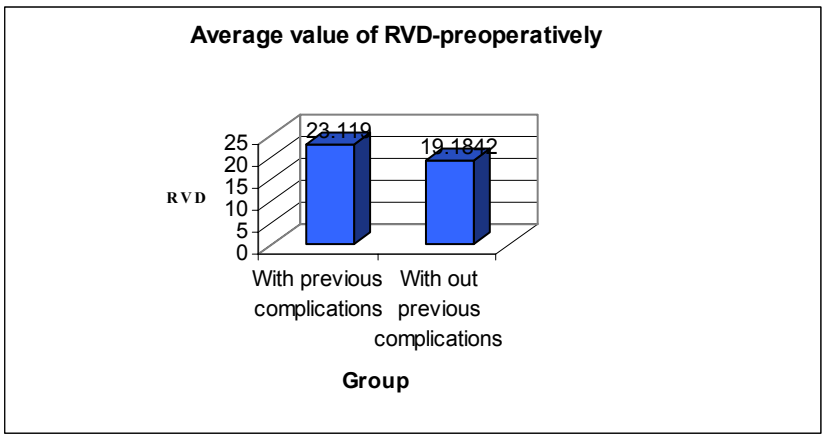


*RVEF (right ventricular ejection fraction) ‡ (desno ventrikularna ejekciona frakcija)

Figure 6 – Average value of RVEF – pre and postoperatively in patients without previous complications

Slika 6 ‡ Prose~na vrednost na RVEF ‡ pred i postoperativno kaj pacienti bez prethodni komplikacii

10 (25%) of the patients had right ventricle enlargement. At 40% of them the dimensions were between 25 and 28 mm and the others had bigger enlargement (Figure 7, 8, 9, 10).



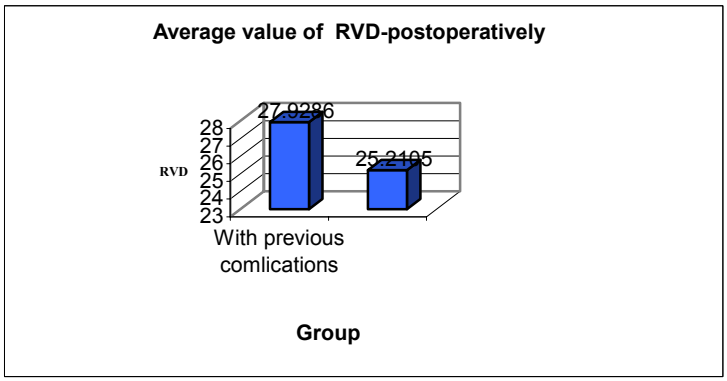
*RVD (right ventricular dimension) – (desno komorna dimenzija)

Figure 7 – Average value of RVD – preoperatively
Slika 7 ‡ Prose~na vrednost na RVD – predoperativno

Table 1 – Tabela 1

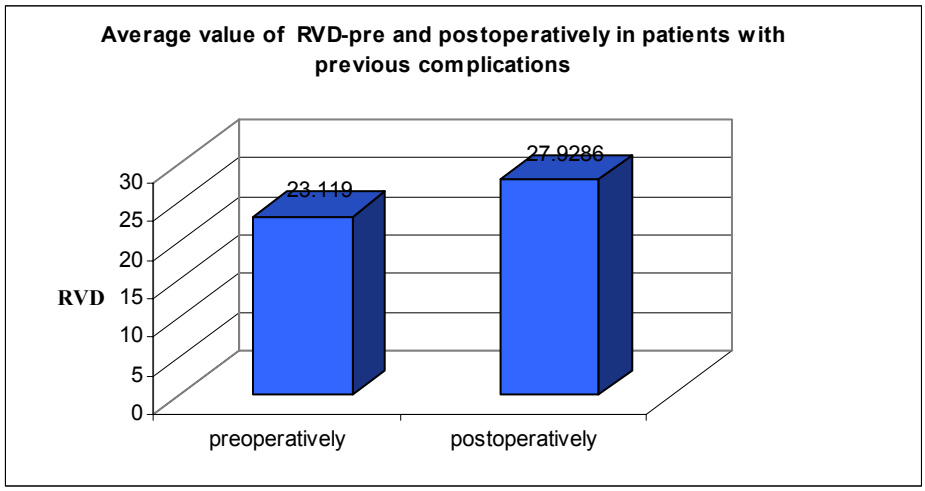
Distribution of the patients according to the postoperative hearth complications
Distribucija na pacientite spored postoperativnite srcevi komplikacii

