Hindawi Publishing Corporation
ISRN Endoscopy
Volume 2013, Article ID 217505, 6 pages
http://dx.doi.org/10.5402/2013/217505

Clinical Study

Indications and Efficacy of Fiberoptic Bronchoscopy in the ICU: Have They Changed Since Its Introduction in Clinical Practice?

Pablo Álvarez-Maldonado,[1] Carlos Núñez-Pérez Redondo,[1] José D. Casillas-Enríquez,[1] Francisco Navarro-Reynoso,[1] and Raúl Cicero-Sabido[1,2]

[1] *Servicio de Neumología y Cirugía de Tórax, Hospital General de México O.D. "Dr. Eduardo Liceaga", HGM, Balmis 148, 06726 México, DF, Mexico*
[2] *Facultad de Medicina, UNAM, México, DF, Mexico*

Correspondence should be addressed to Pablo Álvarez-Maldonado; pamyacs@yahoo.com

Received 18 January 2013; Accepted 12 February 2013

Academic Editors: S. Dissanaike, S. M. Selvaggi, and U. F. Wellner

Purpose. We describe characteristics, utility, and safety of fiberoptic bronchoscopy (FOB) in an intensive care unit (ICU). *Methods*. Prospective and descriptive cohort of patients admitted to a respiratory ICU from March 2010 to June 2012. *Results*. A total of 102 FOBs were performed in 84 patients among 580 patients that were admitted to the ICU. Mean age was 48 ± 17 years. FOB was useful in 65% of diagnostic procedures and 83% of therapeutic procedures, with an overall utility of 75%. Indications and utility according to indication were pneumonia in 31 cases, utility of 52%; percutaneous tracheostomy guidance in 26 cases, utility of 100%; atelectasis in 25 cases, utility of 76%; airway exploration in 16 cases, utility of 75%; hemoptysis in two cases, utility of 100%; and difficult airway intubation in two cases, utility of 100%. A decrease in oxygen saturation (SpO_2) of >5% during FOB was present in 65% of cases, and other minor complications were present in 3.9% of cases. *Conclusions*. Reasons for performing FOB in the ICU have remained relatively stable over time with the exception of the addition of percutaneous tracheostomy guidance. Our series documents current indications and also the utility and safety of this procedure.

1. Introduction

Fiberoptic bronchoscopy (FOB) was first introduced in clinical practice in 1967 [1]. Since then, it is considered one of the most important techniques in pulmonary medicine. New advances emerge in the field over the years [2] and its potential is being recognized around the world as a contributor to the management of every pulmonary condition [3].

A wide range of indications exists for FOB in the intensive care unit (ICU) [4]. Most correspond to basic bronchoscopy with exploration, lavage, brushing, and forceps sampling as the primary used techniques [5–7]. It is recommended that intensive care units account for the facility to perform urgent and timely FOB for a range of therapeutic and diagnostic purposes [8]. Critical care settings demand that respiratory system problems be resolved and clinical decisions be made in a timely manner. Here we describe the impact in decision-making and problem solving of FOB in an ICU along with indications, complications and results of the procedure.

2. Materials and Methods

2.1. Study Design. This is a prospective and descriptive cohort.

2.2. Setting. The seven-bed respiratory intensive care unit (RICU) of the Department of Pneumology and Thoracic Surgery is one of the eight ICUs of the Hospital General de México O.D., a 901-bed teaching hospital. The RICU works as a closed unit with certified critical care physicians and pulmonologists and functions on a 24/7 basis of coverage. The Department of Pneumology and Thoracic Surgery administers a one-year fellowship-training program in thoracic endoscopy, which includes teaching of interventional bronchoscopy (flexible and rigid) and thoracoscopy. An intensivist

(primary specialty in internal medicine) trained in thoracic endoscopy and accounting for 3-year experience in FOB works in morning RICU rounds as part of a multidisciplinary team and performs FOB when required. Pulmonologists of the RICU team and thoracic endoscopy fellows may also perform FOB.

