Egyptian Journal of Anaesthesia 33 (2017) 277–281

HOSTED BY

Contents lists available at ScienceDirect

Egyptian Journal of Anaesthesia

journal homepage: www.sciencedirect.com

Anaesthesia and peri-interventional morbidity of rigid bronchoscopy: A retrospective analysis

Jerry Tan [a,*], Dinoo Kirthinanda [b], Dawen Esther Yu [c], Ruban Poopalalingam [a], Harikrishnan Kothandan [a]

[a] Department of Anaesthesia, Outram Road, Singapore General Hospital, Singapore 169608, Singapore
[b] Singhealth Residency Program, Ministry of Health Holdings, Singapore 099253, Singapore
[c] Duke-National University of Singapore Graduate Medical School, Singapore

ARTICLE INFO

Article history:
Received 31 October 2016
Revised 21 March 2017
Accepted 28 April 2017
Available online 4 May 2017

Keywords:
Bronchoscopy
Anaesthesia
Morbidity
Intravenous

ABSTRACT

Background: Rigid bronchoscopy is an invasive procedure that requires general anaesthesia with different ventilation strategies. Various mechanical and systemic complications can arise from the procedure and anaesthetic technique employed. The aim of this study is to evaluate the two common anaesthetic techniques and the peri-interventional morbidity of rigid bronchoscopy.

Methods: We retrospectively analysed all the rigid bronchoscopies conducted in Singapore General Hospital between 1999 and 2014. Patient characteristics, type of procedures, type of anaesthesia, duration of procedure, ventilation strategies, various intra-operative medications, pre-operative and post-operative arterial blood gas, oxygen saturation and pulmonary function test, and peri-interventional complications were collected. Continuous data were reported as mean and categorical data were reported as percentages.

Results: Majority of patients that underwent rigid bronchoscopy received total intravenous anaesthesia (81%). A significantly higher proportion of patients in the volatile groups were scheduled for biopsy (29.4%) using rigid bronchoscopy. Choice of ventilation strategies were largely similar in both groups. A higher complication rate of hypertension (11.8%), acute myocardial infarction (11.8%) and pneumothorax (17.6%) was seen in the volatile group.

Conclusion: The choice of anaesthetic technique possibly affects the complication of patients undergoing rigid bronchoscopy. Volatile anaesthetics appeared to be driven by presumably shorter procedure, but was associated with higher systemic complication.

1. Introduction

The rigid bronchoscopy defined by the as the passage of rigid instruments trans-orally or trans-tracheostomy for diagnostic or therapeutic purposes, aided by various light sources, telescopes and accessory instruments [1]. Although the use of rigid bronchoscope was largely replaced by the use of flexible bronchoscopes for most therapeutic and diagnostic purposes in adults, it maintains its value for better control of the compromised airway, massive haemoptysis, airway stent placement and removal of large foreign bodies [2]. The indications and contraindications for rigid bronchoscopy are listed in Table 1.

Mechanical complications associated with rigid bronchoscopy include those arising from the underlying pathology as well those associated with the procedure. The requirement for general anaesthesia for rigid bronchoscopy predisposes patients to various peri-interventional morbidity that may be attributed to the choice of anaesthetic and airway management.

2. Methods

We carried out a retrospective observational study at Singapore General Hospital to assess the perioperative outcomes of the rigid bronchoscopy after obtaining Institutional Review Board (IRB) approval.

Patients who required bronchoscopy at the Singapore General Hospital between 1999 and 2014 was retrieved through Operating Theatre records and Online Operating Theatre Listing Software (OTM). A total of one hundred and twenty-two cases were identified and individual medical records were physically retrieved from

Peer review under responsibility of Egyptian Society of Anesthesiologists.
* Corresponding author at: Blk 5 Level 2, Anaesthesia Office Outram Road, Singapore 169608, Singapore.
E-mail address: tan.jerry@outlook.com (J. Tan).

http://dx.doi.org/10.1016/j.egja.2017.04.004
1110-1849/

Table 1
Indication and contraindications for rigid bronchoscopy.

