ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN — POLONIA
VOL. LVII, N 1, 5 SECTIO D 2002

Department of Cardiac Surgery, Medical University of Lublin
Department of Thoracic Surgery, Medical University of Lublin

JANUSZ STĄŻKA

Comparative analysis of the spirographic and hemodynamic parameters in preoperative evaluation of patients with lung cancer

Surgery is the recommended treatment for lung cancer whenever possible (1). The performance of lung resection in patients with underlying cardiopulmonary dysfunction is associated with the risk of death or prolonged disability (10). The search for the ideal preoperative test to predict those patients at highest risk began with spirometry in 1955 and is still the most common test in pulmonary diseases (11). The spirometric tests completed with gasometric analysis and electrocardiographic investigation are the standard in the evaluation for tolerance of lung tissue resection (13). The afore-mentioned methods do not allow a complete evaluation of the circulatory efficiency, particularly when patients are suspected of occult myocardial failure. The catheterization of the right heart, applied until recently exclusively in cardiac diagnostics, is now more frequently used to assess respiratory and circulatory systems efficiency in patients qualified for removal of pulmonary tissue (7,8).

The purpose of the study was to evaluate the correlations between basic spirographic and hemodynamic parameters measured at rest and after exercise. In case of any relations between individual spirographic and hemodynamic parameters the paper was to determine if any occurrence of such correlations constitutes an indication for the catheterization of the right heart, thus constituting evidence of the occult circulatory failure.

MATERIAL AND METHODS

The study population consisted of 50 consecutive male patients 21 to 72 years old (average of 55.8) with bronchial carcinoma, considered to be candidates for lung tissue resection in the Department of Cardiothoracic Surgery, Medical University in Lublin.

The spirographic evaluation was performed on the patients in the sitting position, with the use of dry Vitalograph spirometer. The results concerned: vital capacity (VC) and one-second forced expiratory volume (FEV_1) and were obtained in milliliters. The results were presented as percentage values according to Berglund's norms in BTPS circumstances (9), in accordance with the formulas:

$$VC\% = \frac{VC_a}{VC_n} \times 100 \; ; \; FEV_{1a}\% = \frac{FEV_{1a}}{VC_a} \times 100 \; ; \; FEV_1\% = \frac{FEV_1}{VC_n} \times 100$$

Where: VC_a – current vital capacity (in milliliters)

VC_n – normal vital capacity according to Berglund's norms (in milliliters)

FEV_{1a} – current one-second forced expiratory volume (in milliliters)

The hemodynamic examination of pulmonary circulation was performed using Swan-Ganz Monitoring Thermodilution Catheter Model 93-115-7F manufactured by Edwards Lab. Inc. California USA connected to the Statham P 23SD pressure transducer. Pressure was read using Simonsen and Weel system 8000 monitor. The catheter was entered into the pulmonary artery in local anesthesia through the dissected free left basilic or external jugular vein or through right subclavian vein using the Seldinger's method. The catheter was introduced to the wedged position under constant pressure curve monitoring. The systolic, diastolic and medium of central venous pressure (CVP), pulmonary artery pressure (PAP) and pulmonary capillary wedge pressure (PCWP) were measured in mmHg. Gasometric examination for peripheral blood was performed on all patients. There were measured PaO_2, $PaCO_2$, pH, SaO_2 (in systemic arterial blood) and PvO_2, $PvCO_2$, pHv, SvO_2 (in mixed venous blood). Gasometric tests were performed using 168pH Blood Gas Analyser manufactured by Corning.

Hemodynamic calculations were performed using Ergooxyscreen – Erich Jager pulmonary hemodynamic computer. There were calculated: cardiac index (CI), left ventricular end diastolic pressure (LVEDP), right ventricular end diastolic pressure (RVEDP), pulmonary vascular resistance (PVR) and systemic vascular resistance (SVR). With the exception of the spirographic examination all the measurements were taken at rest ("r") and after exercise test ("e") – five minutes, 50W workload on the Medicor type KE 11 ergo-meter in supine position.

