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**Research Article** 

# Evaluation of Ventilation Methods and Cardiorespiratory Outcomes in Children with Foreign Body Aspiration Undergoing Rigid Bronchoscopy Within 2008 - 2019

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#### Abstract

**Background:** Foreign body aspiration is a common accident with life-threatening outcomes. Rigid bronchoscopy is considered an effective tool in the diagnosis and treatment of this complication; however, there is still no agreement on the preferred ventilation method for the treatment of patients with foreign body aspiration.

**Objectives:** This study aimed to compare the cardiovascular and respiratory outcomes followed by ventilation methods in patients with foreign body aspiration undergoing rigid bronchoscopy.

**Methods:** In this cross-sectional study, the information was recorded from 90 patients' files, including age, gender, aspirated foreign body, interval from aspiration to referral, signs, and symptoms, comorbidity, bronchoscopic results, ventilation method during the procedure, occurrence of respiratory complications, heart rate, blood pressure, arterial oxygen saturation, length of hospital stay, and mortality of patients. The data were analyzed by SPSS software (version 22). A p-value less than 0.05 was considered statistically significant.

**Results:** Out of 90 reviewed cases, 57.67% were male, and the mean age was  $2.06 \pm 1.25$  years. The most common aspirated foreign body was peanuts (38.89%). The most common clinical signs were cough (81.11%) and wheezing (51.11%). The most common symptoms were wheezing (54.44%) and decreasing respiratory sounds (46.67%). Bronchoscopy was associated with foreign body extraction in 65.6% of the patients. The relationship between the ventilation method with blood pressure changes, length of hospital stay, cardiopulmonary complications, and oxygen saturation was not significant; however, the cases with spontaneous breathing referred at shorter intervals from aspiration and experienced fewer heart rate changes.

**Conclusions:** The results of the present study showed no preference between spontaneous and controlled ventilation during rigid bronchoscopy in patients with foreign body aspiration.

Keywords: Respiratory Aspiration, Foreign Bodies, Bronchoscopy, Pulmonary Ventilation, Respiration

# 1. Background

Pulmonary aspiration refers to the accidental entry of any type of fluid, secretions (e.g., saliva and sputum), gastrointestinal contents, or foreign bodies into the respiratory tract. The foreign body aspiration into the respiratory tract is an otolaryngology emergency case worldwide (1-3). The mortality rate caused by pulmonary bodies in the United States is estimated to be 500 - 2000 individuals per year (4, 5). The most common cause of aspiration is food, although the type of foreign body can be different in each geographical area (2, 5, 6). Foreign body aspiration is more common, especially in patients with low levels of consciousness, the elderly, and children; accordingly, airway foreign body aspiration is responsible for 6 - 7% of accidental deaths among American children under the age of 5 years (7). The prevention of primary harm and proper supervision of caregivers and families particularly should always be a priority; accordingly, after 24 hours of aspiration, the frequency of respiratory complications, such as recurrent pneumonia, pulmonary abscess, pleural effu-

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sion, bronchiectasis, asthma-like attacks, and heart failure, increases significantly (2, 4, 8, 9). In older patients, the aspiration of drugs is more common (10, 11).

Medical history and clinical examination can lead to the diagnosis. Most patients are referred due to the problems, such as cough, feeling of suffocation, cyanosis, and shortness of breath. Loss of respiratory sounds and wheezing are the most common findings in breathing sounds (12, 13). Chest radiography has no specific findings and is normal in most cases. However, in any case, with regard to the suspicion of foreign airway body, bronchoscopy is the most important diagnostic and therapeutic tool in numerous countries (2, 9). A rigid bronchoscopy is an accurate tool for the diagnosis and treatment of foreign bodies in the airways. Hypoxemia has been reported to be the most common complication; nevertheless, its association with ventilation during anesthesia is not clear (2, 13, 14).