Indications for rigid bronchoscopy
• Management of massive haemoptysis
• Treatment of tracheobronchial stenosis
• Foreign body removal
• Tumour resection
• Deep bronchial wall biopsy
Contraindications for rigid bronchoscopy
• Unstable cervical spine
• Severe maxillofacial trauma or deformity
• Obstructing oral or laryngeal disease

Adapted from ERS/ATS statement on interventional pulmonology, 2002 [1].

the Singapore General Hospital Medical Records Office (MRO). Ninety patients were included in the final analysis after exclusion criteria was applied. These exclusion criteria include flexible bronchoscopy and missing medical records. Data were collected by the investigators using a prefabricated data collection form.

We defined hypotension as the reduction of mean arterial pressure (MAP) below 20% of the baseline and/or requirement of inotropic support to maintain MAP more than 65 mmHg, and hypertension as the elevation of MAP above 20% of baseline. Oxygen saturation less than 92% or partial pressure of oxygen less than 60 mmHg was considered as hypoxia. Dysrhythmias was defined as new onset of cardiac rhythm that differ from patient cardiac rhythm at baseline. Acute myocardial infarction (AMI) defines the new onset of ischaemic electrocardiogram (ECG) changes with elevated cardiac troponins. We take into account death that occurred during the admission for rigid bronchoscopy. We accepted diagnoses of various complications by principal clinicians at the time of discharge such as pulmonary oedema, pulmonary embolism, pneumothorax, pneumonia and delirium.

3. Statistics

Statistical analysis was performed using SPSS for Mac version 20.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were reported as mean ± SD. Categorical variables were reported as percentages. Normality for continuous variables in groups was determined by the Shapiro-Wilk test. Student's *t*-test was used for comparison of means of continuous variables between the studied groups. Pearson chi-square test was used for comparison of categorical variables among studied groups. A value of $P < 0.05$ was considered significant.

4. Results

The study was completed with 90 patients. Table 2 shows the demographic characteristics of the patients. Comparatively, the TIVA group has more hypertensive patients than the volatile group.

Table 3 depicts the various procedure performed using rigid bronchoscopy, type of anaesthesia, methods of ventilation and the various medications received intra-operatively. A larger proportion of patients who underwent biopsy received volatile agents (29.4% vs. 8.2%, $P = 0.016$). Of note, there was no significant difference in the method of ventilation between both groups. Remifentanil was used more often in the TIVA group (63.0% vs. 11.8%, $P < 0.001$) and fentanyl more so in the volatile group (41.2% vs. 15.1%, $P = 0.015$).

Table 4 summarises pre-operative and post-operative arterial blood gas, pulse oximetry and pulmonary function test data. Baseline pre-operative parameters were similar between both groups. Post-operatively, patients who received volatiles had a lower pH on arterial blood gas (7.30 ± 0.10 vs. 7.43 ± 0.09, $P = 0.021$). In addition, the volatile group was found to have a significantly higher forced vital capacity (2.73 ± 0.60 vs. 2.19 ± 0.62, $P = 0.034$) than the TIVA group after rigid bronchoscopy.

There were no significant differences in the mechanical complications between the two groups of patients in terms of stent dislodgement, laryngospasm, bleeding, tooth dislodgement or a need for switch to fibre-optic bronchoscopy due to failure to locate lesion. Patients who received volatiles had significantly higher systemic complications of hypertension (11.8% vs. 1.4%), myocardial infarction (11.8% vs. 0%) and pneumothorax (17.6% vs. 0%) as compared to patients who received TIVA (see Table 5).

5. Discussion

Our study puts into perspective the patient characteristics, interventions performed, ventilation strategies, intra-operative medications used and complications observed into two distinct groups based on the general anaesthetic technique for rigid bronchoscopy. Challenges unique to rigid bronchoscopy include effective attenuation of haemodynamic response to intubation and prevention of hypoxia in the setting of a shared airway compounded by the underlying disease pathology requiring rigid bronchoscopy.

