

ACUTE EFFECTS OF LOBECTOMY ON RIGHT VENTRICULAR EJECTION FRACTION AND MIXED VENOUS OXYGEN SATURATION

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ABSTRACT

Background : The major determinant of postoperative morbidity and mortality after pulmonary resection is the functional status of the cardiac and pulmonary systems. Right ventricular (RV) thermodilution ejection fraction/oximetric catheter has been recently proposed as a new technique to evaluate the pulmonary hemodynamics and gas exchange variables in lung resection.

Aim of the work : The aim of this study was to evaluate the effect of lobectomy on pulmonary hemodynamics and gas exchange variables using the RV thermodilution ejection fraction/oximetric catheter and its possible effects on early morbidity and mortality.

Patients and methods : We evalu-

ated the acute postoperative effects of lung resection on hemodynamic and gas exchange parameters in thirty patients using the RV thermodilution ejection fraction/oximetric catheter. Anesthesia was induced with thiopentone sodium and maintained with midazolam, fentanyl and pipecuronium. Intubation was performed with double-lumen, left-sided endobronchial tube for one lung ventilation. The hemodynamic and gas exchange parameters were recorded before and after induction of anesthesia, and two hours after lung resection.

Results : Lobectomy was associated with significant hemodynamic changes and good maintenance of gas exchange variables. SVI, LVSWI and RVEF were significantly decreased in the early postoperative

period after lung resection. MPAP, COP, CI, SVRI, PVRI, RVSWI, and RVEDVI showed no significant changes during perioperative period. Svo₂ showed a significant increase after lung resection when compared with preinduction values, while Vo₂ significantly decreased. Sao₂, a-A Po₂, QS-QT, Do₂, and O₂ ER showed no significant changes during perioperative period.

No operative mortality is encountered in this study. Post-operative supraventricular arrhythmias were recorded in five patients (16.7%) which were hemodynamically well tolerated and did not correlate with the peri-operative changes in the hemodynamics or gas exchange variables.

Conclusion : We can conclude that the acute post - resection period (up to 2 hours postoperatively) revealed right and left ventricular dysfunction with good maintenance of gas exchange. Despite these changes, lobectomy is well tolerated with minimal morbidity and mortality.

Key Words : anesthesia , lobectomy , hemodynamic, ventilatory , acute changes

INTRODUCTION

The major determinant of postoperative morbidity and mortality after pulmonary resection is the functional status of the cardiac and pulmonary systems. Lung resection results in loss of lung parenchyma. The functional loss resulting from pulmonary resection varies with the extent of resection, the relative function of the tissue removed compared with remaining, and the degree of baseline disease ¹⁻³.

Traditional methods of assessing the operative risk for lung resection has provided only a modest ability to predict postoperative morbidity and mortality ^{1,2}. Previous studies yielded conflicting results regarding the use of preoperative pulmonary function testing as a predictor of postoperative complications ^{3,4}.

The development of the right ventricular (RV) thermodilution ejection fraction/oximetric catheter has allowed assessment of RV performance in a variety of conditions including shock ⁵, sepsis ⁵, thermal injury ⁶, and after coronary bypass grafting ⁷.

Four studies investigating the RV function using thermodilution demon-

strated significant RV dysfunction in the postoperative period after pulmonary resection⁸⁻¹¹. Alterations in RV contractile function and changes in RV afterload are the presumed mechanisms of RV dysfunction.

Supraventricular arrhythmias are a well documented complication after lung resection, however, the aetiology of such arrhythmias has never been clearly proved⁸.

The aim of this study was to evaluate the acute effects of lobectomy on pulmonary hemodynamic and gas exchange variables using the RV thermodilution ejection fraction/oximetric catheter and its possible effect on early morbidity and mortality.

PATIENTS & METHODS

The study was approved by the local ethical committee of Anesthesia Department at Mansoura University Hospitals and all patients gave informed written consent. Thirty patients of either sex, with age ranging from 20 to 50 years undergoing elective lobectomy at Mansoura Cardiothoracic Surgery Unit were studied and all procedures were done with the same senior surgical staffs.