The results were subject to statistical analysis. The correlation between spirographic indicators and hemodynamic parameters were studded. Spearman correlation coefficient and "r" correlation coefficient were calculated. In order to determine whether the values of correlation coefficients were other than "0", there was utilized the distribution of the t-Student test. For sizes of $n > 0$ the distribution of the Spearman correlation coefficient has approximate normal distribution.

$$N / 0\sqrt{1\,(n-1)}$$

The nature of relation was described employing the regression analysis. Regression lines for indices were calculated checking whether the value of the coefficient of regression line significantly differs from zero. Confidence curves at the significance level 0.01 were also calculated.

RESULTS

SPIROGRAPHIC TESTS

The results indicate that VC% value exceeded 78% of to the Berglund norm in most of the patients (78%), and only in one case VC% was lower than 50%. The values of Tiffenau coefficient showed significant differences. The values of FEV_{1a} % were lower than the values of FEV_1 %. The values of FEV_{1a} % and FEV_1 % over 60% were evidenced in 32 (64%) and in 19 (38%) patients and below 50% in 4 (8%) and 24 (48%) patients, respectively.

HEMODYNAMIC EVALUATIONS

Average values of systolic RR oscillated from 85 to 125 mmHg (average 100 mmHg) at rest and from 105 to 170 mmHg (average 130 mmHg) after exercise. It was found that the average value of CVP rose from 5.61 to 8.48 mmHg ($p < 0.01$) and PCWP from 5.85 to 11.13 mmHg ($p < 0.001$) after exercise. Average age, average values of spirographic parameters and their dependence on values of medium pulmonary artery blood pressure presented at rest and after exercise were showed in Table 1. There were no correlations between average PAP and the age of patients. Significant statistical differences occur in values of VC% and FEV_1 % marked in the patients with arterial hypertension at rest and after exercise ($p < 0.01$).

Table 1. Average age, average values of spirographic parameters and their dependence on values of medium pulmonary blood pressure at rest (PAP^r) and after exercise (PAP^c)

PAP^r mmHg PAP^c mmHg	19 mmHg 30 mmHg	< 19 mmHg > 30 mmHg	> 19 mmHg > 30 mmHg
Number of patients	22	9	19
Average age (in years)	53.4	59.9	56.5
Average VC%	89.3	67.7	61.0
Average FEV_{1a} %	69.2	66.1	57.4
Average FEV_1 %	65.0	49.1	40.7

CORRELATION BETWEEN SPIROGRAPHIC AND HEMODYNAMIC PARAMETERS

Correlation coefficients were calculated on the basis of the determined spirographic and hemodynamic results. In the cases of statistically significant correlations, the regression line equation was calculated and the related confidence curves were displayed on the charter.

The values of the correlation coefficients between VC% and hemodynamic parameters, statistical significances and regression line equations are presented in Table 2. 10 out of 18 examined correlations turned out to be of statistical significance. Considerable statistical significance was noted in case of PAP and RVSWI, at rest and after exercise ($p < 0.001$). The value of VC% significantly correlated with the values of RR and LVSWI marked after exercise and the values of CI and PVR at rest as well as after exercise ($p < 0.01$).

Only the values of PAPs and PVRs of the 18 indices revealed statistical significance with FEV_{1a} % ($p < 0.01$).

Table 2. Correlation coefficients between VC% and hemodynamic parameters, statistical significance and regression line equation

	Correlation coefficients	Statistical significance	Regression line equation
RR^e	- 0.047	p < 0.01	y = - 0.223x +149.98
PAP^r	- 0.536	p < 0.001	y = - 0.154x + 32.18
PAP^e	- 0.520	p < 0.001	y = - 0.237x + 52.78
CI^r	- 0.349	p < 0.01	y = - 0.015x + 4.94
CI^e	- 0.421	p < 0.01	y = - 0.287x + 8.35
PVR^r	- 0.334	p < 0.01	y = -1.036x +257.62
PVR^e	- 0.299	p < 0.01	y = - 0.807x +236.32
$LVSWI^e$	- 0.341	p < 0.01	y = - 0.043x + 12.99
$RVSWI^r$	- 0.501	p < 0.001	y = - 0.0134x + 2.274
$RVSWI^e$	- 0.477	p < 0.001	y = - 0.024x + 4.39

The value of correlation coefficients between FEV_1 % and the hemodynamic parameters are presented in Table 3. In the group of 18 examined correlations, 10 revealed statistical significance, and the values of PAP and RVSWI at rest and after exercise