Laryngeal and endotracheal intubation with the rigid bronchoscopy increases the sympathetic nervous system activity and adrenaomedullary catecholamine activity. Tachycardia is more pronounced when tracheal manipulation is involved [3]. The resulting hypertension, tachycardia and dysrhythmias increase the peri-operative risk for subgroup of patients with coronary artery disease, existing hypertension, preeclampsia and intracranial pathologies such as aneurysms [4]. Pharmacological agents such as intravenous or topical lignocaine, opioids such as remifentanil, nifidipine, clonidine, gabapentin, esmolol and magnesium sulphate had been described with variable success in ameliorating the haemodynamic response to tracheal intubation [5–11]. In a recent Cochrane review, the risk of dysrhythmias was reduced with administration of local anaesthetics, calcium channel blockers, beta blockers and narcotics as compared to placebo and showed reduced ECG evidence of myocardial ischaemia [12].

Remifentanil is an ultra-short acting opioid and works synergistically with both propofol and volatile agents such as sevoflurane in ablating the response to laryngoscopy [13,14]. With the myriad of other pharmacological agents to achieve the same haemodynamic suppression to laryngoscopy, the choice of remifentanil may be hindered by cost, need for specialised pumps and familiarity of use. As seen in our study, remifentanil was favoured in the TIVA as compared to volatile group (63% vs. 11.8% $P = 0.000$). We postulated that this was driven by a choice of a simpler anaesthetic by the primary anaesthetist, perceived by a possibly shorter operation time as majority of the cases in the volatile groups were for biopsies (29.4% vs. 8.2% $P = 0.016$). However, this did not translate to an actual shorter operation duration as compared to the TIVA group. Instead, the incidence of intra-operative hypertension was

Table 2
Demographic data of patients undergoing rigid bronchoscopy procedures.

Patient characteristics	Total (N = 90)	TIVA (N = 73)	Volatile (N = 17)	P value
Age (years)	58.28 ± 15.40	59.30 ± 14.25	53.88 ± 19.49	0.193
BMI	20.97 ± 4.12	20.95 ± 4.17	21.07 ± 4.07	0.923
Gender				
Male	62.2%	64.4%	52.9%	0.381
Female	37.8%	35.6%	47.1%	
Ethnicity				
Chinese	83.3%	84.9%	76.5%	0.126
Malay	6.7%	8.2%	0%	
Indian	3.3%	2.7%	5.9%	
Others	6.7%	4.1%	17.6%	
ASA				
2	50.0%	49.3%	52.9%	0.868
3	48.9%	49.3%	47.1%	
4	1.1%	1.4%	0%	
Medical history				
Diabetes	10.0%	8.2%	17.6%	0.243
Hypertension	23.3%	28.8%	0%	0.012*
IHD	11.1%	13.7%	0%	0.106
CVA	3.3%	4.1%	0%	0.395
AF	1.1%	1.4%	0%	0.627
Bronchiectasis	42.2%	43.8%	35.3%	0.521
COPD	11.1%	9.6%	17.6%	0.341
Asthma	4.4%	5.5%	0%	0.323
Tuberculosis	26.7%	23.3%	41.2%	0.133
Lung Abscess	3.3%	4.1%	0%	0.395
Cirrhosis	3.3%	1.4%	11.8%	0.032*
Cancer	57.8%	60.3%	47.1%	0.320
Metastasis	20.0%	21.9%	11.8%	0.424

TIVA = total intravenous anaesthesia, BMI = body mass index, ASA = American Society of Anesthesiologists physical status classification system, IHD = ischemic heart disease, CVA = cerebrovascular accident, AF = atrial fibrillation, COPD = chronic obstructive pulmonary disease.
Data presented as Mean±SD or percentages.
* $P < 0.05$ is significant.

Table 3
Procedure types, ventilation methods and medications received intra-operatively.

