

The influence of high frequency jet ventilation during lung decortications surgery for selected perioperative parameters



Zastosowanie wentylacji wysokimi częstotliwościami do operacji odkorowania płuca

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Abstract

High frequency jet ventilation may be an alternative method of ventilation for thoracic surgery, in which disruption or significant reduction of mobility of the operated lung is important. The aim of this study was to assess the impact of the chosen method of intraoperative ventilation during lung decortication surgery. The following parameters were documented: duration of surgery and operating conditions, postoperative bleeding, duration of air leak from the pleura, the time of maintaining the tubing in the pleura and the time of hospitalization. The anesthetic procedure was not different between groups (high frequency jet ventilation [HFJV] group = 19; one lung ventilation [OLV] group = 21). In the OLV group operating time was significantly longer. Blood loss was significantly higher during operations with OLV. The operating conditions were significantly better during HFJV. The method of intraoperative ventilation did not significantly affect the time or leakage of air from the pleura, pleural drainage or the time of its maintenance. There was no effect of type of ventilation on the duration of hospitalization.

High frequency ventilation may be an alternative method for OLV during lung decortication surgery, because of better operating conditions, shorter operative time and significantly less intraoperative bleeding.

Key words: high frequency jet ventilation, one lung ventilation, lung decortication surgery.

Streszczenie

Wentylacja wysokimi częstotliwościami może stanowić alternatywną metodę wentylacji podczas operacji torakochirurgicznych, w których istotne jest unieruchomienie lub znaczne ograniczenie mobilności operowanego płuca.

Celem pracy była ocena wpływu wybranego sposobu wentylacji śródoperacyjnej podczas zabiegu odkorowania płuca na następujące parametry: czas operacji, warunki operacyjne i krwawienie, a w okresie pooperacyjnym: krwawienie, czas utrzymywania się przecieku powietrza z opłucnej, czas utrzymania drenów w opłucnej oraz czas hospitalizacji.

Postępowanie anestezyjologiczne nie różniło się w obu grupach (Gr HFJV = 19; Gr OLV = 21). W grupie OLV czas operacji był znacznie dłuższy. Utrata krwi była znacznie większa podczas operacji z wentylacją OLV. Warunki operacji były znacznie lepiej ocenione podczas HFJV. Metoda wentylacji śródoperacyjnej nie wpłynęła na czas i wielkość przecieku powietrza z opłucnej, drenażu z opłucnej oraz czas jego utrzymania. Nie wykazano również wpływu rodzaju wentylacji na czas hospitalizacji.

Wentylacja wysokimi częstotliwościami może stanowić alternatywną metodę do OLV podczas operacji odkorowania płuca z otwarciem klatki piersiowej, zapewniając lepsze warunki operacyjne, skrócenie czasu operacji oraz znacznie mniejsze krwawienie śródoperacyjne.

Słowa kluczowe: wentylacja wysokimi częstotliwościami, wentylacja jednego płuca, odkorowanie płuca.

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Introduction

Lung decortication surgery is performed by lateral thoracotomy or video-assisted thoracoscopy (VATS). An important factor in anesthesia for these types of surgery is choosing ventilation that allows proper oxygenation and good operating conditions. The gold standard is still one lung ventilation (OLV), although it is linked to a number of disorders and pathologies that have been described well in the literature [1, 2]. An improved method of ventilation for open thoracotomy is high frequency jet ventilation (HFJV), which provides proper blood oxygenation with clinically permissive hypercapnia, hemodynamic stability, good operating conditions and a lower number of iatrogenic complications connected with the use of a double lumen tube (DLT) [3-5]. Significant advantages of HFJV of both lungs for these types of surgery are low respiratory pressures and low respiratory volume, consistent with the lung-sparing ventilation strategy. The European Journal of Anaesthesiology (2008; 25: 15-21 and 2009; 26: 701-702) published reports from our medical centre about the use of HFJV for thoracic surgery in which intraoperative hemodynamics and ventilation were analyzed. The subject of this study is analysis of surgery period as well as intra- and postoperative complications (bleeding, time of the pleural air leak, pleural drainage period and hospitalization period) along with evaluation of surgical conditions.

