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Respiratory Impairment in the Obese Following General Anesthesia –Impact of Anaesthesia and Patient Related Factors

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Abstract

Background: Respiratory impairment is common in the perioperative period, especially in the obese. In this study we evaluated the impact of anesthesia related factors, use of neuromuscular blocking agents, choice of anesthesia maintenance, duration of surgery and patient related factors such as age, gender and body-mass index on postoperative pulse oximetry and lung function in the obese.

Methods: We studied postoperative lung function and pulse oximetry saturation in 397 obese or overweight patients (Body Mass Index 25-40) undergoing minor surgery . Inspiratory and exspiratory lung function as well as pulse oximetry were measured preoperatively (baseline) and at 10min, 0.5h, 2h and 24h after surgery, with the patient supine, in a 30° head-up position. All factors were added within stepwise regression analysis to create a statistical model. Further analysis was performed using the t-test and Wilcoxon-test.

Results: Stepwise regression analysis revealed that, relaxation, in particular using rocuronium rather than cisatracurium ($p<0.008$) as well as anesthesia maintenance with propofol in contrast to desflurane ($p<0.0028$), are the most important factors affecting postoperative respiratory impairment and pulse oximetry saturation within the first 24 postoperative hours. Patient related factors as age, body-mass index and surgery time exhibit a minor effect.

Conclusion: Anaesthesia related factors rather than patient related factors exhibit a greater effect on lung function impairment within the immediate postoperative period. Lung function impairment occurs independently from fast-track criteria and can be attenuated by choosing well predictable agents for general anaesthesia.

Introduction

Respiratory impairment is common after general anesthesia, largely due to a reduction of functional residual capacity resulting in ventilation/perfusion mismatch and atelectasis [1-3]. Obesity, increased age, and duration of surgery are major factors reinforcing the occurrence of atelectasis [4-6]. Compression atelectasis due to increased abdominal pressure in the supine position, more pronounced when using neuromuscular blocking agents, absorption atelectasis due increased inspired fraction of oxygen, hypoventilation and upper airway collapse also contribute [7-10]. Recruitment maneuver followed by PEEP proofed to be effective in increasing functional residual capacity and reducing atelectasis and pulmonary shunting [11]. Nevertheless atelectasis within the postoperative period is still common. Thus several other factors may have a predictive value in terms of postoperative respiratory impairment and atelectasis. Residual effects of neuromuscular blocking agents or hypnotics as well as duration of surgery are well known anesthesia and surgery related predictors for lung function impairment within the immediate postoperative period and patients related predictors are as follows age, BMI and gender [12]. We designed prospective, observational, blinded study to evaluate the impact of these factors and reveal possible interactions within a large study population.

Methods

Study population

The study was approved by the Ethics Committee of the University of Marburg (Germany), and written consent was obtained. Between 2005 and 2009 we studied 397 patients with BMI between 25-40 (ASA II-III) undergoing minor surgery (Table 1/2). In order to minimize potential factors interfering with postoperative lung function measurements (e.g. increased postoperative pain sensations) patients having major surgery, surgery requiring abdominal insufflations (laparoscopy) or head down tilt or additional regional anaesthesia were not included. We also excluded patients with suspected difficult intubation, patients having factors which limit the use of laryngeal mask (gastro- oesophageal reflux disease, hiatus hernia), pregnant women and those who suffer from bronchial asthma requiring therapy, severe psychiatric disorders and cardiac disease associated with dyspnoea (> NYHA II). Patients who had adverse events during anaesthesia (ventilation problems, bronchospasm, intubation difficulties) were excluded as well. The minimum duration of surgery was set at 45 minutes with a maximum duration of 130 minutes.

General anaesthesia

Twenty-four hours before surgery patients were premedicated with chlorazepat 20 mg per os. Prewarming as well as continuous warming of the patient was performed during surgery using a Bair hugger system (Arizant, Trittau , Germany) ensuring a constant body temperature. After 3 min of breathing 100% oxygen by face mask,

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anaesthesia was induced with fentanyl 2-3 µg kg^{-1} and propofol 2 mg kg^{-1} [13]. Patients were manually ventilated with 100% oxygen via a facemask. To facilitate orotracheal intubation, a single dose of rocuronium (0.5 mg kg^{-1} ideal body weight) or cisatracurium (0.15 mg kg^{-1} ideal body weight) was given at the discretion of the attending anaesthesiologist; no neuromuscular blocking agent was administered or for placement of the laryngeal mask airway. A leak pressure test was performed ensuring a minimum leak pressure of 25 cm H_2O. Respiratory settings were standardized. Immediately after intubation or placement of the laryngeal mask, the lungs