Generally, in rigid bronchoscopy, patient relaxation, surgeon convenience, and minimization of complications are considered in addition to establishing ventilation and maintaining oxygenation. In general, there is no golden standard for ventilation. Two main patterns for ventilation and airway management of patients during rigid bronchoscopy include maintaining spontaneous respiration (without prescribing neuromuscular-blocking agents) and controlled mechanical ventilation, in which, with neuromuscular-blocking agents, the respiratory muscles are disabled, and airways become entirely relaxed. The ventilation method for each patient should be planned based on medical history, clinical examination, and diagnostic imaging (15). Although some studies have demonstrated that the lack of muscle relaxants in spontaneous ventilation is a factor for laryngospasm and limited ventilation and considered that partial pressure of carbon dioxide in the arterial blood of this group is higher, the reduced arterial oxygen saturation in these patients has been rarely reported (16, 17). On the other hand, some other studies have shown that arterial oxygen saturation in spontaneous ventilation is higher than in mechanical ventilation (18).

# 2. Objectives

Foreign body aspiration is a common accident with life-threatening cardiovascular and respiratory consequences. Although rigid bronchoscopy is currently considered an effective tool in the diagnosis and treatment of this complication, airway management during this process is still a challenge for anesthesiologists, pulmonologists, and otolaryngology surgeons, and there is still no agreement among anesthesiologists on the evidence-based preferred ventilation method for the treatment of patients in the acute and chronic stages of foreign body aspiration. Therefore, this study aimed to compare the cardiovascular and respiratory outcomes followed by ventilation methods in patients with foreign body aspiration undergoing rigid bronchoscopy.

# 3. Methods

The present study was an analytical, cross-sectional, retrospective, single-center research. The study population consisted of all patients with suspected foreign body airway aspiration referring to Amir Al-Momenin Academic Hospital, Guilan, Iran, within 2008 - 2019. The children who were admitted within 2008 - 2019 with suspicion of airway foreign body aspiration and undergoing rigid bronchoscopy were included in the study.

#### 3.1. Sampling Method and Sample Size Calculation

The sampling method of this study was complete enumeration. Accordingly, over a 10-year period within 2008 -2019, all patients with suspected foreign body aspirations with profiles at Amir Al-Momenin Academic Hospital were evaluated in terms of consequences and ventilation methods. It was expected that 100 patients would be examined during this period, and a total of 90 patients were included in the study after applying the restrictions and exclusion criteria. Patients' files with incomplete information were excluded.

In this study, using the information listed in the profiles, the demographic characteristics, including age, gender, nature of the aspirated foreign body, aspiration scenario, interval from aspiration to referral, signs, and symptoms, comorbidity, taken medical measures, bronchoscopy results, airway management, ventilation method, occurrence of respiratory complications, and description of surgery events, were examined in terms of heart rate, blood pressure, arterial oxygen saturation, length of hospital stay, and mortality of patients. It is necessary to mention that anesthesia planning was the same in both groups [atropine 0.02 mg/kg, fentanyl 1 - 2 mic/kg, propofol 2 mg/kg, and succinylcholine 1 - 2 mg/kg with incremental dose, only in controlled ventilation group and TIVA (propofol 50 mic/kg/min, remifentanil 0.05 mic/kg/min) for anesthesia maintenance]. All the participants underwent electrocardiography, pulse oximetry, noninvasive blood pressure, and precordial stethoscope assessments.

Complications were evaluated during and at the end of the surgery and recovery, including laryngospasm and laryngeal edema, cough, shortness of breath, duration of the procedure, and recovery if reported. The patients were divided into mechanical or spontaneous groups in terms of ventilation during anesthesia and were compared in terms of descriptive variables and hemodynamic parameters. More than 20% of changes in the heart rate and systolic or diastolic blood pressure were considered tangible changes, and arterial desaturation was defined as 90% > peripheral oxygen saturation.

After collecting the data based on the checklist, information was obtained from the files and analyzed by SPSS software (version 22). Frequency, frequency percentage, and 95% confidence interval (CI) were used to determine the ventilation method and its consequences. Mean, standard deviation (SD), and 95% CI were also used to determine the quantitative variables, such as length of hospital stay, systolic and diastolic blood pressure, and heart rate changes. Descriptive results were assessed based on the frequency and frequency percentage with 95% CI of outcomes, mean, SD, and median. The significance level of the tests was considered less than 0.05.

