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Two different methods of lidocaine inhalation before diagnostic flexible bronchoscopy: effects on post-bronchoscopy respiratory symptoms

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Background/aim: Use of topical anesthesia before flexible bronchoscopy for the evaluation of the upper airways prevents cough and stridor during and after the procedure while reducing the need for sedation. In practice, lidocaine is the medication of choice before bronchoscopy. There various types of nebulizers used for inhalation treatments. In this study, we compared the respiratory tract symptoms after flexible bronchoscopy between children who received pre-procedure topical lidocaine with mesh or jet nebulizers.

Materials and methods: We enrolled 4–18 years old subjects that underwent flexible bronchoscopy due to treatment-resistant asthma in this retrospective case-control study. Twenty subjects received topical lidocaine with jet nebulizers while 20 received it with mesh nebulizers. Age, sex, duration of bronchoscopy, duration of anesthesia, time to awaken, and time to recovery were recorded as well as cough and laryngospasm scores after flexible bronchoscopy.

Results: Severe cough after flexible bronchoscopy was not encountered in the mesh nebulizers group but was seen in 10% of the jet nebulizers group ($p = 0.027$). On the other hand, age, sex, duration of bronchoscopy, duration of anesthesia, time to awaken, and time to recovery were not significantly different between the mesh and jet nebulizer groups ($p = 0.44$, 0.34, 0.51, 0.88, 0.88, and 0.22, respectively). Moreover, croup and laryngospasm scores between the two groups were similar ($p = 0.62$, 0.50 respectively). Cough score was significantly worse jet nebulizers group ($p = 0.03$).

Conclusion: Topical lidocaine application with mesh nebulizers decreases the most common complication, cough, after flexible bronchoscopy in children more effectively compare to jet nebulizers. Thus, mesh nebulizers may be a faster way of nebulization before flexible bronchoscopy as an alternative to jet nebulizers.

Key words: Flexible bronchoscopy, mesh nebulizer, jet nebulizer, lidocaine

1. Introduction

Use of topical anesthesia prior to flexible bronchoscopy (FB), performed to evaluate the upper airways and tracheobronchial tree, prevents cough and stridor during and after the procedure while reducing the need for sedation [1,2]. In clinical practice, lidocaine is the medication of choice for topical anesthesia before FB, due to its short half-life and wide safety range [3]spray catheters have been developed, allowing nebulization of the local anesthetic solution. However, there are little data on the efficacy and safety of this approach, or on the consumption of sedative drugs and lidocaine during nebulized administration. Objectives: To investigate the tolerability of nebulized lidocaine compared to conventional lidocaine administration via syringe through the working channel of the bronchoscope in patients undergoing bronchoscopy. Consumption of sedative drugs and lidocaine was also compared between the two lidocaine administration approaches. Methods: Patients requiring bronchoscopy with endobronchial or transbronchial biopsy were randomly assigned to receive topical lidocaine either via syringe or via nebulizer. Endpoints were consumption of lidocaine and sedative drugs, as well as patient tolerance and safety. Results: Thirty patients were included, 15 in each group. Patients in the nebulizer group required lower doses of endobronchial lidocaine (184.7 ± 67.98 vs. 250.7 ± 21.65 mg, $p = 0.0045$. Lidocaine nebulization before FB was found to be well tolerated with better oxygenation and fewer side effects compared to systemic administration [4,5].

Effective delivery of aerosol drugs with a nebulizer depends on age, physical-cognitive development, and patient-device compatibility [6,7]ultrasonic nebulizers, and mesh nebulizers. Newer nebulizer designs are breath-