	Patients with previous complications	Patients without previous complications
Yes	21	21
No	11	27



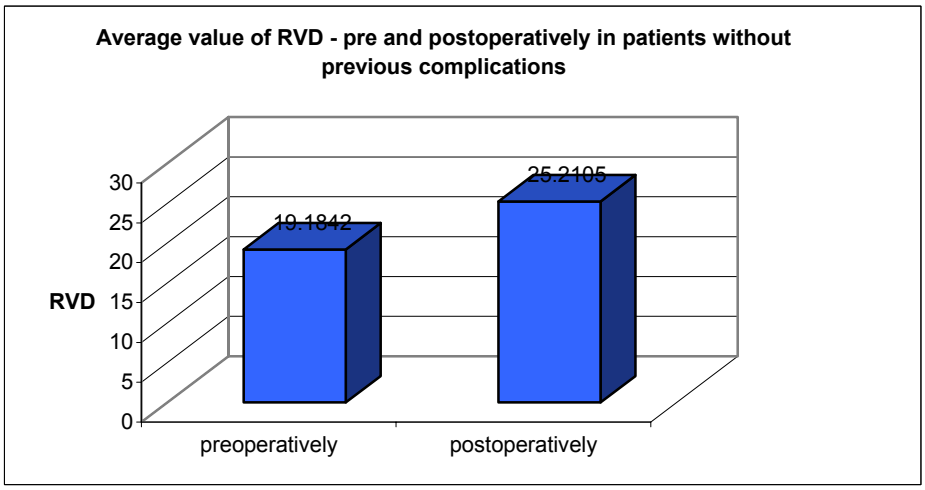
*RVD (right ventricular dimension) – (desno komorna dimenzija)

Figure 8 – Average value of RVD – postoperatively
Slika 8 ‡ Prose~ni vrednosti na RVD ‡ postoperativno



*RVD (right ventricular dimension) – (desno komorna dimenzija)

Figure 9 – Average value of RVD – pre and postoperatively in patients with previous complications
Slika 9 ‡ Prose~ni vrednosti na RVD ‡ pred i postoperativno kaj pacienti so prethodni komplikacii



*RVD (right ventricular dimension) – (desno komorna dimenzija)

Figure 10 – Average value of RVD – pre and postoperatively in patients

with out previous complications
Slika 10 ‡ Prose~na vrednost na RVD ‡ pred i postoperativno kaj pacienti bez prethodni komplikacii

We also registered accelerated heart rate (HR). Primary alterations in the contractile state and the after loads were not registered. We calculated the right ventricular contractility as a relation between the RVSW (right ventricular stroke work) (Figure 17) and RVEDV (right ventricular end diastolic volume). The change of the right ventricular ejection fraction (EF) was towards its reduction. The change in the right ventricular end diastolic volume was very significant.

We also noted arrhythmias, supraventricular tachycardia or atrial fibrillation in 20% of the patients (Figure 4).

Three months after the resection the echo Doppler cardiography showed significant tricuspid regurgitation which suggested increased pulmonary capillary systolic pressure (Figure 11, 12, 13, 14, 15). In almost all patients with preoperative lower FVC and in patients with advanced age the pulmonary artery systolic pressure was higher (Figure 16).

We used T-test and correlation using Prison's formula.