Patients with renal and liver dysfunction, preoperative pulmonary hypertension, arrhythmias, valvular heart diseases, history of recent myocardial infarction in the previous 6 months or pulmonary dysfunction were excluded from the study .

Preoperative evaluation of all patients concerning medical history, clinical examination including ECG and chest x-ray, complete laboratory investigations and EchoDoppler evaluation of the heart and valves were done.

On arrival of the patients to the preoperative area, peripheral intravenous indwelling cannula was inserted. Low molecular weight hydroxyethylstarch solution (7ml.Kg-1) was given before induction of general anesthesia. Premedication consisted of fentanyl (1.0 µg / Kg) and midazolam (0.05mg/Kg) were given (IV) 15 minutes before induction of anesthesia and they were connected to ECG and pulse oximetry [SpO₂] equipment.

Under local lidocaine (0.5%) anesthesia, an arterial catheter of the non dominant hand was placed (20 G) for continuous direct arterial blood

pressure recording and blood sampling for gasometry and pulmonary artery catheter via right internal jugular veins for hemodynamic measurements and blood sampling for gasometry. Correct placement of the pulmonary artery catheter was confirmed with characteristic pressure wave changes and the final position of the pulmonary catheter position tip was confirmed with portable chest x - ray film.

Cardiac output was measured using the thermodilution technique, by the mean value of three successive injections of 10 ml dextrose 5% at room temperature [Cardiac Output/SvO₂ computer, KONTRON KoloMRON TM 7250 plus coloured monitor ,UK].

ECG, oxygen saturation, end - tidal carbon dioxide tension [EtCO₂] and nasopharyngeal temperature were monitored continuously [KONTRON KoloMRON TM 7250 plus anesthesia colour monitor] during the entire procedure.

Anesthesia was induced with thiopentone sodium 3-5m/kg IV. With loss of consciousness, positive pressure ventilation was started via face mask

at a rate of 12-15 breaths per minutes. Pipecuronium (0.07 mg / Kg) was given for muscle relaxation, and intubation was performed with a double-lumen, left-sided endobronchial tube [Broncho-cath TM, Mallinekrodt, laboratories, thlone, Ireland] (gauge no.37-41).

The position of the endobronchial tube was checked by inflating each lung separately while auscultating the breath sounds and by fiberoptic bronchoscopic examination done by the surgeon.

Anesthesia was maintained during the procedure with continuous infusion of midazolam (0.5-1.0 mg/Kg/min) with fentanyl (1.0-2.0g/Kg/h) to maintain systolic pressure 20% of the basal initial value. Pipecuronium was given as (0.03 mg/Kg) increments to maintain adequate surgical relaxation. Patients were mechanically ventilated with 100% o₂. Ventilation was adjusted to maintain the arterial carbon dioxide tension (PaCO₂) at 36-42 mmHg. Ringer's solution was given to maintain CVP at 8 -10 mmHg and urine output at 1ml/Kg/h.

After surgery, extubation was considered if hemodynamics and respira-

tory parameters were stable for 20 minutes. The residual effects of neuro - muscular blockade were reversed with neostigmine ($50 \mu\text{g} / \text{Kg}$) and atropine sulfate ($20 \mu\text{g} / \text{Kg}$).

Surgical procedures was done through standard posterolateral thoracotomy . After freeing the pleural adhesions, hilar dissection was carried out . Classically , the lobar pulmonary arteries then veins were dissected, double ligated with suitable silk ligatures and divided . The bronchial stump was closed with single row of interrupted transverse mattress praline 3/0 sutures. After hemostasis, two pleural drains were inserted and finally thoracotomy was closed anatomically in layers .

