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Comparison of monitored anaesthesia care and general anaesthesia in endobronchial coil treatment

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ABSTRACT

Objective: The aim of this study was to evaluate the efficacy and complications of two different anaesthesia methods in endobronchial coil treatment.
Methods: In this prospective, randomised study, the patients were divided into 2 groups; general anaesthesia with endotracheal intubation was performed in 17 patients (group GA), whereas monitored anaesthesia care (MAC) was performed in 15 patients by using a continuous infusion of propofol and remifentanil (group MAC). During the procedure, peripheral oxygen saturation (SpO_2), transcutaneous partial carbon dioxide pressure ($tcPCO_2$), cerebral oxygen saturation and patient state index were monitored.
Results: Remifentanil consumption was significantly reduced and the recovery duration was shorter in the group MAC compared to GA ($p < 0.001$). SpO_2 values at minute 5 and 10 in group MAC were significantly lower than those for group GA ($p < 0.001$). The $tcPCO_2$ values during the entire procedure were higher in group GA, and the difference between the groups was significant at minute 20 ($p < 0.05$) and 30 ($p < 0.001$).
Conclusion: MAC can be safely used in endobronchial coil treatment and considered as an alternative method to general anaesthesia for endobronchial coil treatment.

1. Introduction

Emphysema, characterised by loss of elasticity in pulmonary tissue and hyperinflation, is a component of chronic obstructive pulmonary disease (COPD), which causes dyspnea, exercise intolerance and deteriorations in quality of life [1]. In recent years, the minimally invasive intervention of bronchoscopic endobronchial coil treatment has been applied to patients with heterogeneous emphysema [2,3]. Several studies demonstrated a reduction in hyperinflation and improvement in elastic recoil after the application of endobronchial lung volume reduction coil (LVRC) treatment. This procedure is applied via flexible fiberoptic bronchoscopy (FFB) under fluoroscopy [4–6]. In the literature, FFB is usually applied under conscious or deep sedation [7,8].

Monitored anaesthesia care (MAC) is an anaesthesia service that involves an anaesthesiologist who manages the entire process of sedation and analgaesia and, if necessary, converts the anaesthesia method to general anaesthesia during the procedure. During MAC, the sedation depth can be appropriately adjusted from minimum to deep [9]. MAC is preferred method during several surgical procedures because of a reduction in recovery duration and protection of spontaneous breathing and minimum body movement allowance.

Endotracheal intubation is the most commonly used technique due to airway safety in endobronchial coil treatment patients [1,2]. However, airway complications with general anaesthesia including cough, laryngospasm, bronchospasm, nausea and vomiting, pneumothorax and prolonged recovery duration are well defined [10]. Endobronchial coil patients are known to have decreased lung capacity. However, during the endobronchial coil insertion procedure, the pulmonologist and anaesthesiologist share the same airway,

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and this factor may lead to inadequate ventilation. Thus, endobronchial coil patients are a stressful patient group for anaesthesiologist due to increased susceptibility to these airway complications. This procedure is expected to be safer to perform under MAC because complications with the airway device and muscle relaxant are bypassed with MAC.

In this study, we hypothesised that application of the LVRC procedures under MAC would reduce the complications associated with endotracheal intubation and shorten the recovery duration due to protection of spontaneous breathing. The aim of the study was to compare the efficacy and complications of two different anaesthesia methods of endobronchial coil treatment. To the best of our knowledge, this study is the first that compares monitored anaesthesia care and general anaesthesia in endobronchial coil treatment.

2. Material- methods

Approval for this study was granted by the Institutional Ethics Committee (decision number: 2018-KAEK-189_2018.01.25_22). All patients were informed about both anaesthesia methods. Endobronchial coil treatment was applied to COPD patients with a residual volume of % 200 or more compared to the expected value in pulmonary function tests.

This prospective, randomised study included 32 patients. The patients were randomised using the coin toss method to one of the two groups: the protected spontaneous breathing group under MAC (group MAC, n = 15) and the endotracheal intubation group under general anaesthesia (group GA, n = 17). Patients with heart failure and pre-treatment peripheral oxygen saturation (SpO_2) values < 70 were excluded from the study.

Demographic data and pulmonary function test results were recorded for all patients. Each patient was routinely administered 40 mg methylprednisolone intravenous (i.v.) and 2.5 mg salbutamol and 500 μg ipratropium bromide via inhaler 30 min before the procedure. On admission to the operating room, each patient was administered 1 mg midazolam i.v. and was monitored continuously with electrocardiography (ECG), SpO_2, non-invasive arterial blood pressure (NIBP), transcutaneous partial carbon dioxide pressure ($tcPCO_2$; SenTec V-SignTMSystem Therwil, Switzerland), regional cerebral oxygen saturation (rSO_2; MasimoNASAQ: MASI, Irvine, CA, USA), and the Patient State Index (PSI; MasimoNASAQ Sedline: MASI, Irvine CA, USA). The measurements were recorded at minutes 5,10, 20, and 30 of the procedure. All interventions were performed by a single experienced pulmonologist (B.M.).