2.3. Patients. Data from all patients admitted to the RICU were collected from March 2010 to June 2012 using our own computerized database [9]. Also, for patients who underwent FOB, we prospectively registered the following: indications, results and complications related to the procedure, specialty of the physician who performed FOB (intensivist, pulmonologist or thoracic endoscopy fellow), and where FOB took place (within the RICU or in the operating room).

2.4. Procedures. All procedures were performed according to the RICU procedure manual, which was elaborated based on techniques described elsewhere [10, 11]. These include local anesthesia for FOB, FOB examination of the upper airway and the tracheobronchial tree, bronchial lavage, bronchial brushing (protected specimen brushing), bronchoalveolar lavage (BAL), FOB forceps sampling, FOB techniques for hemoptysis, foreign body removal, FOB tracheal intubation, and FOB assistance for percutaneous tracheostomy. When advanced procedures or other procedures not described above were required, an experienced pulmonologist-bronchoscopist was requested for performing FOB. A 6.0 mm outer diameter fiberoptic bronchoscope (Pentax FB-18X, Asahi Optical Co., Tokyo, Japan) was routinely used and, in selected cases when video documentation was needed, a video bronchoscope (Olympus BF-1T180, Optical Co., Ltd., Tokyo, Japan) was used. If there was no urgent indication, the decision for performing FOB was made according to consensus of the team of the RICU during morning rounds. BAL was the technique used to collect samples for quantitative cultures when FOB indication was suspicion of lower respiratory tract infection. BAL for suspicion of ventilator-associated pneumonia (VAP) was indicated according to the clinical and radiological criteria of the Centers for Disease Control and Prevention [12].

2.5. Definitions. The impact of FOB performed in the RICU is described in terms of its utility. For diagnostic purposes, FOB was defined as "useful" if endoscopic, microbiological, or histopathological findings determined a change in clinical decisions. If FOB was carried out for therapeutic purposes, it was defined as "useful" if the acute problem that demanded FOB in the first place was resolved by this means. A positive BAL culture that determined a change in antimicrobial therapy was defined as useful in cases of pneumonia. In cases of airway exploration, positive findings were those that determined a change or a continuance of an installed treatment and were defined as useful. In cases of percutaneous tracheostomy, adequate visualization, and control of the airway that led to a satisfactory conclusion of the procedure were defined as useful.

Table 1: Demographic characteristics and diagnosis of included patients.

	$n = 84$
Age, years ± SD	48.6 ± 17
M/F (%)	57/45 (44/56)
SAPS 3 ± SD	54 ± 13
Primary diagnosis at RICU admission, no. (%)	
Respiratory failure: pneumonia	38 (45)
Respiratory failure: others*	15 (18)
Neurologic/neuromuscular impairment	10 (12)
Septic shock	9 (11)
Cardiac failure	7 (8)
Hemorrhagic shock	2 (2.3)
Hemoptysis	2 (2.3)
Acute renal failure	1 (1.2)

SD: standard deviation; M/F: male/female; SAPS: simplified acute physiology score; RICU: respiratory intensive care unit.
*Includes obstructive upper airway disease and hypercapnic respiratory failure.

2.6. Statistical Analysis. Data were processed using SPSS v.17 (SPSS Inc., Chicago, IL, USA). Quantitative data are expressed as mean ± SD, whereas qualitative data are expressed as numbers and percentages (%). Student's *t*-test was used to test significance of difference for normally distributed quantitative variables.

2.7. Institutional Review Board Approval. The Institutional Review Board of the *Hospital General de México O.D.* waived the need of ethical approval for this study and informed consent for inclusion. Patients or their families signed informed consent at hospital or ICU admission allowing for diagnostic or interventional procedures if required, including bronchoscopy. Patient confidentiality was maintained.

3. Results

From March 2010 to June 2012, 580 patients were admitted to the RICU. A total of 102 FOBs were performed in 84 patients (see Table 1 for demographic characteristics). Forty-eight percent of the procedures were done for diagnostic purposes and 52% for therapeutic purposes. Indications for FOB and FOB characteristics are described in Table 2. Ninety-eight percent of bronchoscopies took place in the RICU, whereas 2% were performed in the operating room due to the necessity of video documentation in one case of tracheal stenosis and one case of vocal cord paralysis. An intensivist performed 95% of the procedures, while thoracic endoscopy fellows performed 3%, and a pulmonologist performed 2% of FOBs. Reasons for requesting the intervention of an experienced pulmonologist with advanced FOB-training were not present during the study period.