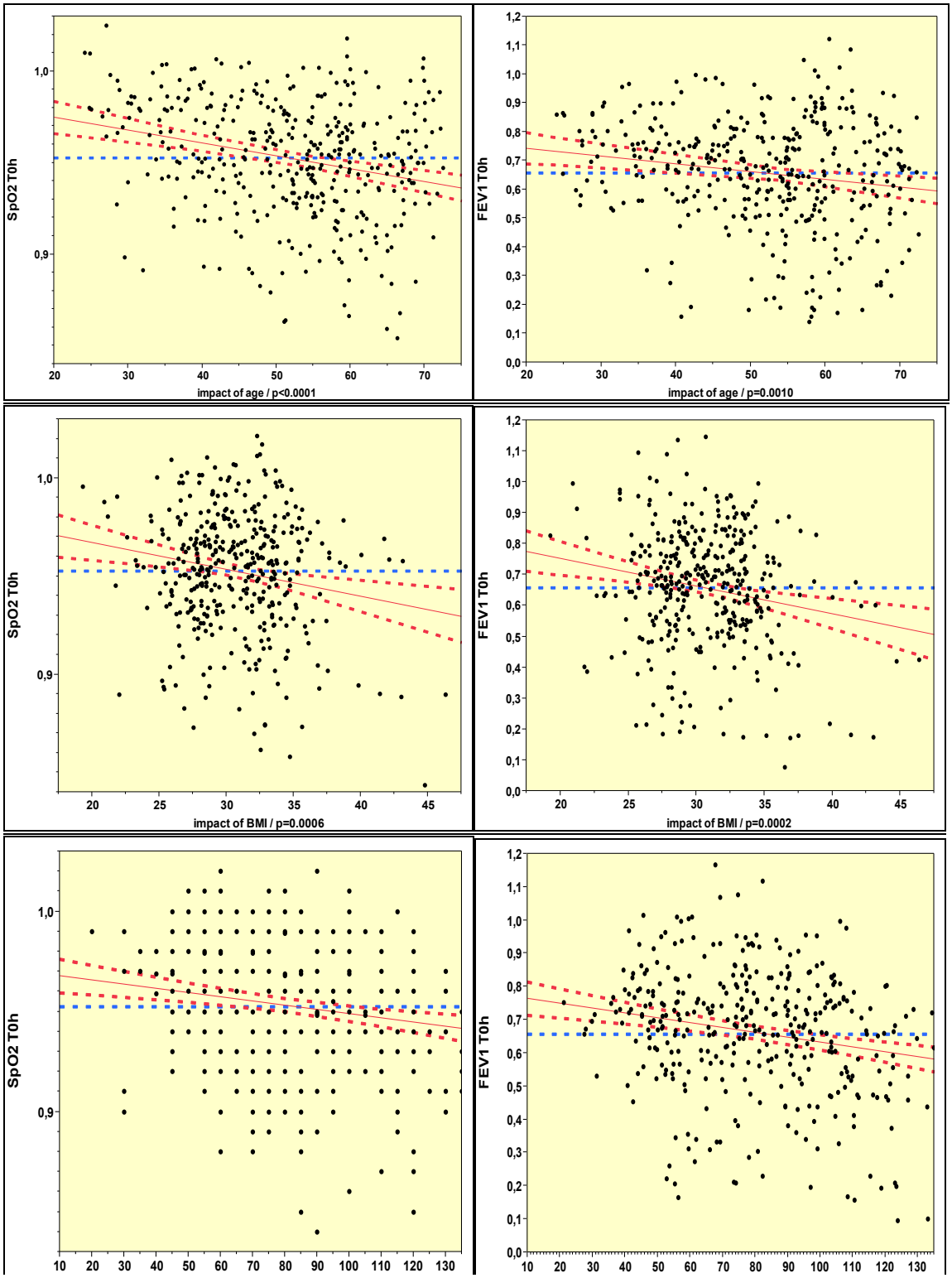

Figure 1: Simple regression analysis of patient related factors (age/BMI/surgery time).