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enhanced, breath-actuated, or have aerosol-storage bags to minimize aerosol loss during exhalation. Nebulizers can be used with helium-oxygen mixture and can be used for continuous aerosol delivery. Increased attention has recently been paid to issues related to the use of a facemask with a nebulizer. The pressurized metered-dose inhaler (pMDI. In addition, airway caliber, breathing rate, inspiratory flow rate, and breathing pattern determine the efficacy of aerosol delivery [8,9]. There are various types of nebulizers; one is a jet nebulizer (JN), which produces aerosol drug particles of various diameters and requires a flow rate of 5 –6 L/min and pressure of 2 bars to transmit these particles to the airway [10]nebulizers have been commonly used to deliver aerosolized medications in the treatment of patients with pulmonary diseases. They are the aerosol device of choice when patients can not coordinate inhalation and actuation needed for the use of the pressurized metered-dose inhalers (pMDIs. Noise generation between 65–100 dB is a disadvantage for JN use in children [11]. The other type of nebulizer is the mesh nebulizer (MN) that used a micro-pump technology for aerosol generation without making noise [10]nebulizers have been commonly used to deliver aerosolized medications in the treatment of patients with pulmonary diseases. They are the aerosol device of choice when patients can not coordinate inhalation and actuation needed for the use of the pressurized metered-dose inhalers (pMDIs. MNs aerosolize the medication in liquid form by passing it through the multiple micro-holes in a vibrating plate [10]nebulizers have been commonly used to deliver aerosolized medications in the treatment of patients with pulmonary diseases. They are the aerosol device of choice when patients can not coordinate inhalation and actuation needed for the use of the pressurized metered-dose inhalers (pMDIs. They are small, portable devices with high output efficiency and minimal residual volume, that work on battery or electricity. Advantages of MNs are the efficiency of aerosol generation, constant aerosol size, the dominantly small aerosol fraction that is suitable to reach the peripheral airways, and nebulization of low drug volume [10]nebulizers have been commonly used to deliver aerosolized medications in the treatment of patients with pulmonary diseases. They are the aerosol device of choice when patients can not coordinate inhalation and actuation needed for the use of the pressurized metered-dose inhalers (pMDIs. MNs have minimal residual drug volume (0.1–0.3 mL) compared to JNs and ultrasonic nebulizers (UN) (0.8–1.5 mL) and are more efficient in drug distribution than JNs [12,13].

The efficacy of topical lidocaine nebulization may influence the rate and severity of post FB respiratory symptoms such as cough and laryngeal spasm. Aerosols generated with different nebulizer types may influence the efficacy. Therefore, in this study, we aimed to compare the respiratory tract symptoms after FB between children who received pre-procedure topical lidocaine with MNs or JNs.

2. Methods

2.1. Study population and ethics committee approval

We enrolled 4–18 years old subjects that underwent FB due to treatment resistant asthma in Pediatric Pulmonology and Allergy Department between January 2015 and April 2019 retrospectively in this study. Total number of FB procedures during this time was 427 and 40 subjects fulfilled the inclusion criteria. Among these, 20 had received topical lidocaine with JN while 20 with MN. Exclusion criteria were foreign body aspiration, short term bronchodilator or systemic steroid use during the previous week, congenital airway anomaly, cystic fibrosis, primary ciliary dyskinesia neurological disease, and cardiac disease. Moreover, subjects in which FB revealed any pathology inconsistent wih treatment resistant asthma were excluded.

This retrospective case-control study was approved by the Institutional Review Board of Celal Bayar University, School of Medicine (Date of Approval: 07.10.2019, Number of Approval: 48).

2.2. Data collection

Age, sex, inhaler treatment used before FB, duration of bronchoscopy, anesthetic and muscle relaxant medications used during FB, duration of anesthesia, time to awaken and time to recovery were recorded from procedure files as well as croup, cough, and laryngospasm scores after FB.

After the bronchoscopy, the patients are routinely followed up by the anesthesiologist until their vital signs are stable and spontaneous breathing starts and time to awaken and time to recovery are recorded in their files. After the procedure, all cases are followed up by the pediatric pulmonology team and group, laryngospasm and cough scores are recorded in their files. Croup score is calculated as the sum of retraction, airflow and cyanosis scores, each of which are graded from 0 to 2, increasing with severity [14]. A total score of 1–3 is mild, 4–6 is moderate, and ≥ 7 is severe croup. Laryngospasm is scored from one to three; just stridor (grade 1), complete closure of vocal cords (grade 2), complete closure of vocal cords and cyanosis (grade 3) [15]. Cough is scored as mild (once), moderate (multiple coughs of short duration < 5 s), and severe (continuous cough > 5 s) [16]"type":"article-journal","volume":"106"},"uris":["http://www.mendeley.com/documents/?uuid=7923a422-d84b-4f11-8870-84edef7ffa68"]}],"mendeley":{"formattedCitation":"[16]","plainTextFormattedCitation":"[16]","previouslyFormattedCitation":"[17]"},"properties":{"noteIndex":0},"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"}. Cough, laryngospasm, and croup scores were recorded from patient files.

