Original Article

Effectiveness of high dose remifentanil in preventing coughing and laryngospasm in non-paralyzed patients for advanced bronchoscopic procedures

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Abstract:

BACKGROUND: Anesthesia for bronchoscopy presents unique challenges, as constant stimulus due to bronchoscope needs to be obtunded using drugs with a minimal post-procedure residual effect. Remifentanil for maintenance is an ideal choice, but optimal doses are yet to be determined.

MATERIALS AND METHODS: Bronchoscopic procedures were prospectively evaluated for 4 months studying the frequency of complications and anesthesia techniques. Anesthesia was maintained on remifentanil/propofol infusion avoiding neuromuscular blockers. Laryngeal mask airway was used for the controlled ventilation (with high oxygen concentration) that also served as a conduit for bronchoscope insertions. Anesthesiologists were blinded to the study (avoiding performance bias) and the Pulmonologist was blinded to the anesthesia technique (to document unbiased procedural satisfaction scores). Procedures were divided into 2 groups based on the dose of remifentanil used for maintenance: Group-H (high dose –0.26 to 0.5 μg/kg/min and Group-NH (non-high dose ≤0.25 μg/kg/min).

RESULTS: Observed 75 procedures were divided into Group-H (42) and Group-NH (33). Number of statistical difference was found in demography, procedural profile, hemodynamic parameters and total phenylephrine used. Chi-square test showed Group-NH had significantly higher frequency of laryngospasm ($P = 0.047$) and coughing ($P = 0.002$). The likelihood ratio of patient coughing and developing laryngospasm in Group-NH was found to be 4.56 and 10.97 times respectively. Minimum pulse-oximeter saturation was statistically higher in Group-H (98.80% vs. 96.50% $P = 0.009$). Pulmonologist satisfaction scores were significantly better in Group-H.

CONCLUSIONS: High dose of remifentanil infusion is associated with a lower incidence of coughing and laryngospasms during bronchoscopy. Simultaneously, it improves Pulmonologist's satisfaction and procedural conditions.

Key words:

High dose remifentanil, laryngospasm during bronchoscopy, remifentanil for bronchoscopy

The current advancements in bronchoscopy can be compared to the similar advancements in cardiology in the 1980s. Patients presenting for bronchoscopy procedures often have significant cardiorespiratory ailments and are at a high-risk for adverse events relating to sedation and or anesthesia. A unique challenge faced by the Anesthesiologist during many bronchoscopic procedures is the need for akinesia, despite ongoing and sustained bronchoscopic irritation. As many trials have shown, a consistent and strong association between post-operative pulmonary complications and perioperative use of neuromuscular blockers (NMBs), this akinesia should preferably not be achieved by using NMBs, especially in patients with pre-operative pulmonary pathologies. Unlike surgical procedures, skeletal muscle relaxation is not a procedural requirement; however, akinesia is a necessity. Thus, short-acting opioids like remifentanil along with propofol (as part of total intravenous anesthesia [TIVA]) have emerged as maintenance agents of choice to achieve akinesia without NMBs. Majority of the experience of remifentanil comes from its use as a sedative or an intraoperative analgesic. Hence, the ideal dose for bronchoscopic procedures is yet to be well established. Minimum alveolar concentration (MAC) for preventing autonomic responses to intubation is known to be higher than MAC for suppressing the responses to surgical stimuli. Analogous to the above, dose requirements of remifentanil for averting responses to bronchoscopy may be clinically different from those extrapolated from other studies.

Materials and Methods

Approval for the study was obtained from the institutional review board of the Hospital of the

University of Pennsylvania. A written informed consent from the participating patients undergoing advanced bronchoscopic procedures was obtained before the procedure. We investigated 100 consecutive advanced bronchoscopic procedures performed under general anesthesia during a span of 4 months (from April 2013 to June 2013). The anesthesia for bronchoscopy at the Hospital of the University of Pennsylvania is provided by a group of Anesthesiologists who use varied techniques for anesthetizing patients undergoing bronchoscopy. Most of the patients undergo bronchoscopy with anesthesia maintained on remifentanil infusions with various combinations. Some Anesthesiologists assisting these procedures prefer using higher infusion doses (about 0.3-0.5 μg/kg/min) of remifentanil (more than the conventionally documented doses) as a part of propofol-based TIVA. Other Anesthesiologists involved in these procedures use lower (conventional) maintenance doses (about 0.2-0.25 μg/kg/min) of remifentanil infusion with TIVA or rarely, even general anesthesia with inhalation agents. It was also noticed by Pulmonologists that coughing and laryngospasms were less frequent on some days than other. It was likely that the difference in the rate of complications observed were possibly related to the different anesthesia techniques (or more specifically, doses of remifentanil). In the absence of available published evidence supporting the above notion, this prospective trial documents the incidence and severity of adverse respiratory events in patients undergoing advanced bronchoscopic procedures.