Parameters	Total (N = 90)	TIVA (N = 73)	Volatile (N = 17)	P value
Procedures				
Laser	64.4%	68.5%	47.1%	0.096
Stent insertion	57.8%	60.3%	47.1%	0.320
Dilation	36.7%	35.6%	41.2%	0.668
Foreign body removal	3.3%	4.1%	0%	0.395
Biopsy	12.2%	8.2%	29.4%	0.016*
Stent removal	3.3%	4.1%	0%	0.395
Surgery duration (minutes)	64.90 ± 29.23	64.04 ± 27.86	68.59 ± 35.24	0.566
Ventilation methods				
Spontaneous	87.8%	90.4%	76.5%	0.114
IPPV	12.2%	9.6%	23.5%	0.114
Intra-op medication				
Local anaesthetics	56.7%	60.3%	41.2%	0.152
Morphine	1.1%	0%	5.9%	0.037*
Fentanyl	20.0%	15.1%	41.2%	0.015*
Remifentanil	53.3%	63.0%	11.8%	0.000*
Alfentanil	27.8%	23.3%	47.1%	0.049*
Dexamethasone	74.4%	72.6%	82.4%	0.406
Antibiotics	18.9%	21.9%	5.9%	0.128
Inotropes	7.8%	9.6%	0%	0.184

TIVA = total intravenous anaesthesia, IPPV = intermittent positive pressure ventilation.
Data presented as Mean ± SD or percentages.
* $P < 0.05$ is significant.

significantly higher in the volatile group (11.8% vs. 1.4% P = 0.032) and there was also a significantly higher incidence of acute myocardial infarction in the volatile group (11.8% vs. 0% P = 0.003). Indeed, volatile anaesthetic was shown to produce a higher heart rate and mean blood pressure as compared to propofol-remifentanil anaesthesia in the paediatric population, despite providing a faster induction and recovery time [15]. The incidence of hypotension between our study group did not differ significantly. Alfentanil is also a rapid-acting opioid with onset of effect 4× faster than fentanyl. However, the pressor response to rigid bronchoscopy was proven inferior compared to remifentanil with remifentanil providing greater haemodynamic stability and more effective attenuation of tachycardia [16]. The use of Alfentanil has been replaced with remifentanil in our institution despite a larger proportion of patient in the volatile group receiving Alfen-

Table 4
Preoperative and postoperative comparison of arterial blood gas, pulse oximetry and pulmonary function test measurements.

Parameters	Total (N = 90)	TIVA (N = 73)	Volatile (N = 17)	P value
Arterial blood gas				
Pre-op O_2	92.08 ± 40.02	94.81 ± 41.56	70.76 ± 12.79	0.210
Post-op O_2	121.46 ± 76.72	120.56 ± 83.73	125.75 ± 32.68	0.905
Pre-op CO_2	39.95 ± 10.77	40.67 ± 11.09	34.34 ± 5.94	0.220
Post-op CO_2	45.58 ± 15.79	44.05 ± 15.87	52.25 ± 7.62	0.322
Pre-op pH	7.44 ± 0.08	7.44 ± 0.08	7.45 ± 0.04	0.727
Post-op pH	7.41 ± 0.10	7.43 ± 0.09	7.30 ± 0.10	0.021*
Pulse oximetry				
Pre-op SpO_2	97.57 ± 2.11	97.67 ± 2.17	97.12 ± 1.80	0.334
Lowest SpO_2	93.06 ± 5.94	92.81 ± 6.37	94.12 ± 3.48	0.416
Pulmonary function test				
Pre-op FEV1	1.42 ± 0.47	1.37 ± 0.49	1.66 ± 0.24	0.174
Post-op FEV1	1.80 ± 0.51	1.77 ± 0.59	1.88 ± 0.23	0.644
Pre-op FVC	1.96 ± 0.64	1.92 ± 0.66	2.13 ± 0.49	0.466
Post-op FVC	2.35 ± 0.62	2.19 ± 0.56	2.73 ± 0.60	0.034*
Pre-op FRC	73.48 ± 12.84	72.22 ± 11.92	80.00 ± 16.54	0.178
Post-op FRC	77.32 ± 11.93	80.18 ± 9.16	70.87 ± 15.36	0.065
Pre-op PEFR	3.52 ± 1.13	3.50 ± 1.12	3.63 ± 1.30	0.838
Post-op PEFR	4.58 ± 1.29	4.60 ± 1.33	4.51 ± 1.31	0.884

