OXYGENATION DURING ONE-LUNG VENTILATION WITH PROPOFOL OR SEVOFLURANE

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Abstract

60 patients, ASA I-III, underwent one-lung ventilation for open or video-assisted thoracic surgery randomized either with intravenous anesthesia with propofol or with inhalational anesthesia with 1 MAC sevoflurane. Propofol was titrated during one-lung ventilation to achieve a mean arterial pressure of 75-80 mmHg. Blood gas analyses, hemodynamic and respiratory parameters were measured during two-lung ventilation at the beginning of the surgical procedure and 10 min, 20 min and 30 min after start of one-lung ventilation. At all time points, hemodynamic and respiratory parameters were comparable in both groups. Oxygenation did not differ between groups at comparable mean arterial blood pressures.

Introduction

Inhibited hypoxic pulmonary vasoconstriction (HPV) during one-lung ventilation (OLV) deteriorates oxygenation by increasing the intrapulmonary shunt. In vitro volatile anesthetics inhibit HPV, whereas intravenous agents, like propofol, do not affect HPV[1,2]. This may lead to favour propofol for thoracic anesthesia. On the other hand fast on-and offset and bronchodilatatory effects may encourage the use of volatile agents like sevoflurane during OLV.

In a prospective randomized study we compared the effects of sevoflurane and propofol on oxygenation during OLV for thoracic surgery at comparable mean arterial pressures.

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Methods and Materials

The study was performed at the University Hospital in Jena, Germany. Following IRB-approval and with written patient informed consent, 60 patients ASA I-III scheduled for thoracic surgery were randomized to receive either total intravenous anesthesia with propofol, or inhalational anesthesia with sevoflurane.

Premedication was done orally with 25-50 mg clorazepate dipotassium in the evening and 7.5-15 mg midazolam 1h before surgery. Anesthesia was induced with propofol (2 mg/kg) and remifentanil (0.5-1.0 µg/kg). Rocuroniumbromide (0.9 mg/kg) or cisatracurium (0.15 mg/kg) was used to facilitate tracheal intubation with a double-lumen endotracheal tube (Broncho-Cath™, Mallinckrodt, Athlone, Ireland). Tube positioning was controlled via bronchoscopy before and after patients were placed in the lateral position[3]. A radial arterial cannula was inserted in every patient. Anesthesia was maintained by continuous infusion of remifentanil (400-1800 µg/h) and 1.0 MAC sevoflurane in oxygen or propofol, which was titrated within a range of 3-6 mg kg^{-1} h^{-1} to achieve a mean arterial pressure of 75-80 mmHg. If an epidural catheter for postoperative pain treatment was placed before induction of anesthesia, no epidural medication was given until the end of the study period.

After thoracotomy or positioning of the trocars for thoracoscopy OLV was started. Lung collapse was verified by view and by continuous capnometry of the upper lung. Patients were ventilated in a pressure-controlled mode with a PEEP of 5 cm H_20 with a FiO_2 of 0.9 (ADU plus ventilator, Datex, Helsinki, Finland). Respiratory frequency was increased up to 20 per min and the peak inspiratory pressure was raised stepwise up to a maximum of 30cm H_2O to maintain endtidal CO_2 at approximately 32 mmHg during OLV.

10 minutes, 20 minutes and 30 minutes after beginning of OLV, arterial blood gases (ABL 625, Radiometer Copenhagen, Danmark), heart rate, mean arterial pressure, SpO_2 and ventilatory parameters were measured (AS 3, Datex, Helsinki, Finland). During the study period no surgical occlusion of blood flow to the non-ventilated lung took place.

Patients received 15-20 ml/kg of body-warm balanced electrolyte solutions during the study period. If the mean arterial pressure dropped below 60 mmHg norepinephrine was given intravenously.

If at any time patients' SpO_2 decreased below 91%, OLV would be interrupted and the collapsed lung would be ventilated for one minute. Then the study period would start afresh 10 minutes after restart of

Table 1
Demographic Patient Data. Data are presented as numbers or mean and standard deviation when appropriate

	Sevoflurane	**Propofol**
Sex (male: female)	19:9	16:10
Bodyweight	75 ± 14	78 ± 14
Age	61 ± 14	57 ± 14
Cardiovascular disease	17	11
Pulmonary disease	6	5
Operated lung (right/left)	17/11	16/10
Type of surgery		
Video-assisted thoracic surgery	14	10
Metastasectomy	6	10
Lobectomy	6	6
Pneumonectomy	2	0

Cardiovascular disease included hypertension, coronary artery disease, and valvular heart disease
Pulmonary disease included obstructive or restrictive lung disease or a combination of both

OLV. If SpO_2 would decrease two times below 91%, CPAP-should be used continuously and the study would be discontinued in this patient.