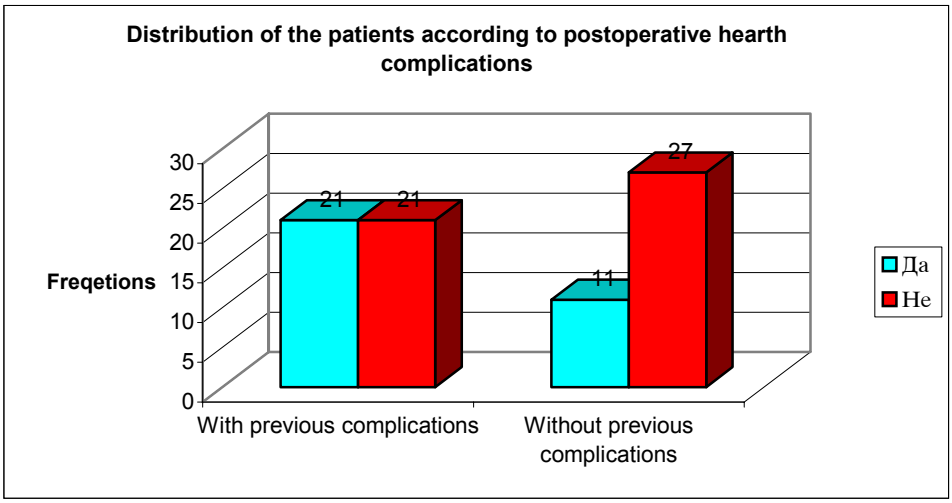
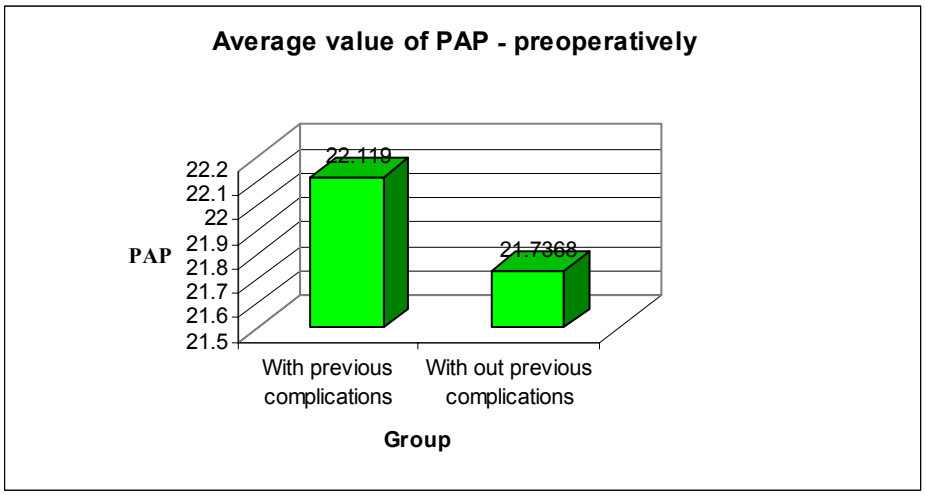
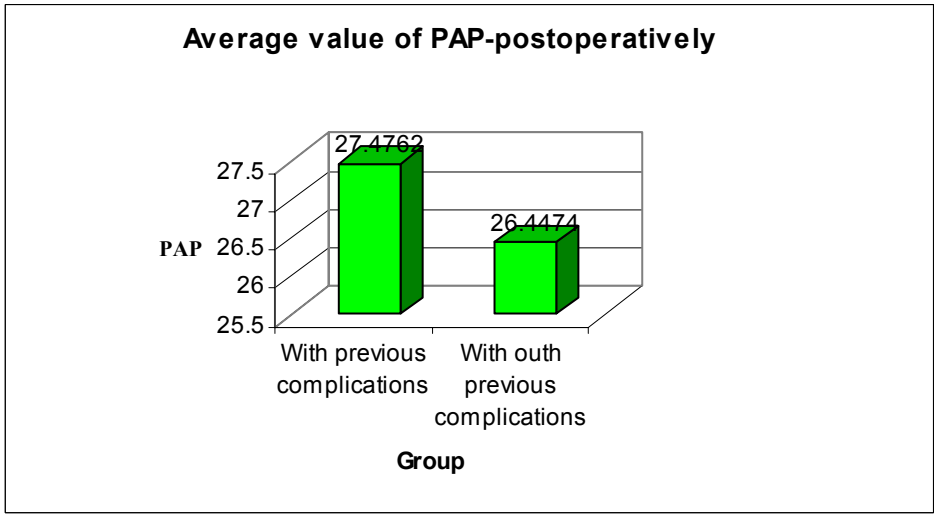


Figure 11 – Distribution of the patients according to postoperative hearth complications
Slika 11 ‡ Distribucija na pacienti spored postoperativnite srcevi komplikacii



