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OPIS PRZYPADKU
CASE REPORT

Fiberoptic bronchoscopy supported with HFNC/NIV as promising management in patients with high risk of respiratory failure

Bronchofiberoskopia wspomagana HFNC/NIV jako skuteczna metoda postępowania u pacjentów z wysokim ryzykiem niewydolności oddychania

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ABSTRACT

INTRODUCTION: Fiberoptic bronchoscopy (FOB) is a minimally invasive procedure which improves diagnostics and therapeutic management in patients with lung-related conditions. Although it is a generally well-tolerated intervention and there are only few contraindications for FOB, it has to be acknowledged that it causes acute narrowing of the airways and patients with inadequate oxygenation and respiratory acidosis may be disqualified from bronchoscopy due to an increased risk of respiratory failure (RF) development. Noninvasive techniques such as a high-flow nasal cannula (HFNC) and non-invasive ventilation (NIV) are accepted methods of respiratory support in patients with RF, however, their usage in patients undergoing FOB is still poorly represented in the literature.

PRESENTATION OF CASES: Five patients requiring different bronchoscopy procedures were included in this retrospective case series. Two of them suffered from airway obstruction caused by laryngeal tumors, one from foreign body aspiration complicated with recurrent pneumonia, one from ventilator-associated pneumonia and one from RF in the course of ischemic stroke. FOB was safely performed in every patient despite the presence of relative contraindications in each case. Due to respiratory distress, FOB was supported with HFNC or NIV based on the patient's overall condition and pathomechanism of RF. The parameters of HFNC and NIV were set according to ongoing randomized controlled trials.

CONCLUSIONS: Active oxygen therapies, like HFNC and NIV, are promising methods of management in patients with a high risk of RF during FOB.

KEYWORDS

fiberoptic bronchoscopy, non-invasive ventilation, high-flow nasal cannula, airways diagnostics, respiratory failure

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STRESZCZENIE

WPROWADZENIE: Bronchofiberoskopia (*fiberoptic bronchoscopy* – FOB) to małoinwazyjna procedura medyczna, powszechnie używana w diagnostyce i leczeniu chorób układu oddechowego. Zabieg jest na ogół dobrze tolerowany i istnieje niewiele przeciwwskazań do jego stosowania. Podczas FOB wprowadzany bronchofiberoskop powoduje ostre zwężenie dróg oddechowych, mogące skutkować rozwinięciem się lub zaostrzeniem niewydolności oddychania (*respiratory failure* – RF). Z tego powodu pacjenci z RF mogą zostać zdyskwalifikowani z zabiegu bronchoskopowego. Nieinwazyjne techniki wspomagania oddechu, takie jak donosowa terapia wysokoprzepływowa (*high-flow nasal cannula* – HFNC) oraz maska do wentylacji nieinwazyjnej (*non-invasive ventilation* – NIV), są cenionymi metodami wsparcia układu oddechowego u pacjentów z RF, jednak możliwości ich wykorzystania u pacjentów poddawanych FOB są wciąż niejasne.

OPIS PRZYPADKÓW: W opracowaniu opisano przypadki pięciu pacjentów poddanych bronchoskopii z różnych wskazań. W dwóch przypadkach rozpoznano guza krtani, w jednym obecność ciała obcego powikłanego nawracającymi zapaleniami płuc, u jednej pacjentki zapalenie płuc związane z przedłużoną intubacją, a w ostatnim przypadku RF po udarze niedokrwiennym mózgu. W każdym przypadku podczas FOB zastosowano wsparcie oddychania w postaci HFNC lub NIV z powodu wysokiego ryzyka rozwoju lub zaostrzenia RF. Parametry HFNC i NIV ustawiono zgodnie z założeniami dwóch trwających obecnie badań randomizowanych.

WNIOSKI: Metody wsparcia oddechowego, takie jak HFNC oraz NIV, są obiecującymi metodami u pacjentów z wysokim ryzykiem rozwinięcia się RF podczas FOB.

SŁOWA KLUCZOWE

bronchofiberoskopia, wentylacja nieinwazyjna, terapia wysokoprzepływowa, diagnostyka dróg oddechowych, niewydolność oddychania

INTRODUCTION

Fiberoptic bronchoscopy (FOB) is a procedure in which a flexible endoscope is inserted into the bronchial tree. It is commonly performed in pneumonology departments and intensive care units (ICU) as an effective tool both for diagnostic and therapeutic purposes. It allows bronchogenic carcinoma to be diagnosed but also neck malignancies, biopsy samples to be taken by using endobronchial ultrasound with transbronchial needle aspiration (EBUS-TBNA), bacteriological samples in unresolved pneumonia, and bronchoalveolar lavage (BAL) salvage to be obtained in patients with interstitial diseases. FOB is also used in foreign body removal, dyspnea and persistent cough assessment, providing visualization and airway clearance. There are only a few absolute contraindications for FOB. Beside malignant arrhythmias and bleeding diathesis (if a biopsy is anticipated), the most important remain inadequate oxygenation in patients with hypoxemia and/or respiratory acidosis.