Measurements:

[1.] HEMODYNAMIC PARAMETERS :

Heart rate [HR], mean arterial blood pressure [MAP], central venous pressure [CVP], mean pulmonary artery pressure [MPAP] and pulmonary artery occlusion pressure [PAOP] were recorded. Cardiac index [CI] , stroke volume index [SVI], right ventricular end diastolic volume [RVEDV] and right ventricular ejection fraction [RVEF] were measured. Systemic vascular resistance

index [SVRI], pulmonary vascular resistance index [PVRI], left ventricular stroke work index [LVSWI] and right ventricular stroke work index [RVSWI] were calculated .

[2.] Gas exchange PARAMETERS :

End-tidal carbon dioxide tension [EtCO₂] , oxygen saturation in the peripheral blood [SpO₂], mixed venous oxygen saturation [SVO₂ , by fiber-optic reflectance spectrophotometry], were recorded. Two blood samples were withdrawn from both the radial artery cannula (arterial sample) and the distal tip of pulmonary catheter (mixed- venous sample), simultaneously, for blood gasometry. Oxygen saturation of both arterial and mixed - venous blood [SaO₂ & SvO₂], arterial oxygen tension of both arterial and mixed - venous blood [PaO₂ & PvO₂], carbon dioxide tension of arterial blood [PaCO₂] were measured. Alveolar oxygen tension [PAO₂], Oxygen content of arterial, venous and pulmonary capillaries blood [CaO₂ , CO₂ , CcO₂], shunt fraction [Qs -Qt], arterial - end tidal carbon dioxide tension [a - EtCO₂], and arterial - alveolar oxygen tension ratio [a/A PO₂], the oxygen delivery [DO₂] , oxygen uptake {VO₂}, and

oxygen extraction ratio [O_2 ER] were calculated.

The hemodynamic and gas exchange parameters were recorded at following time intervals:

- 1: preinduction (basal)
- 2: 15 minutes postinduction
- 3: 2 hours postoperative in the ICU.

Data was presented as mean \pm SD. Distribution of raw data was done by Shapiro-Wilk's W test. One way analysis of variance was used to compare perioperative changes in hemodynamic and gas exchange variables. For F value < 0.05 , multiple means were compared by Tukey's post hoc test. $P < 0.05$ was considered significant.

RESULTS

Demographic data (mean, range), indications for lung resection and site of lobectomy are presented in Table (1).

Table (2) shows HR, MAP, and hemodynamic changes before induction of anesthesia (basal values), 15 minutes after induction of anesthesia, and 2 hours postoperatively in the ICU. Perioperative Hb concentration

showed no significant changes. HR and MAP did not change significantly during the perioperative period. CVP showed no significant changes during perioperative period.

Lobectomy was associated with significant hemodynamic changes. SVI and LVSWI significantly decreased from 47 ± 8.75 (preinduction values) to 35 ± 10.57 (postresection values) $\text{ml} \cdot \text{beat}^{-1} \cdot \text{m}^{-2}$, 53.6 ± 8.51 to 33.9 ± 9.89 $\text{g} \cdot \text{m} \cdot \text{m}^{-2} \cdot \text{beat}^{-1}$, respectively. RVEF showed significantly decrease from 37 ± 6.63 to 27 ± 12.74 (%) after resection. MPAP, PAOP, COP, CI, SVRI, PVRI, RVSWI, and RVEDVI showed no significant changes during perioperative period.

As regard the gas exchange variables (Table 3), cont. S_{vo2} and S_{vo2} showed a significant increase after lung resection when compared with preinduction values, while Vo_2 significantly decreased from 157 ± 44 (preinduction values) to 118 ± 34 (post-resection values) $\text{ml} \cdot \text{min}^{-1} \cdot \text{m}^{-2}$. Sa_{o2} , $a-A Po_2$, $QS-QT$, Do_2 , and O_2 ER showed no significant changes during perioperative period.