The Anesthesiologists caring for patients presenting for bronchoscopies were unaware of the ongoing study (wherefore avoiding any performance bias). The Pulmonologist involved was aware of the study being conducted and was asked to write down his satisfaction score regarding the technical ease of performing the bronchoscopy. The Pulmonologist was blinded to the anesthetic technique being used. The scores were ranged from 0 to 3 (0 being completely dissatisfied to 3 being highly satisfied). The number of episodes of coughing and laryngospasms (graded by visualizing the vocal cords by the bronchoscope) during the procedure were recorded. At the end of this study, computerized anesthesia records were scrutinized to record the type of anesthesia used in each case. Patient and procedure specific data were analyzed. All the patients were divided into Group-H (those who received infusion dose of more than 0.25 μg/kg/min) and Group-NH (which TIVA with remifentanil infusion ≤0.25 μg/kg/min.)

Anesthesia technique

All patients were scheduled for bronchoscopic diagnostic/therapeutic procedures were evaluated and kept nil per oral as advised by American Society of Anesthesiologists guidelines. Patients were preoxygenated with a high flow of oxygen using a tight fitting mask. Anesthesia was induced by using an intravenous bolus of remifentanil (as per the choice of the Anesthesiologist assisting the procedure) along with titrated doses of propofol. On achieving the optimal depth of anesthesia an appropriately sized laryngeal mask airway (LMA) was inserted. Neuromuscular blocking agents were avoided in all patients and patients were maintained on TIVA (propofol infusion at 80 to 150 μg/kg/min). By adjusting the maintenance doses of infusions, the depth of anesthesia was targeted to allow the bronchoscope insertion without the patient coughing/bucking and simultaneously tolerating controlled ventilation through the LMA by suppressing the patient's breathing efforts that otherwise make ventilation difficult. Any intra-procedural laryngospasm (if any) was treated using a small bolus of propofol.

Statistical analysis

Statistical analysis was performed using the statistical package for the social sciences version 21-SPSS (IBM Inc. Chicago, IL, USA) for Macintosh. Descriptive statistics were used for defining patient and surgical profiles. The allowable alpha error was set at 5% and thus $P \leq 0.05$ was considered to be statistically significant. Normality of the data was tested using the Kolmogorov-Smirnov test. Variance of parametric data was compared using the "Levine's test for equality of variance." Comparisons between the groups for parametric data were done using the Student's unpaired *t*-test. Non-parametric frequency data was evaluated for association with a group using Pearson's Chi-square test. Non-parametric variables across the groups were compared using the Mann-Whitney's test/Wilcoxon rank sum test.

Results

Complete perioperative data was available for only 75 of the 100 patients. Since the anesthesiologists assisting the procedure were not aware of the trial (blinded), all values required for study analysis were not adequately documented. Patients using gas anesthesia, or opioids other than remifentanil (fentanyl bolus) were excluded from the comparison. Procedures requiring rigid bronchoscopy where LMA could not be used were also excluded. Of these 75 patients, 42 (56%) received high dose of remifentanil infusion (0.26-0.5 0.25 μg/kg/min) along with propofol (80-150 μg/kg/min) based TIVA. The remaining 33 (44%) patients had received low dose remifentanil infusion (≤0.25 μg/kg/min) with propofol (80-150 μg/kg/min) based TIVA and were included in Group-NH [Figure 1]. The mean infusion doses calculated from total remifentanil consumed in Group-H and Group-NH were 0.39 ± 0.16 μg/kg/min and 0.21 ± 0.11 μg/kg/min respectively ($P < 0.001$). Wake up times after completion of procedure were statistically similar ($P = 0.580$) in Group-H (23.33 ± 21.13) and Group-NH (21.03 ± 10.17). The indications of bronchoscopic procedures in both groups are shown in Table 1. Comparison of patient specific and procedure specific variables between both the groups along with statistical significance is shown in Table 2. Comparison of hemodynamic changes in both groups is also shown in Table 2. Baseline pulse-oximeter saturation (at the start of procedure on FiO_2 of 1) was found to be similar on Mann-Whitney test ($P = 0.617$). The Mann-Whitney test