Although it is a minimally invasive procedure, it has to be acknowledged that it causes acute narrowing of the airways, which can be followed by respiratory failure (RF), especially in predisposed patients [1]. A high-flow nasal cannula (HFNC) and a non-invasive ventilation (NIV) mask are considered to be effective noninvasive methods of respiratory support in patients with RF; however, precise data including indications, contraindications and settings are still scarce and poorly represented in the literature [2,3,4,5]. The usage of these methods is increasingly more accepted in patients with a high risk of developing respiratory complications during medical procedures, in which the supplementation of oxygen via a standard nasal cannula does not provide a proper oxygenation status [6].

According to the guidelines, FOB can be performed under moderate sedation with midazolam and fentanyl in addition to topical analgesia with lignocaine in an outpatient setting or at the bedside. It demands continuous assessment of saturation, arterial blood pressure, heart rate and electrocardiogram monitoring [7].

The aim of the article is to outline the possible management and device settings of HFNC/NIV in patients with a high risk of RF, in which the usage of active oxygen therapy enabled effective FOB for diagnostics and treatment.

PRESENTATION OF CASES

Case 1

A 63-year-old cachectic woman (BMI 17.3 kg/m^2) in an overall bad condition, with many comorbidities and 40 years of smoking a pack of cigarettes a day was referred to the Pulmonology Department from the Emergency Department (ED). The chest X-ray performed in the ED revealed oval opacification in the central field of the left lung (dimensions 25 × 19 mm). Further diagnostics consisted of spirometry, in which the patient presented a very severe obstruction (FEV1%/FVC (ex) = 63%, FEV1 (%/N) = 19), and blood gas analysis revealed hypoxemia (pO_2 52.1 mmHg). In order to assess the airways and obtain biopsy material, FOB was performed. Given the possibility of the patient developing respiratory distress, ventilatory support was initiated with an

HFNC (Table I). When the procedure began, a tough neoplastic laryngeal tumor was visualized. It covered the glottal area causing almost complete constriction of the larynx on inspiration (the lumen of the larynx was approximately 2 mm). Considering the high risk of respiratory failure or exacerbation during transport to the Otorhinolaryngology ward in another medical center, it was decided to perform debulking of the tumor in order to preserve airway patency (Figure 1). After that, a computed tomography (CT) scan revealed massive infiltration of the cervical lymph nodes and the result of the biopsy was nonkeratinizing squamous cell carcinoma stage G2. As the patient's state was 4 on the ECOG scale, she was disqualified from further specific oncological therapy.

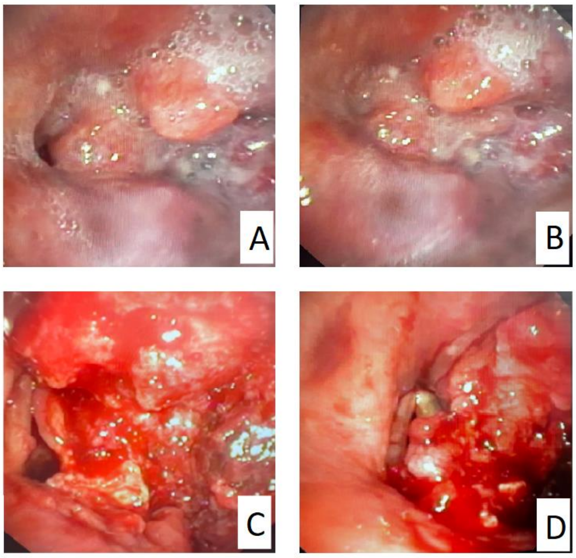

Fig. 1. Images from fiberoptic bronchoscopy examination and debulking of neoplastic laryngeal tumor: A – larynx on inspiration; B – larynx on expiration; C – after partial removal of tumor; D – condition after debulking.