Mean orotracheal tube/tracheostomy cannula internal diameter on intubated patients was 8.1 ± 0.3 mm (range: 7.0–9.0 mm). In three patients with 7.5 mm orotracheal tubes in

Table 2: Characteristics of 102 bronchoscopies performed in 84 patients of the RICU.

	No. (%)
Indications for FOB	
Pneumonia	31 (30)
Percutaneous tracheostomy guidance	26 (25)
Atelectasis	25 (25)
Airway exploration	16 (16)
Hemoptysis	2 (2)
Difficult airway intubation	2 (2)
Number of FOBs performed per patient	
One	70 (83)
Two	11 (13)
Three	2 (2.4)
Four	1 (1.2)
Type of ventilatory assistance during FOB	
Invasive mechanical ventilation	83 (81)
No assistance	18 (18)
Noninvasive mechanical ventilation	1 (1)
Route for FOB	
Orotracheal tube	73 (71)
Nose	15 (15)
Tracheostomy cannula	11 (11)
Mouth	3 (3)
Operator	
Intensivist	97 (95)
Thoracic endoscopy fellow	3 (3)
Pulmonologist	2 (2)

RICU: respiratory intensive care unit; FOB: fiberoptic bronchoscopy.

Table 3: Pathogens isolated in 30 positive cultures of samples obtained by FOB in the RICU.

	No. (% of all isolates)*
Acinetobacter baumannii	15 (35)
Pseudomonas aeruginosa	7 (16)
Klebsiella pneumoniae	5 (12)
Escherichia coli	5 (12)
MRSA	3 (7)
MRCoNS	3 (7)
Enterococcus faecalis	1 (2)
Burkholderia cepacia	1 (2)
Other	
Candida sp.	2 (5)
Ziehl-Neelsen stain positive for mycobacteria	1 (2)

FOB: fiberoptic bronchoscopy; RICU: respiratory intensive care unit; MRSA: methicillin-resistant *Staphylococcus aureus*; MRCoNS: methicillin resistant coagulase-negative staphylococcus.
*Two pathogens were isolated in 13 cultures.

whom adequate ventilation was not achieved during FOB, these were replaced by 8.0 mm internal diameter orotracheal tubes. Controlled ventilation modes were used during FOB in mechanically ventilated patients: pressure control in 47 (57%) patients and volume control in 36 (43%) patients, with mean positive end expiratory pressure of 7.4 ± 3.5. Sedative agents were used alone or in combination as follows: propofol in 66% of cases, midazolam in 32% of cases and fentanyl in 16% of cases. Muscle paralysis with vecuronium bromide was used in 14% of mechanically ventilated patients during FOB. Local anesthesia with 2% lidocaine was also used in patients in whom FOB was performed by oral or nasal route.

FOB was useful 65% of times when required for diagnostic purposes and 83% of times when there was a therapeutic indication, with an overall utility of 75%. Utility according to indication was 52% for pneumonia when positive BAL cultures determined a change in antimicrobials (microbiologic isolation was made in 68% of cases) (Table 3), 100% for percutaneous tracheostomies, 76% for resolution of atelectasis, 75% positive findings for airway exploration (Table 4), 100% in identifying the source of hemoptysis, and 100% success in cases of difficult airway intubation. Also, in 11 cases with a therapeutic indication, bronchial lavage was performed, resulting in nine positive cultures and determining a change in antimicrobials in six cases. In the two cases of hemoptysis, an intervention was performed at the same time with Fogarty catheter bronchial occlusion in one and selective intubation of the left main bronchi in the other. Both interventions served as a bridge to definitive treatment with artery embolization and lobectomy, respectively. Unexpected findings were vocal cord granuloma and tracheal bronchi in two patients with atelectasis.