Table 1: Indications of bronchoscopy in both the groups with mean durations in minutes`

Indications of bronchoscopy		
Procedure	**Group NH (mean duration)**	**Group H (mean duration)**
Endobronchial ultrasound	24 (42.12)	35 (38.00)
Tracheobronchial dilation/ biopsies	2 (48.50)	1 (67.34)
Flexible diagnostic bronchoscopy	4 (54.00)	3 (52.27)
Others	3 (51.27)	3 (45.69)

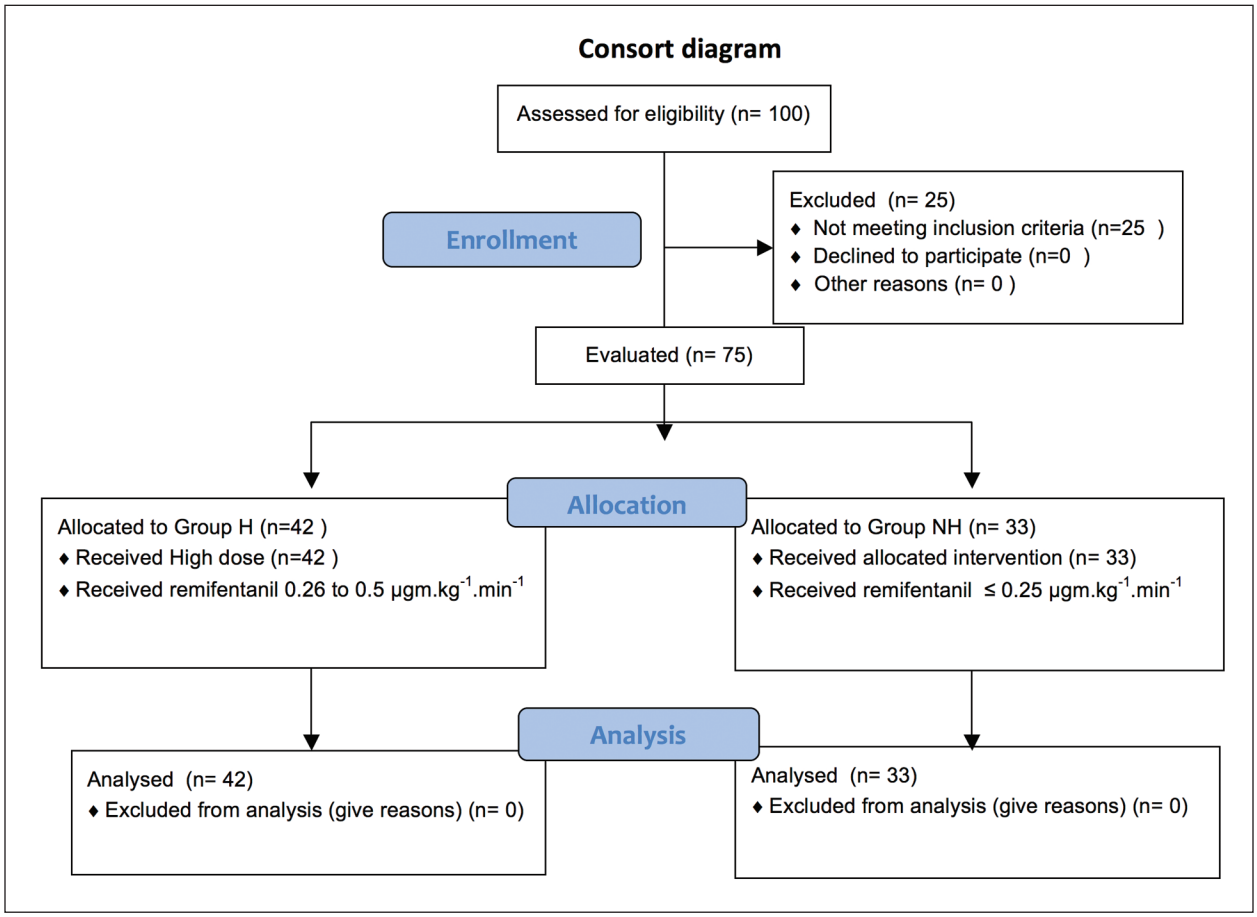

Figure 1: Plan of the study as flow chart

Table 2: Comparison of various parameters between the groups

Parameter	Group H	Group NH	Statistical significance
Patient age (years)	61.63±12.83	60.79±12.4	*P*=0.777
BMI (kg/m^2)	27.63±6.71	27.91±7.99	*P*=0.872
Gender (male:female)	18:24	14:19	*P*=0.898
ASA status (II:III:IV)	8:34:0	8:24:1	*P*=0.337
Bronchoscopy duration (min)	46.64±23.78	49.19±27.69	P=0.664
Total procedure duration (min)	90.85±49.59	105.76±104.35	*P*=0.416
Wake up time (min)	23.33±21.13	21.03±10.17	*P*=0.580
Maintenance propofol (mg)	379.41±201.38	358.43±260.99	*P*=0.701
Total maintenance remifentanil (μg)	1706.32±868.89	896.68±534.46	*P*<0.001
Mean remifentanil infusion dose (μg/kg/min)	0.39±0.16	0.21±0.11	*P*<0.001
Phenylephrine during maintenance (mg)	3.17±1.97	2.76±1.69	*P*=0.441
Minimum heart rate (beats/min)	57.85±10.29	60.37±11.97	*P*=0.342
Maximal fall in BP (mm of Hg)	35.61±18.14	33.75±12.46	*P*=0.621
Baseline start median saturation (at FiO_2-1)	100	99.80	*P*=0.117
"Median" minimum pulse oximeter saturation (%)	98.80	96.50	*P*=0.009

Parametric variables are compared using Student's Unpaired *t*-test, Their values are shown as mean ± SD, Non-parametric variables were compared using Mann-Whitney test and median values are shown, $P \leq 0.05$ are considered as significant, SD = Standard deviation, BMI = Body mass index, BP = Blood pressure, ASA = American society of Anesthesiologists