were mechanically ventilated with a tidal volume of 8 ml kg^{-1} (ideal body weight). The rate was adjusted to maintain an end-tidal CO_2 pressure of approximately 4–4.7 kPa. A maximum peak pressure of 30 cm H_2O was permitted, and the inspiratory: expiratory ratio was adjusted to 1:1.5. A positive end expiratory pressure of 8 cm H_2O was used throughout in all patients. The cuff pressure was continuously adjusted to 30 cm H_2O (LMA-Pressure 50 cm H_2O). During maintenance of anaesthesia, oxygen in nitrogen was administered (FiO_2: 0.5). To achieve comparable anaesthetic depth levels, a self-adhesive BIS-EEG electrode strip (BIS Quatro™; Aspect Medical Systems) was positioned on the forehead as recommended by the manufacturer. Maintenance of general anaesthesia was performed with continuous infusion of propofol 3–6 mg kg^{-1} h^{-1} (ideal body weight) or desflurane 0.5-1 minimum alveolar concentration (MAC). Remifentanil (0.1-0.2μg kg^{-1} min^{-1}, ideal body weight) and propofol infusions (desflurane, MAC) were adjusted according to hemodynamics and to keep BIS within the range 40 - 60. Fifteen minutes before extubation, each patient received 1mg granisetron and 4mg dexamethason as PONV prophylaxis. Neuromuscular block was monitored via TOF ratio, ensuring a ratio >0.90 before extubation [14]. When the patient was fully awake and spontaneously breathing, the trachea was extubated or the LMA removed without suction in a head up position, with a positive pressure of 10 cm H_2O and an adjusted oxygen concentration of 100%. Patients were then transported to the post-anaesthesia care unit (PACU), breathing room air during transport; pulse oximetry was used throughout. Patients were nursed in the head up position in the PACU and maintained on supplemental oxygen (4l/min via face mask), which was stopped 5 minutes before spirometric and pulse oximetry measurements were taken. Each patient remained in the PACU for at least 2h.

Postoperative pain management

Both groups received basic non-opioid analgesia with intravenous (i.v.) paracetamol 1g and metamizol 1g i.v. Piritramide i.v. was given whenever the visual analogue scale (VAS) was > 4. Overall piritramide consumption within the first twenty-four hours was recorded.

General assessment

The potential for a selection bias was minimized by the support of anesthetists not involved in the study, who were responsible for giving patients preoperative information. Additionally, postoperative spirometry was performed by trained nurses who were unaware of the study hypothesis and were not involved in this study.

Spirometry and pulse oximetry

Spirometry and pulse oximetry were standardized, with each patient in a 30° head-up position [15] after breathing air without supplemental oxygen for 5 minutes. At the pre-anaesthetic visit, baseline spirometry and pulse oximetry were performed after a thorough demonstration of the correct technique. For this purpose we used the selfcalibrating "Easy One CS Spirometer" (GE healthcare, Munich, Germany). According to the manufacturer guidelines in order to produce reliable measurements, a minimum quality, degree "C", had to be attained ensuring sufficient inspiratory and expiratory cooperation by the patient. Within our analysis we focus on clinical relevant parameters. Pulse oximetry saturation as a surrogate for optimal lung ventilation/perfusion, forced expiratory volume in 1 s (FEV1) as the ability to cough, peak expiratory flow (PEF) and forced inspiratory vital capacity (FIVC) as surrogate for in and expiratory muscle strength.

At each assessment, spirometry was performed at least three times to be able to meet the criteria of the European Respiratory Society (ERS), and the best measured values were recorded [16]. On arrival in the recovery room, at about 5-10 min after extubation, we repeated spirometry (T0) as soon as the patient was alert and fully cooperative (fast track score >10) [17] ; pain and dyspnoea during coughing were assessed using the fast track score before and, if necessary, after analgesic therapy. All included patients met these criteria within 20 min of extubation.

In order to reveal lasting effects, spirometry and pulse oximetry were repeated in the PACU at 0,5h (T1), 2h (T2) and 24 h (T3) after extubation. Prior to each measurement, all patients were free from pain during coughing and had a fast track score >10. Factors that interfered with breathing (e.g. pain, shivering) were eliminated or at least minimized to produce reliable measurements.

Statistical analysis

We tested the null hypothesis (H_0) that postoperative pulse oximetry values between the two groups (propofol vs desflurane) are comparable. For this purpose the postoperative values for each time point were calculated as percentage of the individual preoperative values.