Post-operative supraventricular arrhythmias were recorded in five pa-

tients (16.7%), three of them had left lobectomies and two had right lobectomies. Arrhythmias were hemodynamically well tolerated and did not correlate with the peri-operative

changes in the hemodynamics or gas exchange variables. No patient died during hospitalization and none of the patients had to be reported due to post-operative complication.

Table 1: Demographic data (Data are in Mean \pm SD)

Age (Years)	38 \pm 11.79
Sex (% female)	26 %
Weight (Kg)	72 \pm 11
Height (Cm)	165 \pm 5.8
BSA (Kg.m ⁻²)	1.77 \pm 0.12
Right lobectomy (%)	10 patients (33 %)
-Upper lobe	3 patients (10%)
-Middle lobe	1 patient (3.3%)
-Lower lobe	4 patients (13.3%)
-Middle & lower	2 patients (6.7%)
Left Lobectomy (%)	20 patients (66.7%)
-Upper lobe	8 patients (26.7%)
-Lower lobe	12 patients (40%)
Etiology of lung disease	
-Bronchiactesis	10 patients (33 %)
-Tuberculosis	8 patients (26.7 %)
-Bronchial adenoma	6 patients (20 %)
-Lung abscess	6 patients (20 %)

Table 2: Hemodynamic variables (Data are in Mean \pm SD)

	BASAL	Postinduction	Postresection
HR (Bpm)	89 \pm 13.97	86 \pm 10.35	92 \pm 14.28
MAP (mmHg)	92 \pm 14.57	91 \pm 10.93	88 \pm 12.57
CVP (mmHg)	4 \pm 2.75	6 \pm 4.04	5 \pm 3.41
MPAP (mmHg)	18 \pm 4.97	21 \pm 5.44	19 \pm 5.91
PAOP (mmHg)	10 \pm 4.96	12 \pm 6.26	13 \pm 5.37
COP (L/min)	6.8 \pm 1.51	5.7 \pm 1.98	5.5 \pm 1.53
CI (L/min/m ²)	3.8 \pm 0.82	3.2 \pm 0.96	3.1 \pm 0.79
SVI (ml/beat/m ²)	47 \pm 8.75	40 \pm 14.21	35 \pm 10.57*
SVRI (dyne.sec.m ² /cm ⁵)	1878 \pm 445.87	2261 \pm 898.10	2333 \pm 586.32
PVRI (dyne.sec.m ² /cm ⁵)	155 \pm 52.87	188 \pm 69.06	160 \pm 50.97
LVSWI (g.m/m ²)	53.6 \pm 8.51	45.5 \pm 13.79	33.9 \pm 9.89*
RVSWI (g.m/m ²)	7.6 \pm 3.18	8.5 \pm 2.98	6.9 \pm 3.31
RVEDVI (ml/m ²)	160 \pm 38.51	137 \pm 47.79	141 \pm 49.10
REF (%)	37 \pm 6.63	34 \pm 9.14	27 \pm 12.74*

* Significant when compared with basal values

Table 3: Gas exchange variables (Data are in Mean \pm SD)

	BASAL	Postinduction	Postresection
Sao ₂ (%)	97 \pm 1.92	98 \pm 0.89	98 \pm 0.77
Cont. Svo ₂ (%)	78 \pm 4.77	81 \pm 4.56	85 \pm 5.79*
Svo ₂ (%)	77 \pm 5.47	80 \pm 4.51	84 \pm 6.45*
a-A Po ₂ (%)	37.6 \pm 10.92	44.4 \pm 18.33	47.1 \pm 15.34
Q _S -Q _T (%)	25.28 \pm 8.44	29.07 \pm 12.24	29.97 \pm 11.74
Do ₂ (ml/min/m ²)	705 \pm 135	711 \pm 225	720 \pm 336
Vo ₂ (ml/min/m ²)	157 \pm 44	144 \pm 65	118 \pm 34*
O ₂ ER (%)	21 \pm 6.6	18 \pm 6	18 \pm 5

* Significant when compared with basal values

DISCUSSION

Hemodynamic and gas exchange studies were performed preinduction, postinduction, and 2 hours after lobectomy in thirty patients using RV thermodilution ejection fraction / oximetric pulmonary artery catheter. Lobectomy associated with significant hemodynamic and good maintenance of gas. SVI, LVSWI, RVEF, and Vo₂ were significantly decreased after Lobectomy, while Svo₂ significantly increased.