TIVA = total intravenous anaesthesia, pH = arterial blood pH, FEV1 = forced expiratory volume in 1 s, FVC = forced vital capacity, FCR = functional residual capacity, PEFR = peak expiratory peak flow rate. Data presented as Mean ± SD.
* P < 0.05 is significant.

Table 5
Mechanical and Systemic peri-interventional complications of rigid bronchoscopy comparing TIVA vs. Volatiles.

Complications	Total (N = 90)	TIVA (N = 73)	Volatile (N = 17)	P value
Mechanical complications				
Stent dislodge	1.1%	1.4%	0%	0.627
Laryngospasm	1.1%	1.4%	0%	0.627
Bleeding	2.2%	2.7%	0%	0.490
Tooth dislodge	1.1%	1.4%	0%	0.627
Change to FOB: failed to locate lesion	2.2%	2.7%	0%	0.490
Systemic complications				
Hypotension	13.3%	15.1%	5.9%	0.316
Hypertension	3.3%	1.4%	11.8%	0.032*
Arrhythmia	4.4%	5.5%	0%	0.323
AMI	2.2%	0%	11.8%	0.003*
Hypoxia	4.4%	5.5%	0%	0.323
Carbon dioxide retention	3.3%	4.1%	0%	0.395
Acute pulmonary oedema	2.2%	2.7%	0%	0.490
Pneumothorax	3.3%	0%	17.6%	0.000*
Pneumonia	5.6%	6.8%	0%	0.267
Pulmonary haemorrhage	1.1%	1.4%	0%	0.627
Infection	1.1%	1.4%	0%	0.627
Re-admission within 3mth	10.0%	12.3%	0%	0.127
Tracheostomy for post-op long term ventilation	1.1%	1.4%	0%	0.627
Delirium	2.2%	2.7%	0%	0.490
Death	3.3%	4.1%	0%	0.395

TIVA = total intravenous anaesthesia, AMI = acute myocardial infarction, FOB = fibre-optic bronchoscopy. Data presented as percentages.
* P < 0.05 is significant.

tanil (47.1% vs. 23.3% P = 0.049). This largely reflected an older anaesthetic practice during the early phase of data collection.

Management of central airway obstruction (CAO) due to neoplastic or non-neoplastic disease is responsible for the resurgence in the interest in rigid bronchoscopy [17]. The management of CAO includes stent placement, dilation, heat therapy using electrocautery or laser and debridement of obstructive lesion. Independent of the aetiology, site of intervention or type of intervention, therapeutic rigid bronchoscopy was able to alleviate symptoms associated with CAO and improve objective spirometric measurements such as forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV1), quality of life and survival [18]. The FVC and FEV1 in our study had improved following rigid bronchoscopy (FVC 1.96 vs. 2.35; FEV1 1.42 vs. 1.80). Comparing data from TIVA and volatile group, the volatile group had more significant post-operatively improvement in FVC (2.73 vs. 2.19, P = 0.034) as compared to the TIVA group.