2.1. Anaesthesia methods

2.1.1. General Anaesthesia

The patients received 6 L/min 100% O_2 via a mask for preoxygenization and an i.v. injection of 2 mg/kg propofol, 2 μg/kg fentanyl and 0.6 mg/kg rocuronium bromide for anaesthesia induction. All patients in this group were ventilated for 2 min with a face mask and intubated with an 8.5-mm endotracheal tube to enable the passage of the FFB. General anaesthesia was maintained with 0.1 μg/kg/min i.v. remifentanil infusion using a 50:50 oxygen-air mixture and 2% sevoflurane. Using the volume control mode, the tidal volume was adjusted to 6–8 mL/kg, respiratory rate was maintained at 12–14/min and positive end-expiratory pressure was set to 5 cm H_2O. PSI values were maintained in the range of 25–50. End-tidal CO_2 ($EtCO_2$), $tcPCO_2$, rSO_2, SpO_2, air leakage and peak pressure values were monitored and recorded. When the procedure was completed, the patients were awakened with 2 mg/kg i.v. sugammadex.

2.1.2. Monitored Anaesthesia care

After monitorisation, 2% lidocaine spray was administered into the mouth and 6 L/min oxygen (100%) was routinely administered via a mask. Propofol (30–50 μg/kg/min) and remifentanil (0.1–0.2 μg/kg/min) infusion were used. A level of 2–3, according to the deep sedation scale, was maintained (PSI values > 50). The bronchoscope was applied from the nasal route. During the procedure, the patients were monitored in respect of $tcPCO_2$, rSO_2, SpO_2, NIBP and ECG. After placement of the final coil, the infusions were terminated.

Recovery duration was evaluated as the time between the end of the procedure and eye opening. All patients were taken to the post-anaesthesia care unit (PACU) after they provided adequate spontaneous breathing and eye opening. They were transferred to the ward after 1- h of monitoring with no complications.

During and after the procedure, cough, bronchospasm, laryngospasm, nausea and vomiting, bleeding, the need for intubation and re-intubation, needs for intensive care, and pneumothorax were recorded.

2.2. Sample size and statistical analysis

The number of patients included in the study was determined according to a power analysis [10]. According to this analysis, when the alpha value was set at 0.05 and the power value was 80%, there should be at least 16 patients for each group.

Data obtained in the study were analysed statistically using the Statistical Package for the Social Sciences software package (SPSS version 20.0, IBM). The Shapiro-Wilk test was used to assess conformity of the data to a normal distribution. Normally distributed quantitative data are presented as mean ± standard deviation, and the independent samples *t*-test was used for analysis. Non-normally distributed data and non-parametric data were evaluated using the Mann-Whitney *U* test, and chi-square ($\chi 2$) test was used to compare qualitative data. A value of $p < 0.05$ was accepted as statistically significant.

3. Results

The pulmonologist stated that there was no difficulty in the coil application procedure due to the differences in anaesthesia techniques. All procedures were completed successfully, and there were no incomplete procedures due to either anaesthesia techniques.

There were no significant differences between the patient groups with in respect to age, sex, weight, forced expiratory volume in 1 s (FEV1) and FEV1/forced vital capacity (FVC) values ($p > 0.05$; Table 1). In one patient's procedure, the MAC technique was replaced and completed by endotracheal intubation due to airway secretion and hyper-reactivity.

There were no differences between the groups with respect of anaesthesia and surgical duration. Remifentanil consumption was

Table 1
Age, gender, weight, forced expiratory volume in 1 s (FEV1) and FEV1/forced vital capacuty (FVC) values for the patients in this study.

	Group MAC (n = 15)	Group GA(n = 17)	P
Age (years)	66.46 ± 8.47	67.52 ± 4.54	0.669
Gender (Female/Male)[a]	(3/12)	(3/14)	0.608
Weight (kg)	60.86 ± 11.74	63.64 ± 10.78	0.490
FEV1%	36.86 ± 8.10	33.00 ± 10.16	0.248
FEV1/FVC%	46.26 ± 7.30	43.00 ± 7.76	0.240

Data are presented as, mean ± standard deviation (X±SD) and analysed with independent samples *t*-test.
[a] Data analysed with the chi-square test.

Table 2
The anaesthesia, operation and recovery durations and remifentanil consumption for the groups.