Material and methods

This prospective, randomized trial was approved by the Ethics Committee of the Medical University of Silesia. Forty patients rated ASA I-III scheduled for lateral thoracotomy were randomized to receive either double-lung high frequency jet ventilation (HFJV) ($n = 19$) or one lung ventilation (OLV) ($n = 21$) during the operation. Patients with obesity (BMI > 30), 2nd or 3rd degree stenosis of the larynx, with airway injury, difficulty to visualize laryngeal glottis chink in direct laryngoscopy, patients short and petite, patients with history of COPD and patients with significant blood loss were excluded from the study.

Patients in the HFJV group were ventilated using the Monsoon DeLuxe Universal Jet Ventilator (Acutronic, Hirzel, Switzerland) and intubated with a traditional endotracheal tube (Portex, Bristol, PA, USA) with a special adaptor (T-piece Jet Adaptor, Acutronic, Hirzel, Switzerland). Ventilation parameters were: drive pressure – DP 1.5 atm., frequency (respiratory rate) 180–200/min, inspiratory time (IT) – 40%, hydration of respiratory gases 20%.

Patients in the OLV group were ventilated using a conventional anaesthesia machine (Fabius, Dräger, Germany) and were intubated with a DLT (Bronchocath, Mallinckrodt, Ireland).

All patients received the same type of anesthesia. Both the induction and maintenance of general anaesthesia were achieved with a target-controlled propofol infusion (Diprivan 1%, AstraZeneca, London, UK) to reach 4.0-3.0 $\mu\text{g}/\text{mL}$ plasma concentration. A bolus dose of 0.6 mg/kg of rocuronium (Esmeron, Organon, Belgium) was used to facilitate intubation. When adequate relaxation was achieved, a left-sided DLT (OLV group only) was inserted. Proper tube

position was confirmed using a fiberoptic bronchoscope (LF-2 Olympus Optical, Tokyo, Japan) before and after turning the patient to the lateral position. During anesthesia 4-6 mL/kg/h of crystalloid and colloid (HAES 6%, Voluven, Fresenius Kabi, Bad Homburg v.d.H., Germany) solutions at the ratio of 3:1 were administered in all patients.

After induction, patients in both groups underwent conventional BLV with tidal volume 8 mL/kg and a respiratory rate of 12 min. The chosen mode of ventilation (HFJV or OLV) was started 15 min after induction when all hemodynamic and respiratory parameters had been documented.

After tracheal intubation, ventilation with an FiO_2 of 1.0 was maintained for the rest of the procedure in both groups. Patients in the HFJV group were ventilated with a driving pressure of 1.0 atm, respiratory rate 200/min. The OLV group received a tidal volume of 8 mL/kg and a constant respiratory rate of 12/min.

All patients were given 7.5-15 mg of midazolam (Dormicum, Roche, Switzerland) orally one hour before the surgery.

The anesthesiologist rated intraoperative blood loss and recorded the surgery period and surgeons rated the operating conditions on a scale from 1 (very bad) to 4 (very good). The drainage was measured and rated in the surgical ward by attending surgeons for the first 24 hours. The drainage period was rated in patients' documentation. Results were analyzed with the Statistica 6.0 program. After determination analysis with Kolmogorov-Smirnov test, Student's t-test for normal data determination, ANOVA single factor variance analysis and post hoc RIR Tukey test were used. We used Mann-Whitney U and Kruskal-Wallis tests for abnormal determination. Numerical data are presented as mean and standard deviation. The significance level was set at $p < 0.05$.

Results

Patients in both groups did not differ in anthropological data. In the OLV group the surgery period was significantly longer (Table I). Intraoperative blood loss was statistically significantly greater in the OLV group (mean 1100 \pm 450 ml) than in the HFJV group (mean 850 \pm 380 ml). Surgical conditions during high frequency jet ventilation were rated as significantly better by the surgeons: "very good" in 87.5% of cases compared to 18.2% in the OLV group (Table II).