Table 3. Correlation coefficients between FEV1 % and hemodynamic parameters, statistical significances and regression line equation

	Correlation coefficients	Statistical significance	Regression line equation
RR^e	- 0.346	p < 0.01	y = - 0.27x + 145.8
PAP^r	- 0.619	p < 0.001	y = - 0.207x + 30.38
PAP^e	- 0.606	p < 0.001	y = - 0.326x + 50.45
CI^r	- 0.307	p < 0.01	y = - 0.016x + 4.5
CI^e	- 0.413	p < 0.01	y = - 0.033x + 7.73
PVR^r	- 0.411	p < 0.01	y = - 1.48x + 250.23
PVR^e	- 0.331	p < 0.01	y = - 1.05x + 225.43
$LVSWI^e$	- 0.339	p < 0.01	y = - 0.5x + 12.1
RVSWIr	- 0.479	p < 0.001	y = - 0.015x + 1.95
$RVSWI^e$	- 0.522	p < 0.001	y = - 0.031x + 4.05

turned out to be highly significant ($p < 0.001$). Significant correlation was noted in reference to CI and PVR at rest and after exercise and in RR and LVSWI after exercise ($p < 0.01$).

Regression line and confidence curves related to the equations between the variable FEV_1 % and PAP^r demonstrates Figure 1. The comparison of the correlations between the examined spirographic indices and hemodynamic parameters indicate that both VC and FEV_1 correlate with PAP and PVR at rest and with PAP after exercise.

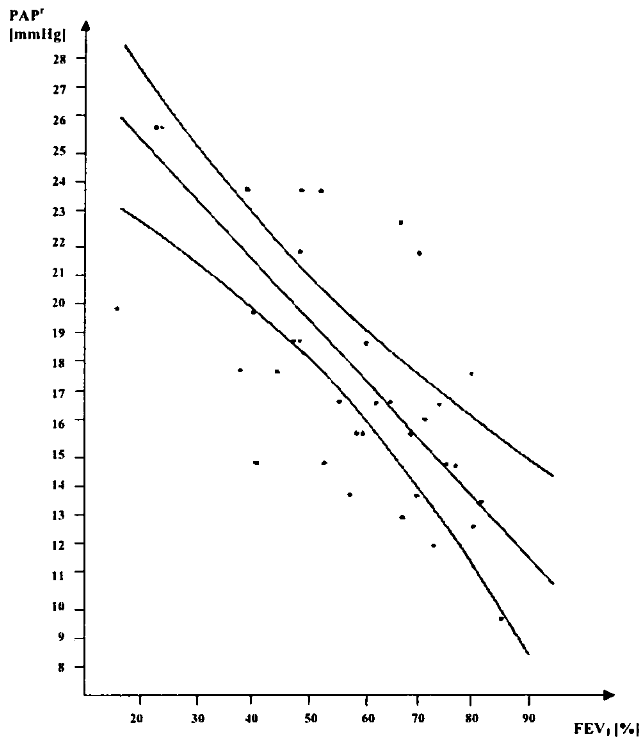

Fig. 1. Regression line PAP^r related to FEV_1 % variable $y = - 0.207 x + 30.38$ $r = 0.62$. Confidence curves for this regression $p = 0.01$

DISCUSSION

Function test of the respiratory system, gasometric analysis of arterial blood and electrocardiographic examinations were performed routinely on the patients to undergo resection of lung tissue. In most cases they are sufficient for the assessment of the circulatory and respiratory efficiency in order to decide on the operational treatment. However, the above methods are not sufficient for the evaluation of circulatory efficiency, especially in case of patients likely to suffer from unrevealed circulatory failure.

For a thorax surgeon it is imperative to determine: a) whether or not the popular and commonly applied methods (spirography, arterial blood gasometry, electrocardiography) can prove useful for diagnosis of circulatory and respiratory efficiency, b) what are the indications for performing catheterization of the right heart in the patients of higher operational risk.

Most patients in this study diagnosed with lung cancer and prepared for the resection of lung tissue revealed dysfunctions in circulatory hemodynamics. Out of 50 patients examined merely 22 (44%) had proper values of average blood pressure in the pulmonary artery, both at rest and after exercise. In 9 cases (18%) the values were proper at rest, while they turned out to be pathologically higher after exercise ($PAP^c > 30$ mmHg). In 19 cases (38%) the pressure in the pulmonary artery was higher, both at rest and after exercise.