	Group MAC (n = 15)	Group GA (n = 17)	P
Anaesthesia duration (min)	40(28)	49(41.5)	0.173
Operation duration(mins)	40(27)	42(36.5)	0.663
Recovery duration (min)	5 (2)	18 (12.5)	<0.001
Remifentanil consumption (μg)[a]	187.20 ± 75.21	303.76 ± 71.36	<0.001

Data are presented as median (interquartile range [IQR]) and were analysed with the Mann-Whitney *U* test.
[a] Data are presented as mean ± standard deviation and were analysed with the independent samples *t*-test.

statistically significantly lower in group MAC ($p < 0.001$; Table 2). No respiratory depression was observed in any MAC patients. The recovery duration was statistically significantly shorter in group MAC ($p < 0.001$; Table 2).

During the procedure, the mean air leakage was 309.05 ± 69.30 mL and peak pressure values were 18.23 ± 7.12 cm H_2O in group GA.

At intraoperative minute 5; SpO2, rSO2 and blood pressure values were lower in group MAC compared to GA ($p < 0.001$, $p = 0.031$; Table 3). At minute 10, the SpO_2 and pulse values were significantly lower in group MAC compared to GA ($p < 0.001$). At minute 20, the $tcPCO_2$ and pulse values were significantly higher in group GA ($p = 0.032$; Table 3). At minute 30, rSO2 values were lower ($p = 0.004$) and tcPCO2 and pulse values were higher in group GA compared to MAC ($p < 0.001$; Table 3).

Three patients in group GA required intensive care secondary to pneumothorax as a complication of the procedure. The general number of complications was higher in group GA, but this difference was not statistically significant ($p > 0.05$; Table 4).

4. Discussion

In this study, we investigated the effects of two different anaesthesia methods in a specific and susceptible patient group. The results of our study demonstrated that deep sedation during endobronchial coil treatment reduced airway complications in the postoperative period and shortened the recovery period.

Endobronchial coil treatment improves quality of life and exercise capacity [1]. This procedure is generally performed with tracheal intubation under general anaesthesia. The main aim of anaesthesiologist is to minimise risks during surgery and anaesthesia and to reduce complications and adverse effects. However, during the general anaesthesia procedure or the postoperative period, adverse effects such as cough, bronchospasm, bleeding or pneumothorax associated with intubation have been reported [2,10].

The use of inhalation anaesthetics and neuromuscular blockage agents causes a reduction in lung volume and difficulties in the ability to clear airway secretions [11]. Additionally, laryngoscopy and intubation increase the risk of haemodynamic changes and airway complications. COPD is an independent risk factor for the postoperative complications. Increasing the risk of haemodynamic changes and airway complications with the selected anaesthesia technique in these susceptible patients is undesirable [12,13]. In this study, airway complications were higher in group GA compared to MAC. This finding suggests that airway complications were due to intubation.

FFB is a procedure applied for diagnostic or treatment purposes such as LVRC. When undergoing FFB, the patients may experience pain, discomfort, and breathing difficulty. Thus, FFB should be performed under anaesthesia, namely topical anaesthesia-analgaesia, sedation or general anaesthesia [14]. Interestingly, in the literature, application of FFB during endobronchial coil was performed only with general anaesthesia and aother anaesthesia techniques compatible with FFB were not investigated in these patients.

Monitored anaesthesia care is a technique that provides sedo-analgaesia while maintaining spontaneous breathing. MAC application during LVRC procedures can compromise airway safety. However, the primary follow-up of patients by an anaesthesia specialist enables rapid intervention for any airway problems. Moreover, patient comfort increased with the provision of faster recovery duration and a reduction in intubation-related

Table 3
SpO_2, rSO_2, $TcPCO_2$, heart rate and blood pressure values for the groups during the procedure.

	Group MAC (n = 15)	Group GA (n = 17)	P
Minute 5			
SpO_2	88.46 ± 6.87	97.23 ± 2.46	<0.001
rSO_2	66.20 ± 6.59	70.88 ± 5.08	0.031
$TcPCO_2$	41.86 ± 3.64	42.88 ± 3.58	0.434
Heart rate/min	88.66 ± 9.81	94.17 ± 10.22	0.132
Blood pressure (mean) mmHg	86.58 ± 10.01	100.66 ± 11.53	0.001
Minute 10			
SpO_2	88.60 ± 6.87	97.23 ± 2.46	<0.001
rSO_2	67.00 ± 5.90	69.52 ± 4.04	0.164
$TcPCO_2$	46.46 ± 5.02	48.58 ± 5.17	0.250
Heart rate/min	84.40 ± 5.60	97.58 ± 9.81	<0.001
Mean blood pressure (mmHg)	86.66 ± 10.56	85.41 ± 21.41	0.838
Minute 20			
SpO_2	91.20 ± 3.42	92.76 ± 7.04	0.441
rSO_2	69.66 ± 3.94	66.64 ± 5.92	0.105
$TcPCO_2$	47.93 ± 4.93	52.88 ± 7.15	0.032
Heart rate/min	83.26 ± 6.77	102.35 ± 11.55	<0.001
Mean blood pressure (mmHg)	82.46 ± 13.78	90.11 ± 18.92	0.206
Minute 30			
SpO_2	93.46 ± 2.40	89.84 ± 9.18	0.182
rSO_2	72.84 ± 3.97	62.61 ± 11.05	0.004
$TcPCO_2$	45.21 ± 5.61	56.53 ± 8.46	<0.001
Heart rate/min	82.84 ± 7.30	107.69 ± 10.31	<0.001
Mean blood pressure (mmHg)	83.38 ± 14.64	84.53 ± 15.31	0.846

Data are presented as mean ± standard deviation and were analysed with the independent samples *t*-test.