In five procedures in patients without assisted ventilation and who had significant weakness and underwent FOB because of atelectasis, noninvasive ventilation was started in four and connection to a mechanical ventilator with pressure support ventilation was done in one tracheostomized patient just after FOB to prevent fatigue. None required noninvasive ventilation or pressure support ventilation for >4 h. Of the 18 patients without invasive ventilation at the time of FOB, none had to be intubated within 24 h after the procedure. A decrease in SpO_2 of >5% during FOB was common and present in 65% of the procedures. Mean pulse-oximeter oxygen saturation (SpO_2) before FOB (patients were ventilated with 1.0 fraction of inspired oxygen) was 95 ± 5.3%. During the procedure, the mean lowest SpO_2 was 86.8 ± 8.4% ($P < 0.0001$) and the mean postprocedural SpO_2 was 94.8 ± 4.5% ($P = 0.81$). SpO_2 values of <90% were observed in 31% of cases during FOB, with 14% of cases having pre-FOB SpO_2 values of ≤90%. Minor complications other than SpO_2 drop were present in 3.9% of cases including one case with transient bigeminism that resolved spontaneously five minutes later, two cases with hypertension and tachycardia that resolved within one hour after FOB, and one case with hypotension that required initiation of vasopressor therapy, which was discontinued three hours later. Two patients in whom percutaneous tracheostomy was performed had moderate bleeding at the surgical site. These patients did not require blood transfusion or surgical hemostasis and

Table 4: Cases in which airway exploration was the indication for FOB.

Indication or suspicion	Findings	Management
Upper airway obstruction, non intubated	Laryngotracheitis*	Conservative plus steroids
Postintubation tracheal stenosis	Bilateral vocal cord paralysis	Tracheostomy
IOP before withdrawn of tracheal stent	Adequate tracheal lumen	CIT
IOP after tracheoplasty	Adequate tracheal lumen and cicatrization	CIT
IOP after dilatation of tracheal stenosis	Adequate tracheal lumen	CIT
IOP after dilatation of tracheal stenosis	Adequate tracheal lumen	CIT
IOP after dilatation of tracheal stenosis	Adequate tracheal lumen	CIT
IOP airway obstruction, intubated	Adequate airway patency*	NC
IOP airway obstruction, intubated	Organized clot occluding OTT*	Change of cannula
IOP airway obstruction, intubated	Clots and mucus plugs occluding OTT and trachea*	Change of cannula and lavage
IOP airway obstruction, tracheostomized	Adequate airway patency*	NC
IOP airway obstruction, tracheostomized	Tracheostomy cannula displacement	Correct placement of cannula
Infected tracheostomy, tracheal damage	Complex tracheal cartilage loss	Change to large tracheostomy cannula
Postextubation laryngeal stridor	Normal larynx and trachea*	NC
Postlobectomy bronchial fistula	No findings suggestive of fistula	NC
Metastasis of esophageal cancer	Positive biopsy on histopathology*	CIT

FOB: fiberoptic bronchoscopy; IOP: inspection of airway patency; CIT: continuance with the installed treatment; NC: no change in treatment; OTT: orotracheal tube.
*Cases in which complete bronchial exploration was performed.

bleeding was not attributed to FOB. There were no major complications related to FOB.

4. Discussion

Guidance for percutaneous tracheostomy is a relatively new indication for FOB in the ICU, which was first introduced in the mid-1980s [13]. Other indications have not changed during the last four decades [5, 6, 14–17]. This series demonstrates a high level of utility of FOB, and complications, when present, were minor.

Although diagnosis of VAP and treatment of atelectasis are the most common indications for bronchoscopy in the ICU, there are others such as hemoptysis, difficult airway intubation, and inhalational airway injury assessment that require a timely procedure [18–20]. VAP diagnosis requires BAL or protected brush sampling, techniques that imply some proficiency to obtain the highest sensitivity and specificity [21]. Evidence supporting superiority of these techniques over other less invasive sampling techniques is currently lacking [22]; however, its usage in our institution is based upon recommendations on equipment availability and personnel expertise [23].