was used to compare minimum pulse-oximeter saturations recorded in both groups and values in Group-H were found to be significantly higher (P = 0.009) [Table 2]. The mean consumption of propofol and phenylephrine were statistically similar in both groups and are shown in Table 3. A total of 20 episodes of transient laryngospasm were recorded in both groups. The frequency of association of laryngospasms was significantly higher in Group-NH (χ^2 = 6.11, P = 0.047) with 16 and 4 episodes in Group-NH and Group-H. The likelihood ratio of larayngospasm in Group-NH was found to be 4.56

Table 3: Bronchoscopic grading of laryngospasm and frequency in both the groups

Grade	Clinical finding	Frequency in groups	
		Group-H	Group-NH
1	Partial, less than 30 s Minimal desaturation (decrease of 5 %) Did not require treatment	1	3
2	Partial, less than 30 s Minimal desaturation (decrease of 5 %) Required deepening of anesthesia	1	2
3	Partial, less than 30 s Minimal desaturation (decrease of 5 %) Required deepening of anesthesia and succinylcholine	1	2
4	Partial more than 30 s Moderate to severe desaturation lasting more than 30 s Required deepening of anesthesia	0	3
5	Partial more than 30 s Moderate to severe desaturation Required deepening and succinylcholine	0	1
6	Complete laryngospasm Urgent intervention No scope withdrawal	1	3
7	Complete laryngospasm Urgent intervention Scope withdrawal	0	2

(P = 0.022) times of that in Group-H. Overall 24.24% patients (4/33) in Group-NH and 9.52% patients (4/42) in Group-H developed at least a single episode of laryngospasm. A total of 92 coughing episodes were documented, 29 and 63 in Group-H and Group-NH respectively. Pearson's Chi-square test showed a statistically significant association between Group-NH and higher coughing rates (χ^2 = 20.87, P = 0.002). The "likelihood ratio" of the possibility of coughing and Group-NH was found to be 10.97 (P = 0.001) times that in Group-H. In Group-NH 45.45 % patients (15/33) and in Group-H 35.71% patients (15/42) developed one or more coughing episodes during the study. Wilcoxon rank sum test showed that median procedural satisfaction scores reported by pulmonologists were significantly higher in Group-H (3/3) compared with Group-NH (2/3) (P = 0.05) [Figure 2].