A prospective power analysis performed with the PASS2002 software (Number Cruncher Statistical Systems, Kaysville, Utah, USA) showed that 25 patients per group provided a >80% chance to detect an absolute improvement of 1% (e.g. 95% SaO_2 to 96% SaO_2) with an expected standard deviation of two in both groups using Student´s t-test with a type-I error of 5%. To increase overall stability within our data we doubled the required number of patients for analysis within each group. As a result of this a minimum of 50 patients had to be included in each group for analysis.

Statistic analysis was performed at each measurement point up to 24 hours after surgery. In order to identify independent parameters within our statistic model a limitation of variables was necessary for final analysis. Thus several clinical data (e.g. volatile **vs** i.v. anaesthetics, BMI, age, surgery-time) were recoded into separate dichotomous variables. BMI was dichotomized according to current literature postulating an increased risk at BMI >30. Age was dichotomized at >50 years (yrs) according to changes of FRC and closing capacity as previously described [18]. Univariate statistic (Mann-Whitney or T-test) was calculated for each variable. Factors with a P value of 0.10 or less were defined as potentially relevant and were further evaluated using stepwise regression analyses applying the maximum likelihood function. As there was no significant effect of gender, we thus included five factors in a multivariate model. The validity of the model was verified by comparing it with the results of a forward and a mixed forward-backward procedure. During each step the least significant factor was eliminated if P was greater than 0.05. The quality of the final regression model was judged using the amount of explained variance of the model and by checking if the standardized residuals were normally distributed using a normal quantile plot as a graphical tool and the Shapiro–Wilk test as a statistical confirmation. The Durbin–Watson statistic (a value between 0 and 4 with an optimum of 2.0), leverage plots [19] as a graphical tool, and the variance inflation factor (VIF) were used as indicators of autocorrelation or collinearity of parameters included in the model. Interactions between these factors were investigated using graphical tools (interaction profiles plots) offered by the statistical package used for data analysis (JMP 8; SAS Institute Inc., Cary, NC, USA). Bonferroni correction was applied to compensate multiple testing.

Overall 397 Patients included	LMA n=162	ETT n=235	Desflurane n=217	Propofol n=180	Cisatracurium n=86	Rocuronium n=149
Age(yr)	52 (±11)	53 (±13)	51 (±12)	52 (±10)	54 (±15)	54 (±10)
BMI	31 (±3.3)	32 (±2.5)	31 (±2.9)	31 (±3.8)	31 (±2.9)	33 (±3.7)
Surgery time (min.)	78 (±22)	83 (±18)	79 (±20)	82 (±21)	80 (±18)	85 (±20)
Remifentanil consumption	1315µg (±210)	1279µg (±199)	1036µg (±270)	1088µg (±191)	1202µg (±210)	1376µg (±172)
Propofol consumption	665 mg (±122)	679 mg (±143)	4.2±0.9%	668 (±156 mg)	694 mg (±131)	658 mg (±180)
BIS-Value during surgery	49 (±5.9)	46 (±5.2)	51 (±4.1)	49 (±5.3)	47 (±5.0)	52 (±4.7)
BIS-Value at discontinuation of anesthesia	62 (±5.1)	63 (±6.7)	65 (±7.1)	62 (±6.6)	67 (±4.9)	65 (±6.8)
Time to extubation (min.)	8.3 (±4.9)	9.2 (±5.3)	7.8 (±4.1)	8.9 (±5.3)	8.6 (±5.0)	7.7 (±4.9)
fast track score >10 (min.)	11.2 (±3.5)	10.5 (±3.9)	9.3 (±5.2)	11.1 (±3.5)	9.6 (±4.2)	11.8 (±4.0)
Postoperative pritramide(mg) consumption (within 24h)	7.5 (±4.3)	8.1 (±5.8)	7.1 (±3.2)	6.8 (±3.0)	8.3 (±2.4)	6.4 (±3.9)
Pulse oximetry saturation	97.1% (±1.1)	97.2% (±1.2)	97.2% (±1.2)	97.3% (±1.1)	97.1% (±1.4)	96.9% (±1.3)
FEV1	2.85l (±0.9)	2.75l (±1)	2.78l (±0.7)	2.72l (±0.9)	3.13l (±1.2)	2.88l (±1.0)
PEF	5.99l (±2.0)	6.08l (±2.3)	5.88l (±2.3)	6.18l (±2.1)	5.71l (±2.2)	5.92l (±2.4)
FIVC	3.58l (±1.5)	3.49l (±1.6)	3.45l (±0.9)	3.51l (±1.3)	3.51l (±1.2)	3.44l (±1.4)

Table 1: Basic data for 397 patients undergoing elective minor peripheral surgery/preoperative pulse oximetry saturation and lung function measurements. No significant differences between groups.