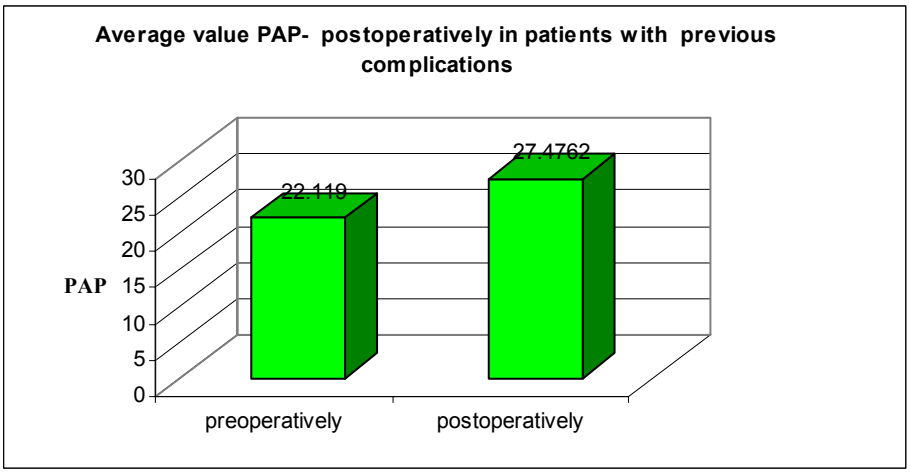
*PAP (pulmonary arterial pressure) – (pritisok vo belodrobnata arterija)

Figure 12 – Average value of PAP – preoperatively
Slika 12 ‡ Prose~ni vrednosti na PAP ‡ predoperativno



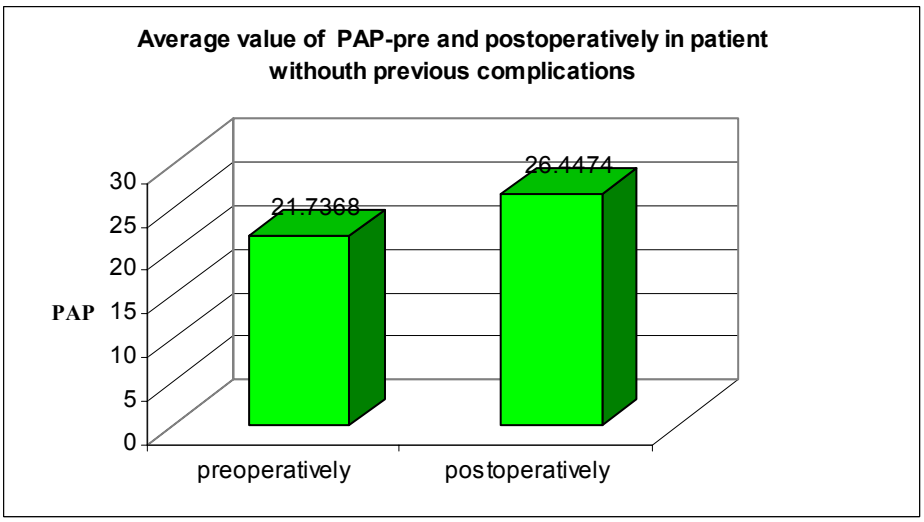
*PAP (pulmonary arterial pressure) – (pritisok vo belodrobnata arterija)

Figure 13 – Average value of PAP – postoperatively
Slika 13 ‡ Prose~ni vrednosti na PAP ‡ postoperativno



*PAP (pulmonary arterial pressure) – (pritisok vo belodrobnata arterija)

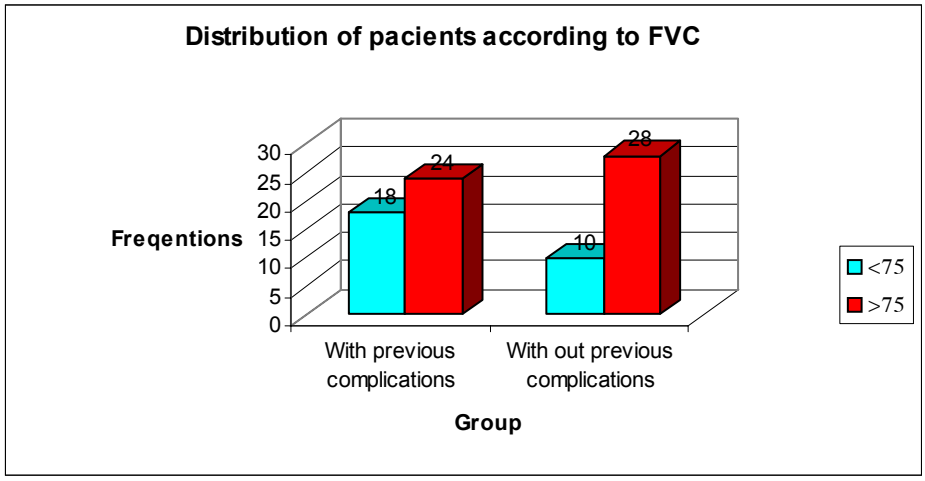
Figure 14 – Average value PAP – postoperatively in patients with previous complications
Slika 14 ‡ Prose~na vrednost na PAP ‡ postoperativno kaj pacientite so prethodna komplikacija