Table 4
Complications in the groups.

	Group MAC (n = 15)	Group GA (n = 17)	P
Need for intubation or re-intubation	1	3	0.349
Laryngospasm	0	2	0.486
Bronchospasm	2	7	0.122
Nausea	2	5	0.402
Vomiting	0	3	0.229
Cough	9	11	0.784
Bleeding (>4 ml)	1	5	0.178
Need for intensive care	0	3	0.229
Pneumothorax	0	3	0.229
Respiratory depression	0	0	-

Data were analysed with the chi-square test.

complications. Studies compared MAC with general anaesthesia in many interventional procedures (e.g. transcatheter aortic valve replacement, closure of atrial septal defect). MAC provides rapid awakening, shortening of the procedure time and reduction in hospital/intensive care stay [9,15]. MAC has been applied for several procedures in many clinics. We believe that it may be an alternative to general anaesthesia in the treatment of endobronchial coil and can be routinely applied in every clinic.

In the current study, air leakage values were high in GA patients. This air leakage is expected to originate from the port placed at the end of the endobronchial tube for the FFB passage. Thus, in group GA, the desired ventilation could not be provided. To provide an appropriate depth of anaesthesia in this situation, remifentanil consumption was increased. Furthermore, the $ETCO_2$ values could not be properly recorded due to leakage. To monitor ventilation, we used $tcPCO_2$ monitoring (a reliable tool) [16]. Although there was an airway device to provide ventilation in group GA patients, the placement of a connection port to pass the FFB and having to use the airway together with the pulmonologist also caused air leakage. This issues explain the inadequate ventilation and the reason for the increased CO2, especially seen during the later minutes of the procedure.

In the current study, sufficient depth of anaesthesia and continuity of spontaneous respiration was provided with MAC. Sedation during bronchoscopy did not increase tcPCO2 or cause respiratory depression in a previous study [17].

Cerebral oximetry is an intraoperative follow-up technique that non-invasively shows regional cerebral oxygen saturation in real-time using near infra-red spectroscopy. It has become a popular technique in recent years. Cerebral oxygenation is affected by both hypoxia and hypercarbia [18]. In this study, one GA patient had decreased rSO_2 value (40%) and hypercarbia ($tcPCO_2$:67) without a reduction in SpO_2 during the procedure, whereas we did not observe any hypoperfusion in MAC group.

PSI is a quantitative EEG index for assessing the level of consciousness during sedation and general anaesthesia. It has a high degree of sensitivity and specificity in assessing consciousness similar to the bispectral index [19]. In order to perform a standard evaluation of both groups, we evaluated the depth of anaesthesia using the PSI.

In the current study, the heart rate and blood pressure values for group MAC patients were lower than those of group GA. These finding demonstrated that a more sufficient depth of anaesthesia was provided in the sedation group. The FFB procedure itself may cause haemodynamic changes, including tachycardia and hypertension. Laryngoscopy and intubation can also cause tachycardia and hypertension by increasing a stress response in the patient [20]. Sedation provides cardiovascular stability against the physiologic response that is associated with anxiety and airway manipulation [21]. We think that the difference in the early haemodynamic response in group GA may be related to the laryngoscopy, whereas the late difference in pulse and blood pressure likely arose due to insufficient ventilation.

The most important limitation of the current study is the small number of patients. Other limitations include the lack of a scale used to evaluate patient satisfaction related to the anaesthesia technique. In future research, adding the patient satisfaction scale will enable the patients to evaluate the effect of the anaesthesia method her/his comfort. Additionally, the patients were followed up for 1 h after anaesthesia in the PACU. We do not have any data on how the difference in anaesthesia affected the treatment outcome over longer periods. However, our study is a preliminary one that focussed on the use of sedation anaesthesia in endobronchial coil treatment. Thus, it may be the subject of further studies. Multicentric, prospective and randomised studies are needed to confirm the advantage of MAC in endobronchial coil patients as well as our findings.

5. Conclusions

Although intubation is a safe method in provide an airway in LVRC treatment, MAC applied with the protection of spontaneous breathing can also be considered as an alternative anaesthesia technique that can be safely and advantageously for these procedures.

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Declaration of competing interest

None.

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