2.3. Nebulization and anesthesia prior to FB

All patients received 4 mg/kg of 2% lidocaine before FB either with JN (Hospyneb Professional, 3A Healtcare, Italy) or MN (Aerogen Solo with Ultra, Aerogen Ltd., Ireland) through an age appropriate mask. The decision to use JN or MN depended on the time left before the procedure when the subject arrived the procedure room. Since the JN takes a longer time to finish nebulization, the patients who arrive to the procedure room early get their lidocaine through a JN which takes about 10 min, but if the time is shorter then they receive it with MN which takes about 5 min. The nebulization was completed 5 min before the induction of anesthesia. Nebulization times and nebulization types of patients were recorded from their files.

Anesthesia was induced by an anesthesiologist in the operation room with intravenous (IV) propofol for induction and sevoflurane inhalation for maintenance. Use of neuromuscular blocker IV Rocuronium was recorded from the files. FB (Fujinon EB-470S - Fujinon EB-470P, Fujifilm Corp., Saitama, Japan) was performed by a pediatric pulmonologist using age and weight appropriate scopes. During the procedure, all cases were monitored in terms of cardiac and respiratory parameters and the bronchoscopy procedure is recorded in their files along with a video.

2.4. Statistical analysis

In this research; data analysis was performed using SPSS v: 15.0 (IBM Corp., Armonk, NY, USA). Statistical analysis included descriptive statistics, Student-t test, Pearson chi-square tests, and Mann–Whitney analysis. Group comparisons were performed using Student t test for continuous variables and $\chi 2$ test to compare categorical variables. Categorical variables were reported as frequency and percentage. Mann–Whitney U test was used to compare continuous variables not normally distributed between MN and JN group. A p-value of 0.05 was considered statistically significant.

3. Results

3.1. Sociodemographic characteristics

Age was not significantly different among the two groups (8.3 ± 3.6 years in the JN group vs. 9.5 ± 4.6 years in the MN group, p = 0.44) (Table 1).

3.2. Procedure and anesthesia

Bronchoscopy duration was not significantly different between the two groups (8.6 ± 2.9 vs. 9.6 ± 5.4 min in the JN and MN groups respectively, p = 0.51). Similarly, anesthesia duration was similar (15.3 ± 6.2 and 15.9 ± 9.7 min in the JN and MN groups respectively, p = 0.88). Awakening and recovery times were not significantly different between the two groups, either (p = 0.10 and p = 0.22 respectively) (Table 1).

During bronchoscopy, 21 subjects received rocuronium as a neuromuscular blocker; duration of bronchoscopy and anesthesia, time to awaken and recovery time were not significantly different among the subjects who received rocuronium and who did not (p = 0.94, p = 0.06, p = 0.35 and p = 0.80 respectively). There was no difference in the croup, laryngospasm and cough scores of the subjects that received rocuronium or not (p = 0.73, p = 0.66, and p = 0.66, respectively).

3.3. Post-bronchoscopy respiratory symptoms

Most of the subjects enrolled had a mild croup score after the procedure (95% in the MN and 90% in the JN groups, p = 0.62). Similarly, majority of the subjects did not develop any degree of laryngospasm (80% in the MN and 90% of the JN groups, p = 0.50). On the other hand, cough was

Table 1. Sociodemographic and procedure characteristics of the study population.

	MN group (n = 20)	JN group (n = 20)	p =
Age (years) ****	9.5 (4.6)	8.3 (3.6)	0.44*
Sex (male) *****	12(60)	8 (40)	0.34***
Bronchoscopy duration (min)****	9.6 (5.4)	8.6 (2.9)	0.51**
Anesthesia duration (min)****	15.9 (9.7)	15.3 (6.2)	0.88**
Time to awaken (min)****	7.9 (9.0)	7.6 (3.0)	0.10**
Recovery time (min)****	4.8 (1.8)	5.9 (1.8)	0.22**

*Student T test.
**Mann–Whitney U test.
*** Pearson Chi-Square.
**** Expressed as mean (SD).
*****Expressed as n (%).

the most common post-FB respiratory symptom. Overall, 70% of the MN group had mild and 30% had moderate cough scores but the JN group, 30% had mild, 60% had moderate and 10% had severe cough score. On JN group; cough score was significantly worse than the MN group (p = 0.03) (Table 2).