Mucus plug aspiration is still controversial if there is no contraindication for aggressive physiotherapy when resolution of atelectasis is desired. Most evidence regarding atelectasis treatment relies on uncontrolled, nonrandomized trials or observational studies [24]. Only two randomized trials, one of them including postlobectomy patients only, had compared FOB versus chest physiotherapy [25, 26]. Due to the conflicting evidence FOB is generally reserved for certain circumstances regarding atelectasis. In our RICU, FOB is performed when aggressive physiotherapy fails in improving lung aeration or if there is a contraindication for this type of therapy.

Exploration of the airway in ICU patients commonly involves diagnosis of upper or lower airway obstruction or lesions derived from intubation [6, 14]. Not uncommon, correct artificial airway placement and patency are also indications for FOB examination [13, 16, 27, 28]. In this series, suspicion of malignancy was an indication for FOB in only one case where endobronchial biopsies were positive for metastases of esophageal cancer. This patient eventually died. FOB diagnosis of bronchogenic cancer remains an infrequent indication in the ICU, as there are other diseases that could produce endobronchial disease [6, 13, 16]. Airway explorations before advanced airway procedures, including surgery, were also present in this study. We consider this due to the type of patients admitted to our respiratory ICU. Recently, another RICU reported on similar indications for airway exploration [28].

Rigid bronchoscopy may be preferred in cases of massive hemoptysis for control of hemorrhage, but FOB allows for rapid identification of the source of bleeding and, as seen in the two cases presented, can serve as a bridge for definitive treatment with interventions such as selective Fogarty catheter bronchial occlusion, instillation of cold saline, epinephrine or fibrin precursors, and selective intubation [4, 29, 30].

A FOB-trained intensivist performed the vast majority of procedures over the study interval. A pulmonologist with advanced training was available for FOB as needed, but his services were not required; the dominant indications for FOB in the RICU were "basic" procedures, which required

competence but not advanced training. The high efficacy and low complication rates substantiate the concept that a well-trained intensivist can perform most of the FOB needed in the process of ICU care.

Reports of overall utility of FOB in the ICU range from 38% to 71% [6, 13, 27, 31]. Overall utility in this paper was 75%, higher than that reported in previous series. This probably results from the addition of FOB for percutaneous tracheostomy and the definition of its utility. Some authors would argue that FOB is not mandatory for percutaneous tracheostomy [32, 33]. We would disagree. FOB guidance for percutaneous tracheostomy increases the safety margin of the procedure and allows tracheal examination and confirmation of correct tracheostomy placement [34–36]. We considered FOB useful in these cases only if adequate visualization and airway control were achieved during the entire process. FOB following extubation or tracheostomy withdrawal in the ICU might also be useful in patients who had prolonged intubation or those at high risk of airway narrowing in search for sequels [37–39].

Patients in ICU are considered at high risk from complications when undergoing FOB [8]. They are often unstable and have failure of one or more organs. This could raise concern for the safety of FOB [4, 40]. Bronchoscopy has demonstrated to be a safe procedure with a low rate of complications, even in training programs [41, 42]. In ICU scenarios, major complications are present in 0.15%, and minor complications could arise in 6.5% of cases [18]. The most common event is a drop in SpO_2 mainly due to determinants that reduce tidal volumes [4, 30]. In this series, a drop in SpO_2 >5% was observed in 65% of patients during FOB, with post-FOB SpO_2 values not significantly different from pre-FOB values. In a study by Lindholm et al. [40], it was observed that gas exchange abnormalities slowly return to baseline after FOB and that PaO_2 values could decrease by about 40% if suctioning is applied during FOB. Krell [43] described that critically ill patients could experience a PaO_2 drop greater than the average 20 mm Hg observed in healthy subjects, with decreases of 30 to 60 mm Hg during FOB, and that hypoxemia may persist for several hours after the procedure. Desaturation defined as SpO_2 <90% in a study by Turner et al. [6] was present in 20% of patients who underwent FOB in the ICU. In our series, although a decrease of >5% was present in 65%, a SpO_2 <90% during FOB was observed in 31% of cases, with 14% of cases having pre-FOB values ≤90%. Dunagan et al. [44], and more recently Estella [27], described an incidence of desaturation during FOB of 13% and 6.7%, respectively.