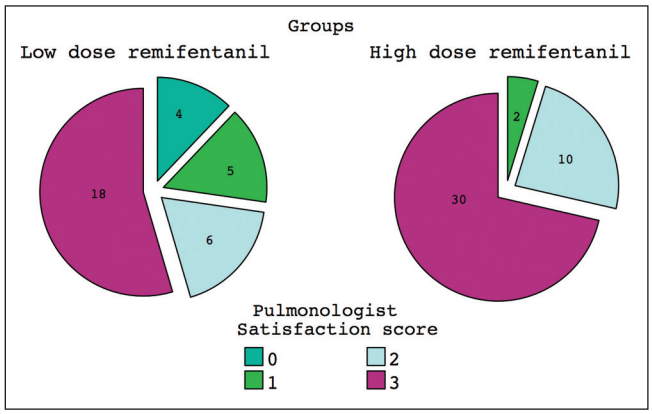

Figure 2: Pie graphs comparing satisfaction scores as rated by the Pulmonologist evaluating procedural conditions. Median value in Group-H (3) was statistically higher than in Group-NH (4)

Discussion

The present study shows that remifentanil used at higher infusion rates (>0.25 μg/kg/min), as part of anesthesia maintenance during bronchoscopy, is associated with significantly lower frequency of coughing and laryngospasm. Its efficiency is further recognized by the fact that minimal pulse-oximeter saturation values recorded in Group-H were also higher than those in Group-NH. Target controlled infusions (TCIs) using remifentanil are proven to be safe and effective in non-paralyzed, critically ill-patients undergoing flexible fiber optic bronchoscopy.[1,2] Remifentanil based anesthesia is known to be associated with higher patient satisfaction during bronchoscopy in intensive care unit patients.[3] Although common, previous studies analyzing the complication rates during bronchoscopic procedures have not documented laryngospasm.[4] This may seem valid in situations where patients receive neuromuscular blocking agents, as paralyzed vocal cords cannot develop spasm. Extensive experience with bronchoscopy with paralysis presently exist primarily in pediatric patients, patients with acute lung conditions (post trauma), or patients requiring prolonged mechanical ventilation.[5-8] Most of the pediatric patients have healthy lungs and bronchoscopies are performed for acute conditions like a foreign body removal. Patients on prolonged mechanical ventilation with no prospect of immediate extubation are unlikely to have increased post-procedural complications attributable to the use of neuromuscular blocking agents. However, this may not be the case in patients presenting for bronchoscopy as a day procedure, especially in patients with significant bronchial pathology.

A major predictor of post-operative pulmonary complications in patients with lung pathology planned for extubation is the use of NMBs. Being of an age greater than 60 is another factor that increases the risk of such complications.[9-11] Bronchoscopies performed on day-care basis in our patients involve both previously mentioned risk factors; thus, it would be prudent to avoid NMBs. However, in the absence of NMBs, it is not uncommon for patients to cough or even develop laryngospasms when the bronchoscope is introduced. In multiple trials, remifentanil is shown to suppress these responses (with both controlled or spontaneous ventilation) with no residual sequelae.[12] Vila *et al*., in a study using conventional doses of remifentanil (up to 0.17 μg/kg/min) with propofol based TIVA, found that coughing incidence was as high as 81%.[13] In our practice, the incidence of coughing was almost half that found by Vila *et al*. which again is related possibly to the higher dose of remifentanil used. The ability of remifentanil high dose to suppress coughing, as demonstrated in our trial can assist in providing good akinesia to the Pulmonologist. It can also prevent the possibility of

injury to patient and equipment damage during the coughing episode and thus improves procedural conditions significantly. This could translate into significant clinical advantage for developing ideal techniques for anesthesia for bronchoscopic procedures. Remifentanil suppresses autonomic responses and additionally may possess antitussive effects like other opioids.