Data are presented as mean and standard deviation. Analysis of variance, using a repeated-measures term, was performed for comparison of hemodynamic and respiratory variables between groups and over time. A $p<0.05$ was considered significant.

Results

Six of 60 patients had to be excluded from the analysis: following the study protocol one patient in the propofol group was excluded because SpO_2 dropped without CPAP two times below 91%, in a second patient in the sevoflurane group CPAP of the non-ventilated lung had to be used on demand of the surgeon, in four patients thoracoscopy was finished before the third time point for measurements was reached. 26 of the included 54 patients were treated with propofol (mean dosage 4.54 mg kg^{-1} h^{-1}).

Both study groups were comparable with regard to demographic characteristics, concomitant diseases and type of surgery (Table 1).

Also the demand for norepinephrine during OLV in both groups differed not significantly (5 patients in the propofol group versus 7 patients treated with sevoflurane).

Heart rate and mean arterial pressure differed neither between the groups nor time dependend during the study period (Table 2).

During the study period respiratory parameters, PaO_2, $PaCO_2$, O_2Hb and SpO_2 were comparable between groups at the same time, but differed over time (Table 3, 4).

Discussion

The major finding of this study is that oxygenation during a 30 min period of OLV did not differ between 1 MAC sevoflurane and intravenous anesthesia with propofol in a study protocol which demands comparable mean arterial pressure in both study groups.

Whereas experiments conducted in isolated lung models usually demonstrate direct inhibitory effects of sevoflurane on HPV, *in vivo* the direct effect on HPV interacts with indirect effects of inhalational anesthetics on the hemodynamic status producing different results: Ishibe et al. demonstrated *in vitro* that sevoflurane impairs HPV in isolated rabbit lungs[1]. *In vivo,* however, Lesitsky and Kerbaul found no attenuation of HPV in dogs and piglets[4,5].

Clinical trials may be further influenced by the pulmonary pathology and hemodynamic effects of the operative procedure: Abe et al found a lower oxygenation during sevoflurane anesthesia as during propofol anesthesia[6]. In contrast, Beck et al. reported in a clinical study an unchanged shunt fraction and oxygenation during OLV with sevoflurane compared with intravenous anesthesia with propofol[7]. In 2007 Pruszkowski et al. as well could not demonstrate a difference between sevoflurane and propofol in their study in 65 patients[8]. They used epidural anesthesia during the study period of 40 min OLV in all patients. The application of Sevoflurane and propofol was adjusted to maintain bispectral index monitor (BIS) values between 40 and 60.

The comparison between an inhalational agent and an intravenous anesthetic agent is always difficult. Since in the clinical setting cardiovascular stability is often judged by MAP, we chose to adjust propofol levels in accordance with this parameter. Interestingly the concept of Pruszkowski and coworkers to compare sevoflurane and propofol in a BIS-controlled manner resulted in comparable mean arterial pressures between the two treatment groups[8]. The overall MAP was slightly higher than in our study, which is easily explainable by the lower endtidal sevoflurane concentration of 1.3 ± 0.3% (i.e. ~0.5-0.7 MAC) in the study of Pruszkowski.

In conclusion in our study oxygenation during OLV differed not with propofol or sevoflurane at comparable mean arterial pressures.

Table 2
Hemodynamic parameters and number of patients treated with vasoactive agents. Data are presented as mean and standard deviation

Time (min)	Sevoflurane		Propofol	
	HR (bpm)	MAP (mmHg)	HR (bpm)	MAP (mmHg)
TLV	75 ±18	81 ±14	66 ±11	83 ±16
10 min OLV	75 ±16	89 ±14	69 ±11	81 ±20
20 min OLV	75 ±16	78 ±13	70 ±10	78 ±12
30 min OLV	75 ±15	80 ±12	70 ±11	82 ±12

No significant differences between TLV versus corresponding time within the treatment group or between sevoflurane and propofol