Case 2

A 38-year-old obese man (BMI 38 kg/m^2), who smoked a pack of cigarettes a day for 20 years, was admitted in order to diagnose the cause of dyspnea. During the physical examination he presented laryngeal stridor, hoarseness and diminished vesicular lung sound. The patient was after surgical excision of a lesion on the vocal cords. In body plethysmography, pulmonary distension was observed. Moreover, the diffusion lung capacity for carbon monoxide (DLCO) was decreased to 69%. In a six-minute walk test the patient went a distance of 580 m with desaturation up to 89% (normal value ε 524 m). Finally, in the spirometry examination he presented an irreversible obstruction (FEV1%/FVC (ex) = 63%, FEV1 (%/N) = 52 after salbutamol) and a diagnosis of chronic obstructive pulmonary disease (COPD) was made. It was followed by chest CT, which revealed atelectasis areas in the anterior parts of both lungs and ground-glass opacification in the lower lobes of both lungs. It was decided to perform FOB and considering his obesity, the procedure was carried out under NIV protection (Table I). When the tumor of the right vocal cord was found, bronchoscopy forceps were used to obtain biopsy material (Figure 2). The patient was eventually diagnosed with laryngeal keratinizing papilloma with mild dysplasia.

Fig. 2. Image of patient's larynx with tumor on right vocal cord revealed during fiberoptic bronchoscopy.

Table I. Method and parameters of respiratory support during fiberoptic bronchoscopy and results of arterial blood gas tests before and after procedure in described patients. Settings of high-flow nasal cannula and non-invasive ventilation according to ongoing randomized controlled trials [1,2]

Patient	Method of respiratory support	Parameters of HFNC/NIV during FOB	Arterial blood gas		
			Parameter	Before FOB	After FOB
1	*2*	*3*	*4*	*5*	*6*
Patient 1	HFNC	Temperature: 34°C Flow: 70 L/min FiO_2: 60%	pH pCO_2 [mmHg] pO_2 [mmHg] HCO_3^- [mmol/L] SpO_2 [%]	7.46 41 52 28 93	7.31 51 204 25 99

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1	2	3	4	5	6
Patient 2	NIV	EPAP: 14 cm H_2O IPAP: 30 cm H_2O Tins: 0.8–1 s BPM: 16–18/min Rise time: 100 ms FiO_2: 28–66%	pH pCO_2 [mmHg] pO_2 [mmHg] HCO_3^- [mmol/L] SpO_2 [%]	7.41 44 62 36 92	7.39 47 65 36 93
Patient 3	HFNC	Temperature: 34°C Flow: 60 L/min FiO_2 adjusted to obtain an SpO_2 of 90–92%	pH pCO_2 [mmHg] pO_2 [mmHg] HCO_3^- [mmol/L] SpO_2 [%]	7.42 58 58 37 89	7.42 64 63 38 90
Patient 4	NIV	EPAP: 14 cm H_2O IPAP: 30 cm H_2O Tins: 0.9–1.1 s BPM: 20–21/min Rise time: 100 ms FiO_2: 28–66%	pH pCO_2 [mmHg] pO_2 [mmHg] HCO_3^- [mmol/L] SpO_2 [%]	7.37 69 61 40 90	7.32 72 62 36 89
Patient 5	HFNC → NIV	HFNC settings: Temperature: 34°C Flow: 60 L/min FiO_2 adjusted to obtain an SpO_2 of 90–92% NIV settings: EPAP: 14 cm H_2O IPAP: 30 cm H_2O Tins: 0.8–1 s BPM: 16–18/min Rise time: 100 ms FiO_2: 65%	pH pCO_2 [mmHg] pO_2 [mmHg] HCO_3^- [mmol/L] SpO_2 [%]	7.40 44.3 40.2 27 75.2	7.38 60 42 28 88

HFNC – high-flow nasal cannula; NIV – non-invasive ventilation; FOB – fiberoptic bronchoscopy; FiO_2 – fraction of inspired oxygen; EPAP – expiratory positive airway pressure; IPAP – inspiratory positive airway pressure; Tins – time of inspiration; BPM – breaths per minute.

Case 3

A 66-year-old male with COPD was admitted to the Department of Internal Medicine from the ED in order to determine the cause of dyspnea (NYHA class IV) and dysphagia. He suffered from right sided pneumonia recurring six times that year. Although he was treated each time with antibiotics, he never made a full recovery, leaving him in need for home oxygen therapy with a 1 L/min passive flow of at least 15 hours a day. A CT scan found a hyperdense structure in the right bronchus intermedius. The next diagnostic step was FOB, which was performed with the support of HFNC because of dyspnea (Table I). During the procedure the structure turned out to be a foreign body, the decision was made to remove it with the bronchofiberoscope (Figure 3). This resulted in improvement in the patient's condition and his release from the hospital in a stable state.