# 4. Results

In this study, regarding ventilation method and cardiorespiratory outcomes in the patients with foreign body aspiration undergoing rigid bronchoscopy within 2008 -2019, 90 out of 103 available files of patients were examined after extracting the files with incomplete information. Table 1 shows the characteristics of gender and age in the subjects. According to the data in Table 1, 56.7% and 43.3% of the participants were male and female, respectively. The mean age value of the subjects was 2.06  $\pm$  1.25 years. The youngest and oldest studied cases were 1 and 8 years, respectively. The majority of the samples were in two age groups of under 2 (43.33%) and 2 (38.89%) years, respectively.

<b>Table 1.</b> Demographic Characteristics of Studied Subjects $(n = 90)^{a}$		
Gender Values		
Male	51 (56.67)	
Female	39 (43.33)	
Age (y)		
Under 2	39 (43.33)	
2	35 (38.89)	
3	9 (10.00)	
$\geq$ 4	7(7.78)	
Mean $\pm$ SD (median)	$1.25\pm 2.06(2.0)$	
Highest, lowest (n)	8.0,1.0	

<sup>a</sup> Values are expressed as No. (%) unless otherwise indicated.

Only six patients (6.67%) of the studied samples had

at least one comorbidity. The most important comorbidities of these children were asthma, pneumonia, teratoma, glucose-6-phosphate dehydrogenase (G6PD) deficiency, and a history of lung problems. According to Table 2, the most common aspirated foreign bodies were peanuts (38.98%), walnuts (11.86%), and hazelnuts (11.86%), respectively. Other foreign bodies had a lower percentage. The most common complaints of the patients were cough (81.11%), wheezing (51.11%), shortness of breath (24.44%), and feeling of suffocation (16.67%), respectively. The most common clinical findings were wheezing (54.44%), unilateral decrease in breathing sounds (46.67%), and crackles (18.89%), respectively.

Table 2. Frequency Distribution of Studied Subjects Based on Nature of Foreign Body (n = 59)

Nature of the Foreign Body	No. (%)
Peanut	23 (38.98)
Pistachio	5 (8.47)
Popcorn	1 (1.69)
Plant seed	5 (8.47)
Concentrated airway secretion	1 (1.69)
Pen bottom	1 (1.69)
Corn	2 (3.38)
Hazelnut	6 (11.86)
Walnut	7 (11.86)
Pearls	1 (1.69)
Peas	2 (3.38)
Carrot	5 (8.47)

According to Table 3, in terms of diagnostic and therapeutic measures, bronchoscopy and chest X-ray were performed on nearly 100% of the subjects (98.9%). With the consideration of the results, bronchoscopy extracted foreign bodies successfully in 65.6% of cases, and no foreign body was observed in other cases.

None of the patients needed respiratory support after the procedure, and 17.8% of the subjects had respiratory complications. After bronchoscopic interventions, 15 cases had evidence of pneumonia, and 1 case showed pleural effusion, all of whom were treated. Only one patient (1.1%) had hypoxemia.

According to the obtained data, the mean heart rate values before and after bronchoscopy were 137.76  $\pm$  12.97 and 131.63  $\pm$  12.46 beats per minute, respectively. The systolic and diastolic blood pressure of the studied subjects were 92.11  $\pm$  6.40 and 59.78  $\pm$  6.74 mmHg, respectively. The hospitalization duration of the subjects was 1.89  $\pm$  1.60 days, with a minimum of 1 day and a maximum of 7 days.

Diagnostic-Therapeutic Measures	Values
CXR-bronchoscopy	89 (98.89)
CXR-bronchoscopy-esophagoscopy	1 (1.11)
Bronchoscopy results	
With foreign body extraction	59 (65.56)
Without foreign body extraction	31 (34.44)
Respiratory support after the procedure	
No need	90 (100.00)
Respiratory complications	
No	74 (82.22)
Yes	16 (17.78)
Type of respiratory complications	
Pneumonia	15 (93.8)
Pleural effusion	1(6.2)
Postbronchoscopy complications	
No	89 (98.89)
Hypoxemia	1 (1.11)
Interval from aspiration to referral (days)	
1 day or less	11 (12.22)
More than 1 - 2 days	33 (36.67)
3 - 7 days	26 (28.89)
7 days and more	20 (22.22)
Mean $\pm$ SD	$8.92 \pm 5.90  (3.0$
Highest, lowest (n)	60.0, 0.04

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Abbreviation: CXR, chest X-ray.