There are various approaches to the ventilatory strategies during rigid bronchoscopy. The methods of ventilation include: (1) Apnoeic oxygenation; (2) Spontaneous assisted ventilation; (3) Controlled ventilation; (4) Manuel jet ventilation; and (5) High frequency jet ventilation (HFOV). In our institution, we primarily use either spontaneous assisted ventilation or controlled ventilation via the circle circuit. In all cases of rigid bronchoscopies, either mode of ventilation was accepted by the interventional pulmonologists without compromising the procedure. Spontaneous assisted ventilation is described as a TIVA technique whereby a close titration of anaesthetic is required to maintain spontaneous ventilation by the patient [19]. The avoidance of muscle relaxants purportedly reduced post-procedure re-intubation rate [20]. Con-

trolled ventilation is more challenging as additional steps are required to prevent air leaks. However, administration of nitrous oxide or volatile agents are possible with this technique. With both techniques, hypoxia is the commonest complication. In our study, 5.5% of patients in TIVA group had hypoxia and was not significant different than the volatile group.

Permissive hypercapnia is used to reduce ventilator associated lung injuries and is often seen in rigid bronchoscopy regardless of mode of ventilation. Although the incidence of carbon dioxide retention in our study was 3.3%, it was reported as high as 93.2% in other study. Acute hypercapnia lower than 100 mmHg was not associated with delayed recovery but itself is an independent predictive factor bronchoscopic complications such as congestive heart failure, tracheorrhagia, delayed recovery and ICU admission after surgery [21]. In our study, both groups had raised pCO_2 after procedure with no significant difference between them. However, volatile group had a lower pH value which may be attributed to the respiratory acidosis secondary to hypercapnia.

Pneumothorax is an uncommon complication of rigid bronchoscopy and previous studies with 3149 cases in the paediatric group showed an incidence of 0.3% [22]. Mechanical trauma to the tracheobronchial tree by the rigid bronchoscope as well as high peak inspiratory pressure during mechanical ventilation are likely causes of pneumothorax. This may progress to tension pneumothorax and the signs of hypoxia, tachycardia and hypotension may be masked due to concurrent administration of anaesthesia and stimulating effect of the rigid bronchoscopy. In our study, the pneumothoraces occurred predominantly in the volatile group which had a higher proportion of patient receiving mechanical ventilation.

There are several limitations to our study. The case load of rigid bronchoscope in adults is low in our tertiary centre and practices differ amongst anaesthetists over the years. This skews the perspective of the anaesthetic practice over period of study. Secondly, majority of the data were not on electronic system. Missing or incomplete data which are excluded may contributed to bias in the study. Thirdly, we did not capture data on the use of bispectral index (BIS) and the complication of awareness. As this is a retrospective review, these data were not available.

6. Conclusion

Neither the use of TIVA or volatile for rigid bronchoscopy had shown to be superior over the other. The use of propofol-remifentanil TIVA appeared to be popular and was better at attenuating haemodynamic response during the procedure. Regardless of technique, both groups had improvement in spirometry measurements, did not experience significant hypoxia or hypercapnia, or difference in most complications. Pneumothorax however, was significantly higher in the volatile group, suggesting an association with the use of mechanical ventilation.

Acknowledgement

Nil.