Stroke work is the product of two variables, the pressure generated in the ventricle and the volume output.

The advantages of using stroke work instead of cardiac output or stroke volume are calculation includes HR, preload, and afterload, the major variables affecting the cardiac function¹². In our patients, 2 hours after lung resection, LVSWI significantly decreased. HR showed no significant changes perioperatively. Preload represented by CVP appears normal during perioperative period in relation to normal range. PAOP also showed no significant changes. On the other hand, SVI was decreased after lobectomy. So the marked decrease in LVSWI post - resection in our study are due to parallel decrease in SVI af-

ter lung resection.

In this study, 2 hours after lobectomy, there are significant RV dysfunction as measured by reduced RVEF. This in accordance with previous studies^{8-11,13}. The present study demonstrated that RVEF declined while RVEDVI remains stable in the early postoperative period with significant decrease in SVI. This in accordance with Reed et al.,¹⁰ who found that RVEDV remain stable in the early postoperative hours and increased significantly on postoperative day 1 and 2. In our study, PAP, and PVRI remained unchanged from baseline values. We speculated that afterload is not the causing factor of the RV dysfunction in the early postoperative period and the alteration in the RV contractility may be the causal factor. Other studies contradict this finding and claim that afterload alteration is the major determinant of RV dysfunction^{10,14}. Reed et al.,⁹ suggest that RV dysfunction that occur during the early postoperative period after lung resection are not solely due to changes in RV afterload or changes in contractile state.

In the present study, the left heart decompensation in the early post-

operative period after lobectomy as demonstrated by significant reduction in SVI and LVSWI may be due to a consequence of RV dysfunction, either by decreasing left ventricular preload or by shifting the inter - ventricular septum resulting in a decreased left ventricular volume¹⁵.

In this study, Lobectomy associated with minor deterioration of the gas exchange variables. We demonstrated no significant in the arterial oxygen saturation, alveolar-arterial Po₂, and Circulatory shunt, 2 hours after lobectomy. This in accordance with Sekine et al¹⁶ who found that lobectomy associated with good maintenance of gas exchange for only 6-12 hours after resection and then deteriorated because of peripheral atelectasis.

Few researchers have studied the changes in oxygen uptake after lung resection¹⁷⁻¹⁹. We found a fall in the oxygen uptake (VO₂) of 25%, 2 hours after lobectomy, which was correlated to the simultaneously increase in mixed - venous oxygen saturation (SvO₂). Markos et al¹⁷ found a fall in maximal oxygen uptake of 27%, 3 months after pneumonectomy and 13 % after lobectomy. Corris et al¹⁸ found a fall in maximal oxygen uptake of

23%, 4 months after pneumonectomy. Larsen et al¹⁹ found that pneumonectomy causes a decrease in pulmonary volumes to about 75% of the preoperative values, partly compensated in better oxygen uptake, which postoperatively was about 85% of the preoperative values.

Supraventricular arrhythmias are a well documented complication after lung resection, however, the aetiology of such arrhythmias has never been clearly proved. In this study, five patients experienced supraventricular arrhythmias that lasted a few hours up to three days postoperatively and was controlled pharmacologically. These arrhythmias did not correlate statistically with the site of lobectomy, ventricular dysfunction or gas exchange variables.

Conclusions

From this study, we can conclude that :

- The acute post - resection period (up to 2 hours postoperatively) revealed right and left ventricular dysfunction with good maintenance of gas exchange.
- Despite the observed hemody-

namic dysfunction, lobectomy is a safe procedure with no reported mortality in this study and minimal morbidity.

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