*PAP (pulmonary arterial pressure) ‡ (pritisok vo belodrobnata arterija)

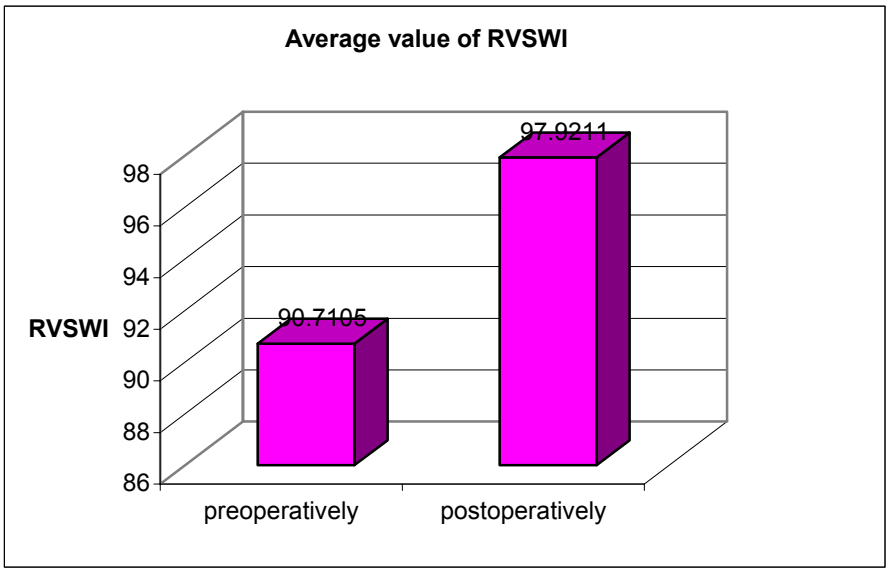
Figure 15 – Average value of PAP – pre and postoperatively in patient withouth previous complications
Slika 15 ‡ Prose~na vrednost na PAP ‡ pred i postoperativno

kaj pacienti so prethodni komplikacii



*FVC (forced vital capacity) – (forsiran vitalen kapacitet)

Figure 16 – Distribution of patients according to FVC
Slika 16 ‡ Distribucija na pacientite spored FVC



*RVSWI (right ventricular stroke work index) ‡ (indeks na desno komorna udarna rabota)

Figure 17 – Average value of RVSWI
Slika 17 ‡ Prose~ni vrednosti na RVSWI

Table 2 – Tabela 2

Patients distribution according to FVC
Distribucija na pacientite spored FVC

	Patients with previous complications	Patients without previous complications
< 75	18	10
> 75	24	28

*FVC (forced vital capacity) – (forsiran vitalen kapacitet)

Discussion

The information about the haemodynamical status in the past was obtained with invasive monitoring with Swan-Ganz catheter. Last few years the Doppler echocardiography was used to estimate the haemodynamical values and has shown high preciseness [1, 9]. The Doppler echocardiography is a non-invasive method which can be easily used preoperative, preoperative and in the postoperative period. A special interest for the lung surgery would be the right heart function pre and postoperatively, the pulmonary hypertension appearance and the ejection fraction. That is the reason we choose the certain group of parameters [4, 5, 6].

The quantitative evaluation of the right heart function is difficult because of its complex geometry. The echo-doppler cardiographic techniques have enabled that in non-invasive, simply and cheaper way.

A significant right ventricular dysfunction is noticed in the post-operative period. It could be estimated trough RVEDVI (right ventricular end-diastolic volume index) and the reduced right ventricular ejection fraction (RVEF) [7, 8, 10] (Figure 3, 4, 5, 6.). The reason should be the elevated right ventricular afterload after the increase of the pulmonary capillary pressure and the increased capillary resistance. The capability of the right ventricle to maintain the stroke volume depends on the capability for adaptation of the right ventricle diastolic volume. The enlarged right ventricle could due to Frank-Starling mechanism improve the ejection fraction, but for some time. All patients from group B had postoperative changes, but RVSWI (right ventricular stroke work index) (Figure 17) was not significantly changed because the right ventricular haemodynamics was corrected with the dilatation. Patients from group A have significant change of the RVSWI what needed aggressive therapy. Important determinant of the coronary flow is the perfusion pressure in

diastola. The changes in the arterial pressure and the heart rate after this operation should have an effect on the right coronary flow and certainly on the right ventricular function. The right heart end-diastolic pressure leads to increased right ventricle wall stress what results with increased oxygen demand and ischemia.