Table 3
Respiratory parameters. Data are presented as mean and standard deviation

Time (min)	Sevoflurane				Propofol			
	p_{max}	PEEP	Respiratory rate	Tidal volume	p_{max}	PEEP	Respiratory rate	Tidal volume
TLV	24 ±4 *	5 ±0	11 ±2 *	672 ±106 *	23 ±4 *	5 ±0 *	11 ±2 *	688 ±106 *
10 min OLV	28 ±4	5 ±0	14 ±4	537 ±132	28 ±3	5 ±0	13 ±4	538 ±125
20 min OLV	27 ±4	5 ±0	14 ±4	537 ±128	29 ±3	5 ±0	13 ±4	538 ±113
30 min OLV	28 ±3	5 ±0	14 ±4	545 ±133	29 ±3	5 ±0	13 ±4	530 ±125

*p<0.01 for TLV versus corresponding time within the treatment group, no significant difference between sevoflurane and propofol

Table 4
Table 4 Oxygenation, oxygen saturation and $PaCO_2$ Data are presented as mean and standard deviation.

Time (min)	Sevoflurane					Propofol				
	PaO_2	SpO_2	O_2Hb	$PaCO_2$	$etCO_2$	PaO_2	SpO_2	O_2Hb	$PaCO_2$	$etCO_2$
TLV	400 ±98 *	99 ±1 *	98 ±1 *	39 ±6 **	32 ±2 **	398 ±95 *	99 ±1 *	98 ±1 *	38 ±4 **	32 ±3 **
10 min OLV	211 ±96	98 ±2	97 ±2	40 ±8	32 ±2	192 ±99	98 ±2	97 ±1	39 ±4	31 ±2
20 min OLV	169 ±77	98 ±2	97 ±2	38 ±4	31 ±2	169 ±106	98 ±2	97 ±1	38 ±3	31 ±2
30 min OLV	166 ±83	97 ±2	97 ±2	37 ±4	31 ±2	161 ±105	98 ±2	97 ±1	38 ±4	31 ±2

* p<0.01 for TLV versus corresponding time within the treatment group, no significant difference between sevoflurane and propofol
** p<0.05 for TLV versus corresponding time within the treatment group, no significant difference between sevoflurane and propofol

References

1. Ishibe Y, Gui X, Uno H, Shiokawa Y, Umeda T, Suekane K: Effect of sevoflurane on hypoxic pulmonary vasoconstriction in isolated rabbit lungs. *Anesthesiology;* 1993, 79:1348-53.
2. Loer SA, Scheeren TW, Tarnow J: Desflurane inhibits pulmonary hypoxic vasoconstriction in isolated rabbit lungs. *Anesthesiology;* 1995, 83:552-556.
3. Klein U, Karzai W, Bloos F, Wohlfarth M, Gottschall R, Fritz H, Gugel M, Seifert A: Role of fiberoptic bronchoscopy in conjunction with the use of double-lumen tubes for thoracic anesthesia: a prospective study. *Anesthesiology;* 1998, 88:346-350.
4. Lesitsky MA, Davis S, Murray PA: Preservation of hypoxic pulmonary vasoconstriction during sevoflurane and desflurane anesthesia compared to the conscious state in chronically instrumented dogs. *Anesthesiology;* 1998, 89:1501-1508.
5. Kerbaul F, Bellezza M, Guidon C, Roussel L, Imbert M, Carpentier JP, Auffray JP: Effects of sevoflurane on hypoxic pulmonary vasoconstriction in anesthetized piglets. *Br J Anaesth;* 2000, 85:440-445.
6. Abe K, Shimizu T, Takashina M, Shiozaki H, Yoshiya I: The effects of propofol, isoflurane and sevoflurane on oxygenation and shunt fraction during one-lung ventilation. *Anesth Analg;* 1998, 87:1164-1169.
7. Beck DH, Doepfmer UR, Sinemus C, Bloch A, Schenk MR, Kox WJ: Effects of sevoflurane and propofol on pulmonary shunt fraction during one-lung ventilation for thoracic surgery. *Br J Anaesth;* 2001, 86:38-43.
8. Pruszkowski O, Dalibon N, Moutafis M, Jugan E, Law-Koune JD, Laloe PA, Fischler M: Effects of propofol vs sevolurane on arterial oxygenation during one-lung ventilation. *Br J Anaesth;* 2007, 98:539-544.