There were no other statistically significant differences between groups regarding time of the pleural air leak in postoperative time. The amount of fluid drained from the pleura in the HFJV group was 450 \pm 250 ml whereas in the OLV group it was 400 \pm 250 ml. The average drainage period was 5.5 \pm 2.7 days in the HFJV group and 7.7 \pm 2.7 days in the OLV group. The hospitalization period in the HFJV group was 14.5 \pm 9 days and in the OLV group 16 \pm 7 days.

Discussion

In an organized pleural empyema (a developed fibrous pleural peel with extensive adhesions and a thick layer of fibrin) the only possible and the most effective treatment is

Tab. I. Comparison of anthropological data and time of surgery in tested groups

	HFJV			OLV			p
	n	mean value	SD	n	mean value	SD	
age in years	19	43,6	12,4	21	43,5	12,4	NS
height in cm	19	170,5	8,1	21	175,8	8,1	NS
body weight (kg)	19	74,4	16,3	21	73,0	16,3	NS
BMI (%)	19	25,4	4,1	21	23,5	4,1	NS
BSA (m ²)	19	1,88	0,24	21	1,89	0,24	NS
surgery period in minutes	19	139,0	21,8	21	177,7	21,8	0,001
female/male	19	8/11		21	9/12		NS
side R/L	19	9/10		21	10/11		NS

Tab. II. Operative conditions in surgeon's opinion

	HFJV		OLV		p
	n	%	n	%	
very good	7	87,5	1	18,2	< 0,05
good	2	12,5	3	27,2	
satisfactory	0		6	54,5	
bad	0		0		

open thoracotomy decortication [6, 7]. The aim of decortication surgery is getting the collapsed lung to decompress and return to physiological mechanics of breathing of the lung, diaphragm and chest wall as well as performing obliteration of the pleural cavity. The procedure involves removal of the pulmonary pleura; it demands precision and caution in order to avoid injuring the lung during the removal of deep infiltration which can lead to air leak and difficulties in maintaining proper ventilation. After the surgery two drains are placed in the pleural cavity. The most important challenge for the anesthesiologist is to provide proper lung ventilation. Because of the technical difficulties of decortication surgery it is important for the lung to be immobilized. If VATS or minithoracotomy is planned, it is strongly advised to use a double-lumen endotracheal tube, which means intraoperative ventilation of only one lung [8]. This allows optimal visualization and immobilization of the operated lung and proper ventilation conditions. In the case of a developed fibrous pleural peel, the mobility of the lung during HFJV is only slight, so using separate-lung ventilation does not affect operating conditions. Using both-lung HFJV for these types of surgery creates good operating conditions, which was proven by a survey in which 87% of the surgeons described operating conditions as very good. It results from the fact that HFJV causes a mild lung distention and allows surface tension of the lung to be maintained, which makes taking off the thick layer of pleura easier. This way of ventilation prevents tearing of the pleura, and even if tearing of the pleura accidentally occurs there is no air leak so it is possible to maintain proper minute ventilation. The level of drive pressure (DP) methodically accepted, circa 1.5 atm, and frequency of 200 breaths per minute allow the lung to

be kept in partial tension and almost still. Use of OLV, on the other hand, does not make the decortication procedure easier and even a slight tear of the pleura in an attempt to change to double-lung ventilation and distend the operated lung results in air leak and difficulties in maintaining proper minute ventilation.

In our own study, high frequency ventilation made taking off the pleura easier, providing better operating conditions and smaller injury of the lung. This resulted in a significantly shorter operating period. In contrast, in the OLV group, difficult operating conditions led to traumatization of the lung, greater intraoperative blood loss and longer operating time. Data from the perioperative period did not vary significantly in tested parameters. We assumed that early mobilization of the patients, thanks to well-conducted and effective epidural analgesia, effective respiratory rehabilitation, and target antibiotic therapy in the postoperative period, reduces the iatrogenic effects of intraoperative OLV. This opinion is consistent with the experience of Choi et al. [9], based on 163 cases of lung decortication, extending methods with spirometry performed before and after the surgery. A similar conclusion was reached by Light based on a study of 71 cases [10].

We believe that HFJV should be considered as an alternative method for OLV in open thoracotomy lung decortication surgery because it provides better operating conditions, allows the surgery period to be shortened, and is linked to less lung injury and less intraoperative bleeding.

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