Knee Arthroscopy	n=125
Minor breast surgery	n=139
TUR-Prostate	n=44
Hand surgery	n=89

Table 2: Basic surgery array.

	SpO2 *T0h*	SpO2 *T24h*	FEV1 *T0h*	FEV1 *T24h*	PEF *T0h*	PEF *T24h*	FIVC *T0h*	FIVC T24h
Rocuronium	<0.0001 R^2=0.22	0.00765 R^2=0.19	0.004 R^2=0.34	n.s.	0.0032 R^2=0.24	n.s.	0.0001 R^2=0.09	n.s.
Propofol	0.0062 R^2=0.26	0.0278 R^2=0.20	<0.0001 R^2=0.29	<0.0001 R^2=0.25	0.0004 R^2=0.16	<0.0001 R^2=0.13	0.0057 R^2=0.19	0.0001 R^2=0.14
Age >50J	0.0233 R^2=0.31	0.0014 R^2=0.09	n.s.	n.s.	0.0431 R^2=0.27	n.s.	0.0497 R^2=0.30	0.0147 R^2=0.21
BMI >30	n.s.	n.s.	n.s	0.091 R^2=0.33	n.s.	n.s.	n.s.	n.s.
Surgery time <90	n.s.	0.0021 R^2=0.15	n.s	n.s	n.s.	n.s.	n.s.	n.s.

Table 3: Factors identified as independent risk factors for pulse oximetry and lung impairment. Stepwise regression analysis with the respective R^2. Nagelkerkes´s R^2 is an incremental measure of the goodness of fit of the regression model as additional variables are included in the model.