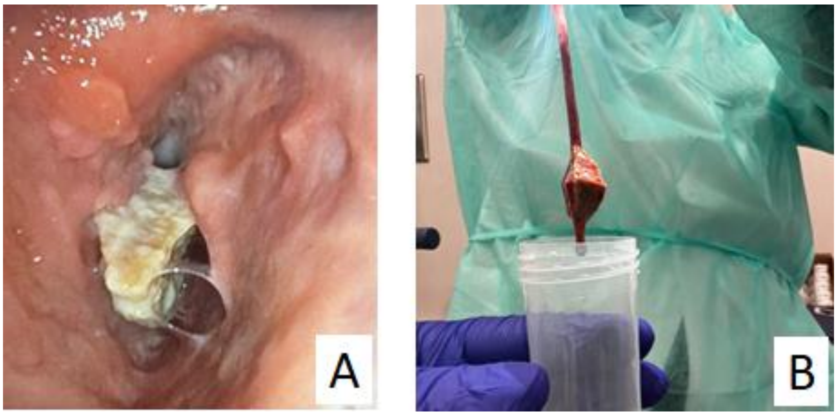

Fig. 3. Fiberoptic bronchoscopy in patient with recurrent pneumonia: A – foreign body in right bronchus intermedius with bronchial mucosa hyperplasia caused by prolonged irritation; B – animal bone after removal from patient's airways.

Case 4

A 72-year-old obese female in an overall bad condition with many comorbidities and 37 years of smoking a pack of cigarettes a day was admitted to the Department of Internal Medicine due to exacerbation of RF. The same night of admission, the patient's condition deteriorated; she was intubated and transferred to the ICU, where she spent 35 days. In the ICU the levels of inflammatory markers gradually rose (CRP: 2nd day – 33.2, 4th day – 146.3 ([0–5 mg/L]); she was treated for ventilator--associated pneumonia (VAP) and she had two pleural drainages due to massive effusion. Oxygen therapy was deescalated and on the 13th day she was extubated and NIV was used as ventilatory support.

Later she was transferred to the Pulmonology Department with NIV support. A blood test on admission still showed an increase in inflammatory markers (WBC 18.97 [4–10.5 × 10^3/μL]). The next diagnostic step was FOB supported with NIV (Table I) due to the patient's respiratory failure. Colonies of *Pseudomonas aeruginosa*, *Proteus* spp. and New Delhi metallo-beta-lactamase 1 (NDM-1) were found in lower bronchial tree samples.

The treatment was targeted antibiotic therapy with colistin *i.v.* and in nebulization.

Case 5

A 72-year-old patient was admitted to the Neurology Department due to speech disturbances and left-sided limb weakness. A CT scan revealed an ischemic stroke in the right hemisphere of the brain. Initially, the patient did not require oxygen therapy, but on the 4th day of hospitalization, his general condition rapidly deteriorated directly after breakfast. Blood tests showed elevated inflammatory markers (CRP 227 [0–5 mg/L], WBC 15.29 [4–10.5 × 10^3/μL]). Due to the suspicion of aspiration pneumonia, FOB was ordered. After calculating the oxygenation index (PaO_2/FiO_2 = 153), it was decided to use HFNC during FOB. Nevertheless, this method turned out to be inefficient because of a low ROX index [(SpO_2/FiO_2) / respiratory rate = 3.40], indicating a high risk of HFNC failure [8]. Therefore, during the procedure, the decision was made to switch respiratory support to NIV (Table I). Despite aggressive NIV settings during the study, the paralyzed and dropped epiglottis lifted only with mandibular luxation was the reason for airway obstruction (Figure 4). Owing to upper airway paralysis observed during FOB, high risk of intubation failure and after anesthesiology consultation, further management included urgent tracheostomy and mechanical ventilation. Broad-spectrum antibiotics were applied.

Fig. 4. Fiberoptic bronchoscopy (FOB) after ischemic stroke: A – FOB with mandibular luxation – larynx view; B – non-invasive ventilation (NIV) parameters during FOB with mandibular luxation; C – FOB with mandibular luxation; D – FOB without mandibular luxation – larynx view; E – NIV parameters during FOB without mandibular luxation; F – FOB without mandibular luxation.

DISCUSSION

Bronchoscopy is a fundamental procedure in lung and airway diseases, nonetheless, the same population has an increased risk of RF, which is the most significant possible complication of FOB because of hypoventilation and increased airway resistance [6]. As shown in our case series in high risk patients, it is not enough to increase the FiO_2 in conventional oxygen therapy (COT), but HFNC or NIV may be required as respiratory support [9]. However, it is still not known in which patient NIV or HFNC should be chosen as both techniques improve respiratory status via generating end-expiratory positive airway pressure (PEEP), recruiting alveoli and decreasing the work of breathing [10,11]. There are meta-analyses which indicate the advantages of HFNC over COT in patients undergoing bronchoscopy [12,13]. HFNC resulted in a lower incidence of hypoxemic events, higher values of minimum SpO_2 and fewer procedural interruptions.