References

[1] Bolliger CT, Mathur PN, Beamis JF, et al. ERS/ATS statement on interventional pulmonology. European Respiratory Society/American Thoracic Society. Eur Respir J 2002;19(2):356–73.
[2] Dutau H, Vandemoortele T, Breen DP. Rigid bronchoscopy. Clin Chest Med 2013;34(3):427–35.
[3] Shribman AJ, Smith G, Achola KJ. Cardiovascular and catecholamine responses to laryngoscopy with and without tracheal intubation. Br J Anaesth 1987;59(3):295–9.
[4] Kovac AL. Controlling the hemodynamic response to laryngoscopy and endotracheal intubation. J Clin Anesth 1996;8(1):63–79.
[5] Qi DY, Wang K, Zhang H, et al. Efficacy of intravenous lidocaine versus placebo on attenuating cardiovascular response to laryngoscopy and tracheal intubation: a systematic review of randomized controlled trials. Minerva Anestesiol 2013;79(12):1423–35.
[6] Lee SY, Min JJ, Kim HJ, et al. Hemodynamic effects of topical lidocaine on the laryngoscope blade and trachea during endotracheal intubation: a prospective, double-blind, randomized study. J Anesth 2014;28(5):668–75.
[7] Prakash N, McLeod T, Gao Smith F. The effects of remifentanil on haemodynamic stability during rigid bronchoscopy. Anaesthesia 2001;56(6):576–80.
[8] Abdel-Razek A, el-Attar AM. Nifedipine versus fentanyl to prevent the pressor response to tracheal intubation. Middle East J Anaesthesiol 1995;13(1):88–99.
[9] Marashi SM, Ghafari MH, Saliminia A. Attenuation of hemodynamic responses following laryngoscopy and tracheal intubation – comparative assessment of clonidine and gabapentin premedication. Middle East J Anaesthesiol 2009 Jun;20(2):233–7.
[10] Efe EM, Bilgin BA, Alanoglu Z, et al. Comparison of bolus and continuous infusion of esmolol on hemodynamic response to laryngoscopy, endotracheal intubation and sternotomy in coronary artery bypass graft. Braz J Anesthesiol 2014;64(4):247–52.
[11] Panda NB, Bharti N, Prasad S. Minimal effective dose of magnesium sulfate for attenuation of intubation response in hypertensive patients. J Clin Anesth 2013;25(2):92–7.
[12] Khan FA, Ullah H. Pharmacological agents for preventing morbidity associated with the haemodynamic response to tracheal intubation. Cochrane Database Syst Rev 2013;3(7):CD004087. doi: http://dx.doi.org/10.1002/14651858.CD004087.pub2.
[13] Bouillon TW, Bruhn J, Radulescu L, et al. Pharmacodynamic interaction between propofol and remifentanil regarding hypnosis, tolerance of laryngoscopy, bispectral index, and electroencephalographic approximate entropy. Anesthesiology 2004;100(6):1353–72.
[14] He L, Wang X, Zhang XF, Tang SR. Effects of different doses of remifentanil on the end-tidal concentration of sevoflurane required for tracheal intubation in children. Anaesthesia 2009;64(8):850–5.
[15] Liao R, Li JY, Liu GY. Comparison of sevoflurane volatile induction/maintenance anaesthesia and propofol-remifentanil total intravenous anaesthesia for rigid bronchoscopy under spontaneous breathing for tracheal/bronchial foreign body removal in children. Eur J Anaesthesiol 2010;27(11):930–4.
[16] Agnew NM, Tan NH, Scawn ND, Pennefather SH, Russell GN. Choice of opioid supplementation for day-case rigid bronchoscopy: a randomized placebo-controlled comparison of a bolus of remifentanil and alfentanil. J Cardiothorac Vasc Anesth 2003;17(3):336–40.
[17] Petrella F, Borri A, Casiraghi M, et al. Operative rigid bronchoscopy: indications, basic techniques and results. Multimed Man Cardiothorac Surg 2014;27(May). pii: mmu006.
[18] Mahmood K, Wahidi MM, Thomas S, et al. Therapeutic bronchoscopy improves spirometry, quality of life, and survival in central airway obstruction. Respiration 2015;89(5):404–13.
[19] Pathak V, Welsby I, Mahmood K, et al. Ventilation and anesthetic approaches for rigid bronchoscopy. Ann Am Thorac Soc 2014;11(4):628–34.
[20] Perrin G, Colt HG, Martin C, et al. Safety of interventional rigid bronchoscopy using intravenous anesthesia and spontaneous assisted ventilation. A prospective study. Chest 1992;102(5):1526–30.
[21] Cheng Q, Zhang J, Wang H, et al. Effect of acute hypercapnia on outcomes and predictive risk factors for complications among patients receiving bronchoscopic interventions under general anesthesia. PLoS One 2015;10(7):e0130771.
[22] Zhang X, Li WX, Cai YR. A time series observation of Chinese children undergoing rigid bronchoscopy for an inhaled foreign body: 3,149 cases in 1991–2010. Chin Med J (Engl) 2015;128(4):504–9.