4. Discussion

Flexible bronchoscopy is a method frequently used by pediatric pulmonologists for the diagnosis of respiratory diseases and pre-operative topical anesthesia via nebulization is applied commonly to decrease complications such as laryngospasm and cough [17–19]. In this study, we compared the efficacy of two different nebulizer types in decreasing the severity of post-procedure complications. There were no severe complications in both JN and MN groups, but cough severity was lower in the MN group.

Cough is the most important and common complication in bronchoscopy with a prevalence of 27% and it can lead to patient intolerance as well as physician dissatisfaction [20,21]. Lidocaine with its rapid onset of action, short half-life and a good safety profile is the most commonly used local anesthetic agent to reduce cough in the bronchoscopy procedure [22]. Although, topical anesthetics carry the risk of side effects upon rapid absorption through mucous membranes, lidocaine has a good safety profile [23]. Thus, lidocaine nebulization either with JN or MN is used for topical anesthesia before FB routinely in our clinic. We did not observe any side effects related to lidocaine nebulization in our study.

Aerosol therapy with nebulizer is frequently used for the treatment of respiratory symptoms and there are various nebulizer types depending on their operating principles. Particle size and delivery rate are critical factors in determining the local and total lung accumulation of inhaled aerosol drugs [24]. JNs, easy to operate and cheap, are frequently used in daily life but have disadvantages of a large residual volume, electrical supply requirement and noise [25]. MNs have gained popularity over the years lately due to its low residual volume, completely silent operation, and easy use and cleaning [26]interfaces, and flow rates are used to deliver aerosolized medications to children. The purpose of this study was to determine the effect of nebulizer type, delivery interface, and flow rate on aerosol drug delivery to spontaneously breathing pediatric and infant lung models. Methodology: A teaching mannequin was attached to a sinusoidal pump via a collecting filter at the bronchi to simulate a spontaneously breathing child (Vt: 250 mL, RR: 20 bpm and Ti: 1 second. MNs are reported to be more efficient in delivery of aerosols to the peripheral airways compared to JNs [27,28]. Therefore, we aimed to evaluate the efficacy of these two nebulizers in terms of post-FB complications. The results of our study revealed that there was no significant difference between JN and MN and lidocaine nebulization groups in terms of croup score and laryngospasm score, whereas the cough score was significantly higher in the group using JN compared to the group using MN.

Cough is one of the most important complication during and after bronchoscopy, that impairs the quality and comfort of the FB procedure and impairs patient quality of life and led to anxiety. In previous studies, the frequency of post-FB cough has been reported to be 27% [21]. The frequency of moderate and severe cough was 30% in MN group and 60% in the JN group in our study.

Table 2. Post FB croup, cough and laryngospasm scores of the groups.

		MN group n = 20	JN group n = 20	p =
Croup score	Mild *	19 (95)	18 (90)	0.62 **
	Moderate *	1 (5)	1 (5)	
	Severe *	0 (0)	1 (5)	
Cough score	Mild *	14 (70)	6 (30)	0.03 **
	Moderate *	6 (30)	12 (60)	
	Severe *	0 (0)	2 (10)	
Laryngospasm score	No *	16 (80)	18 (90)	0.50 **
	Grade 1 *	4 (20)	1 (5)	
	Grade 2 *	0 (0)	1 (5)	
	Grade 3 *	0 (0)	0 (0)	

*Values are expressed as n (%).
** Pearson Chi-square.

This difference may be attributed to the standard particle size and efficient distribution of these particles to the peripheral airways with MNs compared to JNs. Moreover, shorter total duration of nebulization may increase patient adherence to the technique.

The current study has a few limitations. Due to the limited number of mesh nebulizers, the priority of jet nebulizer for routine lidocaine nebulization causes a limited number of patients who receive lidocaine with mesh nebulizer. For this reason, the number of patients who are applied lidocaine with a mesh nebulizer between the research years and who meet the research criteria is limited. A prospective, double-blind study with two groups with a higher number of subjects using JN or MN may add value to the research.

In conclusion, MNs may be used as an alternative to JN for pre-FB local anesthetic administration to decrease cough severity during and post-FB in children. Silent and short duration of nebulization are the advantages of this technique.

Conflict of interest

The authors declare that the study has not received any funding and that there are no conflicts of interest.

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