The right ventricle is very sensitive to after-load changes. The small muscle mass could easily be affected from the liquid balance. The depressed contractility of the right heart needs enlargement of the end-diastolic volume to minimally increase the right ventricle stroke volume and ejection fraction. A contractile deficit could be a reason for right ventricle dysfunction. In our material we registered arrhythmias. They mainly result from hypoxia, vagal irritation, atrial inflammation, heart disease or increased pulmonary arterial pressure. But we also registered arrhythmias in patients without heart disease anamnesis. Our suggestion is that in group B the right heart distension is a reason for arrhythmias (Figure 7, 8, 9, 10).

On the other side, right ventricle contractile function is an index of the right ventricular stroke work. But in group B we did not have significant changes on it. This could suggest that the reduced right ventricle ejection fraction after the lung resection is not a direct result of the defect of the right ventricular contractile function [3].

Finally, we examined the patient with echo Doppler cardiography 3 months after the resection. We found an increase of the pulmonary artery pressure and the right heart dimensions in both groups after 3 months, especially in older patients an patients with lower FVC (Figure 16).

We can conclude that echo Doppler cardiography is a non-invasive and very sensitive way to estimate the right heart haemodynamics in thoracic patients. The lung resections can influent the heart-lung haemodynamics especially in patients with malignant diseases and we need a correct preoperative estimation of the haemodynamic state so that the patient can properly be preoperatively prepared and postoperatively conducted [2]. The most affected parameters are PAPs, RVEF, HR, RVD and RVEDV.

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R e z i m e

DESNO SRCEVA HEMODINAMIKA PO BELODROBNI RESEKCII: ULOGATA NA TRANSTORAKALNATA EHO-DOPLER KARDIOGRAFIJA

Jovev S.,[1] Taxer S.,[2] Spirovski Z.,[1] Arsovski A.,[1] Trajkovska T.,[3] Proevska D.,[4] Kondov G.,[1] ^olan~eski R.,[1] Spirovska V. [4]

[1]Klinika za torakalna i vaskularna hirurgija, Klini~ki centar, Medicinski fakultet, Univerzitet „Sv. Kiril i Metodij“, Skopje, R. Makedonija

[2] Univerzitetska klinika za kardiotorakalna hirurgija, Tel A [omer, Tel Aviv;

[3]Karil, Klini~ki centar, Medicinski fakultet, Univerzitet „Sv. Kiril i Metodij“, Skopje, R. Makedonija

[4]Klinika za kardiologija, Klini~ki centar, Medicinski fakultet, Univerzitet „Sv. Kiril i Metodij“, Skopje, R. Makedonija

Analiziravme 80 pacienti kaj koi be{e napravena belodrobna resekcija zaradi karcinom na bronh. Pacientite bea operirani na Klinikata za torakalna hirurgija. Kaj site pacienti be{e napravena lobektomija ili bilobektomija so medijastinalna limfadenektomija. Site pacienti bea pome|u 50 i 70 godini i predoperativniot status be{e identi~en. Pacientite gi podelivme vo 2 grupi: grupa A ‡ pacienti so anamneza za miokardijalen infarkt, aritmija, belodrobna hipertenzija ili restriktivna belodrobna bolest i grupa B ‡ pacienti bez takva anamneza.

Kaj site pacienti napravivme eho-dopler kardiografija i bea izmereni osnovnite parametri za procenka na srcevo-belodrobnata hemodinamika (RVEDV ‡ desno komoren krajno dijastolen volumen, EF ‡ ejekciona frakcija, PAPs ‡ belodroben arteriski pritisok vo sistola). Duri i vo vtorata grupa registriravme zgolemuvawe na RVEDV, EF, PAPs {to e pri~ina za srcevi komplikacii po ovoj tip na operacii.

Ovie pacienti pobaruvaat dobra predoperativna hemodinamska procenka i podgotovka, zatoa {to srcevite komplikacii po belodrobnite resekcii se vtori po za~estenost po respiratornite, a mo`at da bidat so fatalen ishod.

Eho-dopler kardiografijata e senzitiven i neinvaziven metod za dobivawe na informacii za parametrite {to ja odreduvaat srcevo-belodrobnata hemodinamika.

Corresponding Author:

Jovev Sasko
Clinic for Thoracic and Vascular Surgery
Clinical Centre,
Medical Faculty,
Skopje, R. Macedonia