There were no major complications related to FOB, and the incidence of minor complications did not differ from those of other studies [6, 44]. As we found in this paper, other series describe FOB in the ICU as feasible and safe, even in the presence of mechanical ventilation [5, 6, 28, 44] or when performed by intensivists [27].

A number of limitations in this study deserve to be mentioned. This is a descriptive study on the results of only one center. Indication for FOB was made by a consensus of the ICU team and not following a protocol, with the exception of VAP suspicion. Definitions of utility made by the authors were arbitrary, and, although the sample size is not negligible, small populations result when cases are viewed separately according to indications.

In conclusion, percutaneous tracheostomy is a relatively new indication for FOB in the ICU while other indications have changed little since the introduction of FOB into clinical practice. Our results demonstrate that FOB in the ICU remains a valuable and effective tool with a relatively minor complication profile. Our study has also demonstrated that an intensivist trained in FOB can effectively perform the majority of FOB needed in the process of the care of ICU patients.

Conflict of Interests

The authors deny any conflict of interests related to the preparation of this paper.

Acknowledgments

The authors thank all members of *ARUAL Medicina de Reanimación S.C.*, and Dr. Guillermo Cueto, and Dr. Abel Pérez for they collaboration.

References

[1] S. Ikeda, N. Yanai, and S. Ishikawa, "Flexible bronchofiberscope," *Keio Journal of Medicine*, vol. 17, no. 1, pp. 1–16, 1968.

[2] G. A. Silvestri, D. Feller-Kopman, A. Chen, M. Wahidi, K. Yasufuku, and A. Ernst, "Latest advances in advanced diagnostic and therapeutic pulmonary procedures," *Chest*, vol. 142, no. 6, pp. 1636–1644, 2012.

[3] A. C. Mehta, "'. . .In pursuit of excellence in bronchoscopy': The president's reflections on the 17th World Congress for Bronchology and Interventional Pulmonology," *Journal of Bronchology and Interventional Pulmonology*, vol. 19, no. 4, pp. 268–270, 2012.

[4] E. G. da Cunha Fragoso and J. M. R. Gonçalves, "Role of fiberoptic bronchoscopy in intensive care unit current practice," *Journal of Bronchology and Interventional Pulmonology*, vol. 18, no. 1, pp. 69–83, 2011.

[5] C. O. Olopade and U. B. S. Prakash, "Bronchoscopy in the critical-care unit," *Mayo Clinic Proceedings*, vol. 64, no. 10, pp. 1255–1263, 1989.

[6] J. S. Turner, P. A. Willcox, M. D. Hayhurst, and P. D. Potgieter, "Fiberoptic bronchoscopy in the intensive care unit—a prospective study of 147 procedures in 107 patients," *Critical Care Medicine*, vol. 22, no. 2, pp. 259–264, 1994.

[7] C. E. Lindholm, B. Ollman, J. Snyder, E. Millen, and A. Grenvik, "Flexible fiberoptic bronchoscopy in critical care medicine. Diagnosis, therapy and complications," *Critical Care Medicine*, vol. 2, no. 5, pp. 250–261, 1974.

[8] British Thoracic Society Bronchoscopy Guidelines Committee, a Subcommittee of the Standards of Care Committee of the British Thoracic Society, "British Thoracic Society guidelines on diagnostic flexible bronchoscopy," *Thorax*, vol. 56, supplement 1, pp. i1–i21, 2001.

[9] P. Álvarez-Maldonado, G. Cueto-Robledo, U. Cerón-Díaz, A. Pérez-Rosales, F. Navarro-Reynoso, and R. Cicero-Sabido, "Quality indicators in a respiratory intensive care unit. Initial

analysis of the DEDUCIR database," *Medicina Intensiva*, vol. 36, no. 7, pp. 518–520, 2012.

[10] U. B. S. Prakash, *Bronchoscopy*, Raven Press, New York, NY, USA, 1994.