	LMA	ETT	p-value	Desflurane	Propofol	p-value	Cisatracurium	Rocuronium	p-value
SpO2 after surgery	96.0% (±2.3)	93.9% (±2.9)	<0.0001	96.6% (±2.4)	95.1% (±3.0)	<0.0001	96.4% (±2.6)	92.8% (±3.1)	<0.0001
T 1h	97.1% (±2.3)	95.8% (±2.4)	<0.0001	97.7% (±1.9)	96.5% (±2.8)	<0.0001	97.8% (±2.2)	95.0% (±2.8)	<0.0001
T 2h	97.7% (±2.0)	96.8% (±1.9)	0.0004	98.3% (±1.8)	97.3% (±2.6)	0.0002	98.6% (±1.9)	96.2% (±2.6)	<0.0001
T 24h	98.8% (±1.7)	97.9% (±1.6)	0.0002	99.1% (±1.4)	98.5% (±1.9)	0.0011	98.9% (±1.3)	97.8% (±2.0)	0.0005
FEV1 after surgery	68.9% (±18.6)	60.6% (±16.9)	<0.0001	74.8% (±12.7)	59.9% (±23.3)	<0.0001	70.5% (±13.5)	55.3% (±18.7)	<0.0001
T 1h	74.4% (±16.5)	65.2% (±18.0)	<0.0001	79.3% (±12.8)	65.5% (±20.3)	<0.0001	75.4% (±15.6)	60.1% (18.2)	<0.0001
T 2h	78.7% (±16.4)	68.2% (±18.7)	<0.0001	82.2% (±12.5)	70.3% (±20.1)	<0.0001	76.8% (±14.8)	63.9% (±19.1)	<0.0001
T 24h	88.3% (±21.0)	82.3% (±18.1)	<0.0001	89.8% (±10.1)	83.4% (±16.9)	<0.0001	87.0% (±11.6)	79.8% (±15.9)	0.0069
PEF after surgery	64.6% (±22.7)	54.4% (±21.9)	<0.0001	69.8% (±17.1)	56.6% (±26.2)	<0.0001	66.9% (±15.6)	47.9% (±22.1)	<0.0001
T 1h	67.8% (±19.9)	56.5% (±21.8)	<0.0001	73.3% (±16.8)	58.4% (±22.3)	<0.0001	69.2% (±13.9)	50.5% (±22.8)	<0.0001
T 2h	71.8% (±19.1)	61.4% (±20.3)	<0.0001	76.6% (16.4)	63.7% (±22.7)	<0.0001	70.5% (±14.3)	57.4% (±21.8)	0.0003
T 24h	86.2% (±18.2)	82.7% (±18.0)	0.06(ns)	88.4% (±15.3)	81.7% (±21.0)	0.0022	86.6% (±14.9)	80.8% (±19.3)	0.07(ns)
FIVC after surgery	68.0% (±22.3)	59.7% (24.2)	0.0007	74.55 (±18.0)	59.8% (±21.9)	<0.0001	71.0% (±22.5)	54.0% (±20.0)	<0.0001
T 1h	74.2% (±19.6)	66.2% (23.0)	0.0003	79.1% (±14.7)	66.6% (±22.1)	<0.0001	74.2% (±21.7)	62.7% (±23.0)	0.0062
T 2h	78.9% (±16.4)	68.2% (±22.4)	<0.0001	79.7% (±15.0)	73.6% (±20.9)	0.0067	76.7% (±19.8)	64.0% (±22.8)	0.0019
T 24h	89.3% (±15.7)	84.2% (±20.2)	0.007	89.9% (±10.3)	85.8% (±20.6)	0.0381	90.4% (±16.0)	81.1% (21.6)	0.0125
	Age < 50J	**Age≥ 50J**	**p-value**	**BMI < 30**	**BMI ≥ 30**	**p-value**	**surg.< 90min**	**surg.≥90min**	**p-value**
SpO2 after surgery	96.2% (±2.5)	94.5% (±3.1)	<0.0001	95.5% (±2.9)	95.1% (±2.7)	0.18(ns)	95.5.% (±2.6)	94.9% (±2.9)	0.0451
T 1h	97.4% (±2.5)	96.0% (±2.3)	<0.0001	96.7% (±2.7)	96.5% (±2.5)	0.45(ns)	96.9% (±2.7)	96.3% (±2.7)	0.0239
T 2h	98.2% (±2.2)	96.9% (±2.5)	<0.0001	97.4% (±2.3)	97.5% (±2.6)	0.91(ns)	97.6% (±2.59	97.1% (±2.4)	0.0422
T 24h	99.0% (±1.7)	98.2% (±1.8)	<0.0001	98.6% (±1.7)	98.5% (±1.8)	0.36(ns)	98.7% (±1.8)	98.2% (±1.7)	0.0305
FEV1 after surgery	70.5% (±15.79	62.5% (±21.7)	<0.0001	67.1% (±20.2)	64.8% (±19.5)	0.25(ns)	69.6% (±19.1)	60.4% (±19.5)	<0.0001
T 1h	74.9% (±16.1)	68.1% (±18.6)	0.0002	73.0% (16.3)	69.4% (±19.0)	0.06 (ns)	73.5% (±17.0)	67.3% (±18.7)	0.0007
T 2h	78.5% (±15.5)	72.1% (±19.1)	0.0005	76.7% (±16.2)	73.2% (±19.1)	0.06(ns)	77.2% (±17.6)	71.2% (±18.0)	0.0012
T 24h	88.4% (±13.0)	84.5% (±15.0)	0.0079	88.6% (±13.4)	84.2% (±14.7)	0.0026	88.7% (±12.7)	82.4% (±15.6)	0.0001
PEF after surgery	68.7% (±20.2)	55.1% (±23.1)	<0.0001	61.2% (±22.2)	60.4% (±23.5)	0.75(ns)	65.2% (±22.8)	54.3% (±21.4)	<0.0001
T 1h	69.3% (±18.8)	59.4% (±22.1)	<0.0001	65.1% (±20.8)	62.4% (±21.7)	0.21(ns)	65.6% (±21.4)	60.4% (±20.4)	0.0157
T 2h	72.1% (±18.0)	64.8% (±21.0)	<0.0001	68.8% (±19.8)	67.2% (±20.4)	0.44(ns)	70.5% (±20.5)	64.0% (±19.0)	0.0017
T 24h	86.6% (±18.4)	83.7% (±17.9)	0.12(ns)	86.5% (±17.9)	83.6% (±18.3)	0.11(ns)	86.9% (±17.5)	82.0% (±18.6)	0.0086
FIVC after surgery	72.2% (±21.7)	59.8% (±23.2)	<0.0001	68.7% (±22.6)	61.9% (±23.6)	0.0056	69.8% (±23.0)	58.1% (±22.1)	<0.0001
T 1h	76.9% (±17.9)	67.1% (±22.6)	<0.0001	74.9% (±20.8)	69.1% (±21.5)	0.0056	74.7% (±21.3)	66.3% (±20.3)	0.0001
T 2h	79.2% (±17.8)	70.8% (±19.9)	0.0003	78.0% (±19.5)	71.9% (±19.6)	0.0031	76.8% (±19.5)	72.0% (±19.3)	0.0190
T 24h	90.0% (±16.1)	85.6% (±18.4)	0.0175	90.6% (±19.6)	84.9% (±15.6)	0.0019	90.7% (±17.5)	82.8% (±16.8)	<0.0001

Table 4: Comparison of postoperative pulse oximetry and lung function values (percentage of preoperative baseline) and impact of single anaesthesia related factors (univariate analysis). P-values: T-test or U-test, (ns= no significance).