In a similar research performed separately by Bründler (2) and Daum (3), the percentage of patients with higher blood pressure in the pulmonary artery was greater than the one resulting from my investigation.

In the examined group of patients there was evidenced a correlation between spirographic indicators and the average values of blood pressure in the pulmonary artery at rest and after exercise, while the correlation coefficient between FEV_{1a} % and the values of PAP^r and PAP^c was lower than in the case of FEV_1 %. Similar results were obtained by Falkiewicz (4), Bründler (2), Tendera (12), while the latter did not observe correlation between PAP^r and VC%. These correlations were also not observed by Wiederlanders, Hawryłkiewicz (5), Łukiański (6).

Despite individual significant differences in the values of spirographic and hemodynamic indices, the statistical analysis revealed high repetition rate of the observed changes. There are also other proofs of this finding, as existing in commonly applied spirographic indices and hemodynamic parameters.

The advantage of the correlation and multiple regression consists in the possibility to simultaneously determine the relation between all the indices and examined phenomenon and to evidence the significance of these relations. The applied method of statistical analysis made it possible to evidence the most important ventilation indices characterizing circulation efficiency. The factors that turned out important for predicting hemodynamic indices in the examined material are: a) current vital capacity (VC%) b) one-second forced expiratory volume ($FEV_{1\%}$).

It was evidenced that in many instances the mathematically calculated ventilation and gasometric indices enable determining the level of risk of adverse effects at the early post operational period. The analysis makes it highly probable to select the patients suffering from the diagnosed or suspected pulmonary artery hypertension.

CONCLUSIONS

1. Patients qualified for operational treatment due to bronchial cancer were often diagnosed with higher average values of blood pressure in the pulmonary artery.

2. Statistical analysis revealed high level of correlation between the average blood pressure in pulmonary artery (PAP), both at rest and after exercise, and the ratio of one-second forced expiratory volume related to current vital capacity (FEV_{1a})

3. The revealed correlations allow to solve regression equations making it possible to calculate likely values of the average blood pressure in pulmonary artery on basis of the spirographic values.

4. On the basis of their achieved results, if can be stated that the catheterization of the right heart may be suitable in the case of patients, for whom the results of the calculations of the regression equations indicate that they may suffer from the pulmonary artery hypertension.

REFERENCES

1. Brutsche M. H. et al.: Exercise cocacity and extent of resection as predictors of surgical risk in lung cancer. Eur. Respir. J., May, 15 (5), 828, 2000.
2. Bründler H. et al.: Right heart catheterization in the preoperative evaluation of patients with cancer. Respiration, 48, 261, 1985.
3. Daum S. et al.: Lungenkreislauf diagnostic vor lungenresection. Pneumonologie, 147, 187, 1971.
4. Falkiewicz A. et al.: Narząd krążenia w obturacyjnej i ograniczającej niewydolności oddechowej. Kard. Pol., 6, 57, 1963.
5. Hawryłkiewicz I. et al.: Podstawowe wskaźniki czynności płuc a parametry hemodynamiki płuc u chorych z przewlekłym zapaleniem oskrzeli. Pol. Tyg. Lek., 38, 8, 239, 1983.
6. Łukiański M. et al.: Pomiary ciśnień krwi w sercu prawym a wyniki badań spirometrycznych. Gruźlica, 32, 797, 1961.
7. Muller M. et al.: Effects of dopexamine and volume loading on hemodynamic and oxygenation parameters in patients undergoing pulmonary resection. Acta Anaesthesiol. Scand., 44 (7), 858, August 2000.
8. Okada M. et al.: Right ventricular ejection fraction in preoperative evaluation of candidates for pulmonary resection. J. Thorac. Cardiovasc. Surg., 112 (2), 364, August, 2000.