[11] M. Noppen, "Percutaneous dilatational tracheostomy," in *Interventional Bronchoscopy*, C. T. Bolliger and P. N. Mathur, Eds., Progress in Respiratory Research Series, pp. 215–225, Karger, Basel, Switzerland, 2000.

[12] J. S. Garner, W. R. Jarvis, T. G. Emori, T. C. Horan, and J. M. Hughes, "CDC defionitions for nosocomial infections, 1988," *The American Journal of Infection Control*, vol. 16, no. 3, pp. 128–140, 1988.

[13] J. F. Bearnis, I. Vernovsky, and J. Jacobson, "Flexible bronchoscopy in the critical care unit," *Chest*, vol. 118, article 77S, 2000.

[14] D. M. Kovnat and G. S. Rath, "Fiberoptic bronchoscopy in respiratory failure," *Critical Care Medicine*, vol. 1, no. 5, pp. 274–276, 1973.

[15] J. S. Milledge, "Therapeutic fibreoptic bronchoscopy in intensive care," *The British Medical Journal*, vol. 2, no. 6049, pp. 1427–1429, 1976.

[16] C. R. Barrett, "Flexible fiberoptic bronchoscopy in the critically ill patients. Methodology and indications," *Chest*, vol. 73, no. 5, pp. 746–749, 1978.

[17] D. Y. H. Tai, "Bronchoscopy in the intensive care unit (ICU)," *Annals of the Academy of Medicine Singapore*, vol. 27, no. 4, pp. 552–559, 1998.

[18] S. Raoof, S. Mehrishi, and U. B. Prakash, "Role of bronchoscopy in modern medical intensive care unit," *Clinics in Chest Medicine*, vol. 22, no. 2, pp. 241–261, 2001.

[19] R. P. Dellinger, "Fiberoptic bronchoscopy in adult airway management," *Critical Care Medicine*, vol. 18, no. 8, pp. 882–887, 1990.

[20] J. M. Albright, C. S. Davis, M. D. Bird et al., "The acute pulmonary inflammatory response to the graded severity of smoke inhalation injury," *Critical Care Medicine*, vol. 40, no. 4, pp. 1113–1121, 2012.

[21] G. U. Meduri and J. Chastre, "The standardization of bronchoscopic techniques for ventilator-associated pneumonia," *Chest*, vol. 102, no. 5, supplement 1, pp. 557S–564S, 1992.

[22] The Canadian Critical Care Trials Group, "A randomized trial of diagnostic techniques for ventilator-associated pneumonia," *The New England Journal of Medicine*, vol. 355, pp. 2619–2630, 2006.

[23] F. A. Lerma, A. T. Martí, F. R. de Castro et al., "Recommendations for diagnosing ventilator-associated pneumonia," *Archivos de Bronconeumología*, vol. 37, no. 8, pp. 325–334, 2001.

[24] A. Surka, M. R. Bowling, R. Chin, E. Haponik, and J. Conforti, "Bronchoscopic myths and legends: bronchoscopy in the treatment of lobar atelectasis," *Clinical Pulmonary Medicine*, vol. 14, no. 5, pp. 302–305, 2007.

[25] J. J. Marini, D. J. Pierson, and L. D. Hudson, "Acute lobar atelectasis: a prospective comparison of fiberoptic bronchoscopy and respiratory therapy," *The American Review of Respiratory Disease*, vol. 119, no. 6, pp. 971–978, 1979.

[26] A. Jaworski, S. K. Goldberg, M. D. Walkenstein, B. Wilson, and M. L. Lippmann, "Utility of immediate postlobectomy fiberoptic bronchoscopy in preventing atelectasis," *Chest*, vol. 94, no. 1, pp. 38–43, 1988.

[27] A. Estella, "Analysis of 208 flexible bronchoscopies performed in an intensive care unit," *Medicina Intensiva*, vol. 36, no. 6, pp. 396–401, 2012.

[28] C. M. Lucena, P. Martínez-Olondris, J. R. Badia et al., "Fiberoptic bronchoscopy in a respiratory intensive care unit," *Medicina Intensiva*, vol. 36, no. 6, pp. 389–395, 2012.