Finally we created a decision diagram by the graphic tools provided within the JMP statistical software package using the CHAID-algorithm (chi-square automatic interaction detector). All values for BIS, remifentanil, propofol and piritramide consumption were collected through an online documentary system (Medlinq Easy Software, Hamburg Germany). Statistic analysis was done with JMP 8.01 for Windows (SAS Institute, Cary, NC, USA).

Results

Between 2005 and 2009 we included 397 moderately obese patients (male=174/female=223; mean BMI 32 (SD 5), mean age 52 (SD 11) scheduled for elective minor peripheral surgery. The mean

duration of surgery was 80 minutes (SD 20), range 45 - 130 minutes. All patients had been ventilated to target values; antagonism of muscle relaxation was not necessary in any (Table 1). All patients included achieved a fast track-score >10 within 20 minutes of extubation.

Baseline values

Baseline (preoperative) pulse oximetry values were within normal range. Preoperative lung function values of all patients were within the "upper limit of normal" (ULN) and 'lower limit of normal' (LLN) as previously described [20] (Table 1); there were no differences before or after premedication between our study populations. All patients displayed the lowest values directly at first assessment (T0), in the PACU, after achieving a fast track criteria value >10.

Creation of the statistic model within the stepwise regression analysis

We included the dichotomized factors: age, BMI, gender as well as anaesthesia maintenance, surgery time, neuromuscular blocking agents (airway management).

Within our model, neuromuscular blockade (rocuronium) and anesthesia maintenance (propofol) were identified as the strongest independent factors affecting pulse oximetry saturation (SaO_2) and lung function (FEV1 and peak flows) within the first 24 hours after surgery (Table 2). Increased age (>50 years) and surgery times (<90 minutes) were minor factors. Significant effects were present even 24 hours after surgery (Table 3/4).

Univariate analysis

Except for gender and BMI (>30), all the included factors exhibited a statistical significant effect on pulse oximetry and lung function within the first 24h in the univariate analysis (t-Test, U-Test, Table 4). BMI >30 alone had no negative impact on exspiratory lung function but displayed a negative effect on forced inspiratory vital capacity whereas lung function impairment within the postoperative period was significantly associated with propofol maintenance, use of neuromuscular blocking agents (in particular rocuronium), increasing age (>50) and surgery time (<90min) (Table 4).

Discussion

Respiratory impairment is promoted by general anaesthesia, decreasing chest wall and lung compliance resulting in a reduction of functual residual capacity and finally atelectasis. Furthermore factors directly affecting the immediate postoperative period can contribute to respiratory impairment and atelectasis as well, but fast track scores provide only a superficial view of pulmonary recovery. Atelectasis is mostly detected by computer tomography scans though it is routinely difficult to perform in the immediate postoperative period [21-22]. Thus we used the surrogate parameters pulse oximetry saturation and lung function values to evaluate potential factors contributing to respiratory impairment in the immediate postoperative period. The surgery in our patients was minor and peripheral, general anaesthesia was standardized, and pain was minimal - there was no difference in the amount of pain or pain medication given each group, and wakefulness appeared to be adequate. We therefore postulate that respiratory outcomes depended more on the anesthesia method than on patient related factors. A lack of cooperation seems an unlikely cause, since all patients in this study were alert and fully compliant within 20 min of extubation, and any lack of cooperation and insufficient pain management should affect each study population to the same degree. The finding that impairment differed between desflurane and propofol as well as cisatracurium and rocuronium contributes further to the notion of an anesthetic contribution, because the groups otherwise did not differ in surgery, associated manipulations or patient related factors.