<sup>a</sup> Values are expressed as No. (%) unless otherwise indicated.

According to Table 4, the percentage of respiratory complications was statistically significant only in terms of bronchoscopy results (P = 0.009). The percentage of respiratory complications in patients with successful foreign body extraction (25.42%) was eight times higher than in children without foreign body extraction. The respiratory complications were not significant in terms of other variables in Table 4, especially the ventilation type.

According to Table 5, ventilation type methods were statistically significant only in terms of the interval from aspiration to referral; accordingly, spontaneous breathing in individuals who visited in less than a day was higher than in those who came later. Table 6 shows the comparison of heart rate changes in the studied subjects according to disease-related individual factors. Based on the data in Table 6, heart rate changes were significant regarding the ventilation type (P = 0.05, borderline significance). In

patients with no respiratory complications, the decreased heart rate was higher than in those with respiratory complications. The mean hospital stay length of the patients was significant in terms of respiratory complications (P < 0.001). The patients with respiratory complications had a longer mean hospital stay (4.44  $\pm$  1.86 vs. 1.34  $\pm$  0.82 days). In this study, none of the individuals lost their lives.

#### 5. Discussion

Foreign body aspiration is a common accident with life-threatening cardiovascular and respiratory outcomes. Although rigid bronchoscopy is considered an effective tool in the diagnosis and treatment, airway management during this process is still a challenge for anesthesiologists, pulmonologists, and¬ otolaryngology surgeons, and there is still no agreement among anesthesiologists on the evidence-based preferred ventilation method for the treatment of patients in the acute and chronic stages of foreign body aspiration. Therefore, this study aimed to compare the cardiovascular and respiratory outcomes followed by ventilation methods in patients with foreign body aspiration undergoing rigid bronchoscopy.

According to the results of this study, 57.67% and 43.33% of the study subjects were male and female, respectively. The mean age of the subjects was  $2.06 \pm 1.25$  years. In other studies, the majority of the patients with foreign body aspiration were male (1, 3, 7, 14, 16). Therefore, de Blic and Leon Cortes stated that 80% of the patients with foreign body aspiration were 9-month to 3-year-old male cases (19). Haddadi et al. reported a mean age of  $34.82 \pm 33.4$  months for patients; nevertheless, Sadeghi et al. reported a mean age of  $24.4 \pm 27.21$  months (2, 17). In another study, Bakal et al. stated that most patients with foreign body aspiration were within the age range of 4 - 10 years (4). The sum of all these studies indicates a high prevalence of foreign body aspiration in children, which requires more attention from parents and caregivers.

In this study, only 6.67% of the patients had comorbidities, the most important and common of which were asthma, pneumonia, teratoma, G6PD deficiency, and a history of pulmonary problems. None of the subjects had neurological or musculoskeletal problems. The most common aspirated foreign bodies were peanuts (38.98%), walnuts (11.86%), and hazelnuts (11.86%), respectively. According to Bakal et al., the majority of aspirated bodies were food (4), of which oilseeds and nuts seemed to be the most dangerous ones (14). Samarei considered sunflower seed as the most common aspirated body (3). In another study, Haddadi et al. found that the frequency aspiration of peanuts was higher than other substances (2).