[29] L. Sakr and H. Dutau, "Massive hemoptysis: an update on the role of bronchoscopy in diagnosis and management," *Respiration*, vol. 80, no. 1, pp. 38–58, 2010.

[30] P. Lee, A. C. Mehta, and P. N. Mathur, "Management of complications from diagnostic and interventional bronchoscopy," *Respirology*, vol. 14, no. 7, pp. 940–953, 2009.

[31] D. B. Patel and Z. F. Udwadia, "Role of bronchoscopy in an Indian critical care unit an experience of 118 procedures," *Thorax*, vol. 52, no. 6, article A65, 1997.

[32] L. S. Jackson, J. W. Davis, K. L. Kaups et al., "Percutaneous tracheostomy: to bronch or not to bronch—that is the question," *Journal of Trauma-Injury Infection & Critical Care*, vol. 71, no. 6, pp. 1553–1556, 2011.

[33] M. Klein, R. Agassi, A. R. Shapira, D. M. Kaplan, L. Koiffman, and N. Weksler, "Can intensive care physicians safely perform percutaneous dilational tracheostomy? An analysis of 207 cases," *Israel Medical Association Journal*, vol. 9, no. 10, pp. 717–719, 2007.

[34] R. Hinerman, F. Alvarez, and C. A. Keller, "Outcome of bedside percutaneous tracheostomy with bronchoscopic guidance," *Intensive Care Medicine*, vol. 26, no. 12, pp. 1850–1856, 2000.

[35] F. Beltrame, M. Zussino, B. Martinez et al., "Percutaneous versus surgical bedside tracheostomy in the intensive care unit: a cohort study," *Minerva Anestesiologica*, vol. 74, no. 10, pp. 529–535, 2008.

[36] P. Alvarez-Maldonado, E. Vidal, and U. Ceron-Diaz, "Thacheal ulcers due to endotracheal tube cuff pressure," *Journal of Bronchology and Interventional Pulmonology*, vol. 18, no. 3, pp. 288–289, 2011.

[37] N. K. Panda, S. B. Mann, B. A. Raja, Y. K. Batra, and S. K. Jindal, "Fibreoptic assessment of post intubation laryngotracheal injuries," *The Indian Journal of Chest Diseases & Allied Sciences*, vol. 38, no. 4, pp. 241–247, 1996.

[38] R. Thomas, E. V. Kumar, M. Kameswaran et al., "Post intubation laryngeal sequelae in an intensive care unit," *Journal of Laryngology and Otology*, vol. 109, no. 4, pp. 313–316, 1995.

[39] P. Lee and K. L. Khoo, "A review of current bronchoscopic interventions for obstructive airway diseases," *Therapeutic Advances in Respiratory Disease*, vol. 6, no. 5, pp. 297–307, 2012.

[40] C. E. Lindholm, B. Ollman, J. V. Snyder, E. G. Millen, and A. Grenvik, "Cardiorespiratory effects of flexible fiberoptic bronchoscopy in critically ill patients," *Chest*, vol. 74, no. 4, pp. 362–368, 1978.

[41] M. A. Reinoso, A. Lechin, J. Varon, and L. Wade, "Complications from flexible bronchoscopy in a training program," *Journal of Bronchology*, vol. 3, no. 3, pp. 177–181, 1996.

[42] C. A. Pue and E. R. Pacht, "Complications of fiberoptic bronchoscopy at a university hospital," *Chest*, vol. 107, no. 2, pp. 430–432, 1995.

[43] W. S. Krell, "Pulmonary diagnostic procedures in the critically ill," *Critical Care Clinics*, vol. 4, no. 2, pp. 393–407, 1988.

[44] D. P. Dunagan, H. L. Burke, S. L. Aquino, R. Chin Jr., N. E. Adair, and E. F. Haponik, "Fiberoptic bronchoscopy in coronary care unit patients: indications, safety, and clinical implications," *Chest*, vol. 114, no. 6, pp. 1660–1667, 1998.