Postoperative residual curarisation may be important [23]. A greater variability of neuromuscular block, in particular after rocuronium, may be responsible, even though a TOF-ratio of 0.9 was achieved in all patients. Eikermann et al state that postoperative residual curarisation significantly affects lung function at TOF-ratios above 0.8 [14], although these observations were made in young, healthy non-anaesthetised subjects. TOF-ratio measurement has an error rate up to 40% [24]. This may explain our previous findings favouring the laryngeal mask airway (omission of neuromuscular blocking agents) in contrast to endotracheal intubation in an overweight population and is supported by the overall reduced inspiratory lung function peak flows when neuromuscular blocking agents were used [25]. As a result of this lack of inspiratory muscle strength and increased upper airway collapse overall alveolar ventilation is reduced and thus promotes the development of atelectasis. Moreover this is of particular importance if surgery time is below 90 minutes and is consistent with current literature indicating that clinically undetected residual neuromuscular block is more likely in this setting, even with a single dose of rocuronium [26,27]. But our results indicate that using neuromuscular blocking agents with stable kinetics (cisatracurium) may attenuate this effect [28].

Maintenance with propofol rather than desflurane is another independent factor for postoperative lung impairment. No surgery exceeded 130 minutes, propofol dosage and desflurane concentration were titrated to the same BIS-values, and recovery times did not differ between the two groups. Thus accumulation of maintenance agents or a difference in anesthetic "depth" seems unlikely. Differences in immediate effects on bronchial tone are unlikely to remain at 2 hours, much less 24 hours, after surgery. Nevertheless even sub hypnotic plasma level of Propofol have a negative impact on upper airway tone, but these experimental data generated in rats are not yet proofed in human subjects [29].

What changes might persist for such extended periods of time? Choice of anesthetic may contribute to pulmonary impairment: impairment may be greater immediately (less than 90 min) after induction with thiopental rather than propofol [30], or with isoflurane rather than propofol [31], or with sevoflurane rather than desflurane [32]. Others have suggested that inhaled anesthetics may affect pulmonary function by producing extended periods of genetic upregulation and downregulation [33]. Inhaled anesthetics protect against myocardial ischemia (anesthetic preconditioning) [34]. Anesthetic metabolites could be responsible for the observed differences: desflurane has essentially no metabolites [35]. Might intralipid, combined with other perioperative influences have a minor untoward effect?

Others have found that obesity, age, and surgery times can contribute to impairment of postoperative respiratory mechanics and our results confirm this [30,36,37]. However, only increased age and shorter surgery time showed any independent effect at all on saturation and lung function. But our data indicate that especially inspiratory lung functions are more impaired in the obese (overweight) patients contributing to further loss of inspiratory strength when residual effects of neuromuscular blocking agents are present. Thus a reestablishing of neuromuscular function in the obese in addition with early spontaneous breathing may be beneficial [38].

Are the modest differences within our analysis of clinical relevance? Our measurements are all surrogates for hard measures of untoward effects such as pneumonia, which require large numbers of patients to reveal. Nevertheless, moderately obese patients are at increased risk of early postoperative respiratory complications, so even small improvements in their early or intermediate recovery may be beneficial; such effects persisted within the first 24 hours after surgery. Moreover lung function impairment within the immediate postoperative period occur independently from fast-track criteria but can be attenuated by choosing agents with well defined duration of action for general anaesthesia, as to that the clinical value of fast track scores is questionable. We speculate that the choice of anaesthetic agents might have relevance for postoperative morbidity in patients having minor surgery. Whether these effects are intensified in patients after major or prolonged surgery or in morbidly obese patients is still unknown. A larger study population is required however in order to reveal possible benefits in terms of "gold standards" such as the incidence of untoward pulmonary complications. Our data do suggest that such studies might produce clinically important results.

Limitations

We recruited relatively healthy patients with BMI between 25-40, scheduled for minor peripheral surgery. Due to the necessary categorical dichotomization of BMI, age and surgery time some relevant data (e.g. BMI>35) may be possibly not accurate reflected. Our results may not be applicable in non-obese patients, or those with comorbidity. In order to minimize potential effects interfering with our lung function measurements, patients with respiratory (e.g. COPD or asthma) or heart disease (e.g. heart failure or cardiovascular disease) or having abdominal surgery were not included. These patients might show different responses. Similarly, we excluded patients having abdominal insufflation (laparoscopy) or head down tilt, and these, too, might alter our findings. We recognise that overall lung function and saturation are only surrogates for pulmonary complications. Our findings do not allow us to state that desflurane and cisatracurium are to be preferred as the standard for these cases, nor can we draw any conclusions about respiratory complications. Moreover no routine antagonism of neuromuscular blocking agents was performed in any case. As indicated above, large-scale outcomes studies using "gold standards" such as the incidence of hard untoward pulmonary complications (e.g. pneumonia) are required.

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