High dose remifentanil infusion is thought to be associated with significant bradycardia leading to hypotension. We did find not such adverse events in our study and minimum reported heart rates were comparable in both groups. Consistent with our findings, Hall *et al.* used remifentanil infusion (at 0.5 μg/kg/min along with inhalational anesthesia) for tracheal intubation in non-paralyzed patients and found no significant hemodynamic adverse events.[14,15] Our own previous experience of use of these doses in patients in the gastroenterology suite has been safe and effective.[16] In addition, introduction and constant presence of the bronchoscope in the airway is a very strong stimulus that probably prevents bradycardia in these patients by activating sympathetic system. We did not compare the remifentanil bolus doses used during induction, as the time gap between induction and scope introduction is often well past the half-life of remifentanil. Thus, induction doses are unlikely to have any clinical effect during the procedure itself. Comparison of minimum blood pressure values between the groups did not show a significant difference either. The amount of vasopressor consumed (phenylephrine) was comparable in both groups [Table 2] and thus the higher dose was not associated with a higher likelihood of hemodynamic derangement. Although, vasopressors were used extensively, they were safely tapered off and discontinued before patient was transferred to the post anesthesia recovery unit.

The use of LMA as a conduit for the bronchoscope greatly assists in controlled ventilation. Remifentanil suppresses the intrinsic respiratory drive, thereby preventing ventilator dyssynchrony. The higher infusion rates were even more effective in suppressing ventilatory drive (despite constant stimulation of bronchoscope), thus allowing uninterrupted mechanical ventilation with no leaks around the LMA. This is the likely cause of significantly higher "minimum oxygen saturation" seen in the high dose group. Similarly, the higher dose also proved more effective in decreasing vocal cord responses to the introduction of bronchoscope, leading to lower laryngospasm rates. It could have also contributed to higher saturations in Group-H, as ventilation during laryngospasms (until relieved) is ineffective, leading to desaturation. Trials without opioid infusions (both inhalational and TIVA) have documented significantly lower oxygen saturation values during bronchoscopy[4,17] These studies did not however, mention the incidence of intra procedural laryngospasm that could have been contributory to recorded high incidence of desaturations.

In a recent trial, Ryu *et al*. compared infusions of dexmedetomidine and remifentanil in a propofol based anesthesia for flexible fiber optic bronchoscopy. They concluded that Pulmonologist satisfaction scores for procedural ease were significantly higher in remifentanil group attributable to a lower incidence of coughing.[18] In the present study, the Pulmonologist's satisfaction scores were found to be significantly higher in the high dose group. However, the incidence of coughing failed to produce a statistically significant difference, despite the lower incidence in Group-H. This was attributed to the fact that coughing episodes in Group-H were very short. Unfortunately, we did not document the duration of these episodes and hence, could not make statistical comparisons. More importantly, lower episodes of laryngospasms led to fewer procedural interruptions, wherefore increasing bronchoscopist satisfaction scores.

The present study has one significant limitation. The exact dose of remifentanil was not standardized in groups rather a range of doses were used. This was inevitable due to multiple anesthesia providers assisting the procedure. Alerting them about the study could have led to performance bias. However, these variations were found to be distributed fairly randomly in both the groups and thus are less likely to affect the results of the study. Use of TCI would have been more scientific/accurate method of propofol and remifentanil delivery, but unfortunately TCI pumps at present are not Food and Drug Administration approved in United States, thus we were not able to use the same. We did not quantify the duration or degree of cough during the procedures. Although such scoring would have been subjective, but it would have helped to improve further quantification of pulmonologist satisfaction score. Documenting duration of coughing episodes would have allowed us to further compare procedural conditions more objectively. We documented the grades of laryngospasm [Table 3], but the total numbers of laryngospasm episodes were too few to make further statistical comparisons between various grades. It must be noted that the high dose remifentanil group was clinically found to have a less severe laryngospasm and did not require bronchoscope withdrawal. Obviously, this added to the pulmonologist's satisfaction.