ble 4. Comparison of Respiratory Complicatio	ns Based on Disease-Related Individua	al Variables	
Variables	Respiratory Comj	plications; No. (%)	- P Value
	No	Yes	r value
Gender			0.250 *
Male	44 (86.27)	7 (13.73)	
Female	30 (76.92)	9 (23.08)	
Age (y)			0.930 *
1-2	32 (82.05)	7 (17.95)	
2-3	28 (80.00)	7(20.00)	
3-4	8 (88.89)	1 (11.11)	
$\leq$ 4	6 (85.71)	1(14.29)	
Comorbidity			0.586 **
No	68 (80.95)	16 (19.05)	
Yes	6 (100.00)	0 (00.0)	
Interval from aspiration to referral (days)			0.518 **
1 day or less	9 (81.82)	2 (18.18)	
More than 1 - 2 days	28 (84.85)	5 (15.15)	
3-7	19 (73.08)	7 (26.92)	
7 days and more	18 (90.00)	2 (10.00)	
Diagnostic-therapeutic measures			0.999 **
CXR	1(10.00)	0 (00.0)	
CXR-bronchoscopy	72 (81.82)	16 (18.18)	
CXR-bronchoscopy- esophagoscopy	1(100.00)	0(00.0)	
Bronchoscopy result			0.009 *
With foreign body extraction	44 (74.58)	15 (25.42)	
Without foreign body extraction	30 (96.77)	1(3.23)	
Postbronchoscopy complications			0.999 **
No	73 (82.02)	16 (17.98)	
Hypoxemia	1(100.00)	0(00.0)	
Type of ventilation			0.581 *
Spontaneous respiration	8 (88.89)	1 (11.11)	
Controlled respiration	66 (81.48)	15 (18.52)	

Abbreviation: CXR, chest X-ray.

According to the results of this study, the most common clinical signs in the patients were cough (81.11%) followed by wheezing (51.11%), shortness of breath (24.44%), and feeling of suffocation (16.67%). These results are consistent with the results of several other studies, including Haddadi et al.'s study, where cough, wheezing, and shortness of breath were the most common complaints (2). In another study, Samarei considered cough, shortness of breath, and wheezing the most common complaints, respectively (3). Bakal et al. also reported that the sudden onset of cough was the earliest symptom of foreign body aspiration (4). Therefore, it is necessary to pay attention to this finding in the medical history of patients, along with other clinical examinations.

The most common clinical findings in this study

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were wheezing (54.44%), unilateral decreasing breathing sounds (46.67%), and crackles (18.89%), respectively. In other studies, two findings of wheezing and decreasing breathing sounds are noted as the most common results of examinations. According to Haddadi et al., the most common examination findings were unilateral decreasing breathing sounds, wheezing, and crackles (2). In another study conducted by Bakal et al., unilateral decreasing breathing sounds, wheezing, and emphysema had the highest prevalence in examinations, respectively (4).

Bronchoscopy and chest radiography were performed on 98.9% of the patients as diagnostic and therapeutic measures performed in the present study. It should be noted that bronchoscopy was accompanied by aspirated body extraction in 65.6% of cases, and no foreign body was