In another narrative review, HFNC was superior to COT during FOB as well as EBUS-TBNA and foreign body removal, but with deeper sedation and increasing hypoxemia, NIV was more frequently required to ensure adequate ventilation [14]. NIV seems to be a better strategy for obese patients who have excess retention of carbon dioxide, decreased oxygenation and a higher prevalence of atelectasis due to increased abdominal pressure, and hence a reduced chest capacity. In those patients, higher PEEP applied with the use of NIV can reduce hypercapnia, limit atelectasis and increase oxygenation [15]. It is even more expressed in the horizontal position of the patient during FOB, when hypoventilation increases and upper airways tend to collapse. A moderate level of PEEP generated by HFNC may be insufficient to counteract the collapse of upper airways, therefore NIV seems to be preferable in patients with obesity [16].

Ventilator-associated pneumonia (VAP) is one of the most frequent ICU-acquired infections. VAP often results in a prolonged duration of mechanical ventilation and ICU stay [17]. FOB can have a therapeutic effect on VAP by allowing an aspirate to be taken from the lower bronchial tree for PCR examination, and thus the administration of targeted antibiotic therapy. The strategy of choice in VAP diagnostics in ICU patients who are already intubated is to perform FOB through an endotracheal tube. Nevertheless, inserting a bronchoscope through the tube causes critical airway stenosis (Figure 5). Increased airway resistance and plateau pressure (auto-PEEP) can lead to potential barotrauma, blood pressure reduction and exacerbation of respiratory distress [18,19]. Moreover, the diagnostics of ICU-related infections often take place in other departments and patients might still need some respiratory support while FOB is performed. Reintubation and mechanical ventilation are conditions difficult to meet outside the ICU and they are connected with a high risk of complications.

Fig. 5. Bronchoscope inserted into laryngeal tube – comparison of diameters shows that critically little space for airflow is left.

Although there are no guidelines for HFNC/NIV usage during FOB in patients with RF, using less invasive methods of ventilation lowers the overall risk of complications [20,21]. On the other hand, it can be assumed that COT would not manage RF in the presented patients, as in each case the values of pCO_2 after FOB increased despite the use of noninvasive techniques (Table I). Currently, there is very limited data concerning HFNC/NIV support during FOB and a lack of indications and contraindications to their usage or the settings of these devices. We have shown that NIV and HFNC may be safely used in patients requiring different bronchoscopy procedures, although each one had certain contraindications to perform FOB. It has to be acknowledged that as in Case 5, all noninvasive respiratory support methods may be found ineffective, hence careful monitoring and future studies are required to describe more precisely which technique and settings should be chosen for a particular patient.

Areas for future research

Taking into account that in all the presented cases the respiratory status worsened (Table I), it should be addressed in the future to determine not only the preferable device, but also its specific settings. To address these problems, two randomized controlled trials (RCTs) dedicated to describe more precisely the indications for, and settings of HFNC or NIV in patients undergoing FOB have been initiated [1,2].

Limitations

It should be noted that due to the retrospective nature of the study, the publication lacks uniformity in the analyzed test results of the presented patients if they had not been performed during hospitalization. In the described non-standard situations, the selection of the appropriate method of respiratory support during FOB relied solely on the individual experience of the examining doctor and was predicated on the patient's clinical condition, rather than guidance-based protocols. All of the studies described above were conducted by only one specialist.

CONCLUSIONS

HFNC/NIV are promising methods of management in patients with a high risk of RF during FOB. Both devices have proven to safely support oxygenation during FOB in patients with RF. Precise indications, contraindications and settings of each device should be assessed in prospective RCTs.

Author's contribution

Study design – S. Gawęda, M. Rycerski, Z. Pawlus, A. Oraczewska, A. Danel, P. Dubik, S. Skoczyński
Data collection – S. Gawęda, M. Rycerski, Z. Pawlus, A. Oraczewska, A. Danel, P. Dubik, S. Skoczyński
Manuscript preparation – S. Gawęda, M. Rycerski, Z. Pawlus, A. Oraczewska, A. Danel, P. Dubik, S. Skoczyński
Literature research – S. Gawęda, M. Rycerski, Z. Pawlus, A. Oraczewska, A. Danel, P. Dubik
Final approval of the version to be published – S. Gawęda, M. Rycerski, Z. Pawlus, A. Oraczewska, A. Danel, P. Dubik, S. Skoczyński

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