References

1. Reyle-Hahn M, Niggemann B, Max M, Streich R, Rossaint R. Remifentanil and propofol for sedation in children and young adolescents undergoing diagnostic flexible bronchoscopy. Paediatr Anaesth 2000;10:59-63.
2. Berkenbosch JW, Graff GR, Stark JM, Ner Z, Tobias JD. Use of a remifentanil-propofol mixture for pediatric flexible fiberoptic bronchoscopy sedation. Paediatr Anaesth 2004;14:941-6.
3. Chalumeau-Lemoine L, Stoclin A, Billard V, Laplanche A, Raynard B, Blot F. Flexible fiberoptic bronchoscopy and remifentanil target-controlled infusion in ICU: A preliminary study. Intensive Care Med 2013;39:53-8.
4. Facciolongo N, Patelli M, Gasparini S, Lazzari Agli L, Salio M, Simonassi C, *et al*. Incidence of complications in bronchoscopy. Multicentre prospective study of 20,986 bronchoscopies. Monaldi Arch Chest Dis 2009;71:8-14.
5. Teksan L, Baris S, Karakaya D, Dilek A. A dose study of remifentanil in combination with propofol during tracheobronchial foreign body removal in children. J Clin Anesth 2013;25:198-201.
6. Zhang J, Wang Y, Li B, Zhang W. Remifentail infusion for paediatric bronchoscopic foreign body removal: Comparison of sevoflurane with propofol for anaesthesia supplementation for bronchoscope insertion. Anaesth Intensive Care 2010;38:905-10.
7. Quintard H, Pavlakovic I, Mantz J, Ichai C. Adjunctive remifentanil infusion in deeply sedated and paralyzed ICU patients during fiberoptic bronchoscopy procedure: A prospective, randomized, controlled study. Ann Intensive Care 2012;2:29.
8. Yeganeh N, Roshani B, Azizi B, Almasi A. Target-controlled infusion of remifentanil to provide analgesia for awake

nasotracheal fiberoptic intubations in cervical trauma patients. J Trauma 2010;69:1185-90.
9. Weingarten TN, Kor DJ, Gali B, Sprung J. Predicting postoperative pulmonary complications in high-risk populations. Curr Opin Anaesthesiol 2013;26:116-25.
10. Canet J, Gallart L, Gomar C, Paluzie G, Vallès J, Castillo J, *et al*. Prediction of postoperative pulmonary complications in a population-based surgical cohort. Anesthesiology 2010;113:1338-50.
11. McAlister FA, Bertsch K, Man J, Bradley J, Jacka M. Incidence of and risk factors for pulmonary complications after nonthoracic surgery. Am J Respir Crit Care Med 2005;171:514-7.
12. Natalini G, Fassini P, Seramondi V, Amicucci G, Toninelli C, Cavaliere S, *et al*. Remifentanil vs. fentanyl during interventional rigid bronchoscopy under general anaesthesia and spontaneous assisted ventilation. Eur J Anaesthesiol 1999;16:605-9.
13. Vila E, Mases A, Vela E, Molto L, Sanchez-Font A, Curull V, *et al*. Sedation with propofol and remifentanil for real-time endobronchial ultrasound needle aspiration. Colomb J Anesth 2013;41:120-6.
14. Hall AP, Thompson JP, Leslie NA, Fox AJ, Kumar N, Rowbotham DJ. Comparison of different doses of remifentanil on the cardiovascular response to laryngoscopy and tracheal intubation. Br J Anaesth 2000;84:100-2.
15. Goudra BG, Singh PM, Sinha AC. Outpatient endoscopic retrograde cholangiopancreatography: Safety and efficacy of anesthetic management with a natural airway in 653 consecutive procedures. Saudi J Anaesth 2013;7:259-65.
16. Goudra BG, Singh PM, Sinha AC. Anesthesia for ERCP: Impact of Anesthesiologist's Experience on Outcome and Cost. Anesthesiol Res Pract 2013;2013:570518. Available from: http://www.hindawi.com/journals/arp/2013/570518/abs/. [Last cited on 2013 Jun 7].
17. Lukomsky GI, Ovchinnikov AA, Bilal A. Complications of bronchoscopy: Comparison of rigid bronchoscopy under general anesthesia and flexible fiberoptic bronchoscopy under topical anesthesia. Chest 1981;79:316-21.
18. Ryu JH, Lee SW, Lee JH, Lee EH, Do SH, Kim CS. Randomized double-blind study of remifentanil and dexmedetomidine for flexible bronchoscopy. Br J Anaesth 2012;108:503-11.

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