9. Petro W.: Perioperative funktionsdiagnostik. Prax. Klein. Pneumol., 38, 161, 1984.
10. Semik M. et al.: Lung cancer surgery–preoperative risk assessment and patient selection. Lung Cancer., 33, Suppl. 1, S 9, October 2001.
11. Simon-Rigaud M. L. et al.: Value of sophisticated explorative techniques of the pulmonary function in the preoperative evaluation of respiratory risk. Agressologie, 33 Spec. N 1, 19, 1992.
12. Tendera M. et al.: Zaburzenia w krążeniu płucnym I systemowym w przebiegu przewlekłych nieswoistych chorób płuc. I Dynamika krążenia płucnego. Pneumonol. Pol., 51, 3, 145, 1983.
13. Vaughan M. T. R. et al.: Comparison of PEFR and FEV_1 in patients with varying degree of airway obstruction. Chest, 95, 558, March 1989.
14. Wiederlanders R. E. et al.: The effect of pulmonary resection on pulmonary artery pressures. Ann. Surg., 160, 5, 889, 1964.

2001.04.01

SUMMARY

Surgery is the recommended treatment for nonmicrocellular lung cancer. The spirometric tests completed with gasometric systemic blood analysis and electrocardiographic investigation are the standard in the evaluation for tolerance of lung tissue resection. The catheterization of the right heart is used to assess circulatory systems efficiency in patients qualified for pulmonary tissue resection. The purpose of the study was to evaluate the correlations between basic spirographic and hemodynamic parameters measured at rest and after exercise. The studied population consisted of 50 consecutive male patients 21 to 72 years old with bronchial carcinoma, considered to be candidates for lung tissue resection. The vital capacity, and one-second forced expiratory volume were obtained. The hemodynamic examination was performed using Swan-Ganz thermodilution catheter. The systolic, diastolic and medium central venous pressure, pulmonary artery pressure and pulmonary wedge pressure were measured. Gasometric examination for peripheral arterial and mixed venous blood was performed – pH, PO_2, $PaCO_2$, SaO_2. The results were subject to statistical analysis. The correlation between spirographic indicators and hemodynamic parameters were studied. Statistical analysis revealed high level of correlation between the average blood pressure in pulmonary artery, both at rest and after exercise, and ratio of one-second forced expiratory volume related to current vital capacity. The revealed correlations allow to solve regression equations making in possible to calculate likely values of the average blood pressure in pulmonary artery on the basis of spirographic values.

Porównawcza ocena wartości badań spirograficznych i parametrów hemodynamicznych w przedoperacyjnej ocenie pacjentów z rakiem płuca

Wykonywane rutynowo przedoperacyjne badanie spirograficzne, gazometryczne i elektrokardiograficzne w sytuacjach chorych w starszym wieku i/lub z towarzyszącym zaburzeniem wydolności krążeniowo-oddechowej zmuszają chirurga do oceny wydolności krążenia płucnego celem ostatecznej kwalifikacji chorych do leczenia operacyjnego. Celem pracy była próba oceny współzależności między wskaźnikami rutynowo wykonywanej spirografii a parametrami hemodynamicznymi krążenia płucnego. Badaniami objęto 50 kolejnych mężczyzn w wieku 21–72 lat (śr. 55,8) z rakiem oskrzela, kwalifikowanych wstępnie do zabiegu resekcji miąższu płucnego. U wszystkich pacjentów wykonano badanie spirometryczne, oznaczając VC%, FEV_1 %, FEV_{1a} %, badanie gazometryczne krwi obwodowej (PaO_2, $PaCO_2$, SaO_2, pH) i mieszanej krwi żylnej (PvO_2, $PvCO_2$, SvO_2, pHv). W oparciu o te parametry wyliczono CI, SVR, PVR, LVSWI, RVSWI. Badania gazometryczne i hemodynamiczne wykonano w warunkach spoczynku i po wysiłku na ergometrze rowerowym przy obciążeniu 50 W przez okres 5 min. Uzyskany materiał poddano analizie statystycznej, wyliczając współczynnik korelacji „r" oraz współczynnik korelacji Spearmana. Badano kształt związku, stosując analizę regresji. Liczono proste regresji dla wskaźników, sprawdzając, czy współczynnik prostej regresji różni się istotnie od zera. Liczono również krzywe ufności przy poziomie istotności 0,01.

Na podstawie przeprowadzonych wyliczeń stwierdzono wysoką współzależność między FEV_1% a średnim ciśnieniem w tętnicy płucnej (PAP) w spoczynku i po wysiłku. Wyliczone równania regresji umożliwiają obliczenie przybliżonych wartości ciśnienia w tętnicy płucnej na podstawie parametrów spirograficznych.