Type of Ventilation; No. (%)PhalueGender0.0101 eld VentilationGender0.993Male5 (9.80)Male5 (9.80)Age (y)35 (89.74)Age (y)0.849 **1-24 (10.26)3.4031 (88.57)2-3.400.00.002-3.40.00.002-411 (14.39)6 (85.71)0.389*Comorbdity0.00.00Yes0.00.00No9 (100.00)1 (14.39)6 (85.71)Yes0.00.001 (14.39)5 (85.79)Yes0.00.00More than 1-2 days5 (15.15)2 (14.30)32 (84.85)3.71 (13.5)3.71 (3.5)7 day and more0.900.00Other Arguetic measure0.999 **Oxage scope	Table 5. Comparison of Ventilation Type Base	d on Foreign Body Depending on Individu	ual Variables	
Ministic         spontaneous Ventilation         Controlled Ventilation         Pradue           Gender         0.943 *         0.943 *           Male         5 (9.80)         46 (90.20)           Female         4 (10.26)         55 (89.74)           1 · 2         4 (10.26)         55 (89.74)           2 · 3         4 (11.43)         31 (88.57)           3 · 4         0 (00.0)         9 (100.70)           > 4         0 (100.0)         9 (100.71)           No         9 (100.71)         75 (89.29)           Yes         0 (00.0)         0 (00.0)           Interval from aspiration to referral (days)         6 (85.71)         0.040 **           Iday or less         3 (72.72)         8 (72.73)         0.040 **           Iday or less         3 (72.72)         8 (72.73)         0.940 **           Iday or less         3 (72.72)         8 (72.73)         0.999 **           Iday or less         3 (72.72)         8 (72.73)         0.999 **           Iday or less         9 (10.23)         2 5 (96.15)         0.999 **           Iday or less         9 (10.02)         7 (98.77)         0.999 **           CRR         0 (00.00)         1 (100.00)         0.999 **      <	Variables	Type of Ventilation; No. (%)		DValue
Gender       0.943*         Male       5 (9.80)       46 (90.20)         Female       4 (10.26)       35 (89.74)         Qe(V)       0.849**       0.849**         1 - 2       4 (10.26)       35 (89.74)         2 - 3       4 (10.43)       31 (85.57)         3 - 4       0 (00.0)       9 (10.00)         ≥ 4       0 (10.00)       9 (10.00)         Comot/Guty       0.389*       0.389*         No       9 (10.71)       75 (89.29)         Ves       0 (00.0)       6 (100.00)         Interval from aspiration to referral (Convot       0.040**         (day or less       3 (27.27)       8 (72.73)         1 day or less       3 (27.27)       8 (72.73)         More than 1 - 2 days       5 (15.15)       28 (84.85)         3 - 7       1 (3.85)       25 (96.15)         7 days and more       0 (00.0)       1 (100.00)         CXR bronchoscopy       9 (10.23)       7 (9 (89.77)         With foreign body extraction       7 (11.8	variables	Spontaneous Ventilation	Controlled Ventilation	P Value
Male $5(9.00)$ $46(90.20)$ Female $4(10.26)$ $35(93.74)$ Age(y) $0.849$ ** $1 - 2$ $4(10.26)$ $35(93.74)$ $2 - 3$ $4(10.26)$ $35(93.74)$ $3 - 4$ $0(00.0)$ $9(100.00)$ $\ge 4$ $1(14.29)$ $6(85.71)$ Comoticity $0.00.0$ $6(85.71)$ No $9(00.7)$ $6(98.29)$ Yes $0.00.0$ $6(100.00)$ Intervalion to referral (days) $3(2727)$ $8(72.73)$ No $3(2727)$ $8(72.73)$ $0.040^{**}$ I day or less $3(2727)$ $8(72.73)$ $9(00.7)$ I day or less $3(272.7)$ $8(72.73)$ $9(00.7)$ I day or less $3(272.7)$ $8(72.73)$ $9(00.7)$ I day or less $3(272.7)$ $8(90.00)$ $9(00.00)$ I day or less $3(272.7)$ $8(9(0.0.0)$ $9(00.00)$ I day or less $3(272.7)$ $8(9(8.9)$ $9(0.00.7)$ $9(0.00.7)$ I day or less $3(272.7)$ $8(9(8.9)$ $9(0.00.7)$	Gender			0.943 *
Fende       4(10.26)       35 (8974)         Age (y)       0.849 **         Age (y)       0.849 **         1 - 2       4(10.26)       35 (897.4)         1 - 2       4(10.42)       36 (85.7)         3 - 4       0(00.0)       9(10.00) $\geq$ 4       1(14.29)       6 (85.7)         Comorbidiy       0.809 **       0.809 **         No       9 (10.7)       75 (89.29)       0.040 **         [Max]       9 (10.7)       75 (89.29)       0.040 **         Interval Form aspiration to referral       0.040 **       0.040 **         [May reless       3 (27.27)       8 (72.3)       0.040 **         More than 1 - 2 days       5 (515)       28 (84.85)       0.040 **         J day or less       3 (72.7)       8 (72.3)       99 **         [More than 1 - 2 days       5 (515)       28 (615)       90 (70.00)         J day or less       3 (70.2)       9 (70.3)       9 (70.7)       90 **         [CXR       0 (00.0)       1 (100.00)       90 **       90 **         [CXR-bronchoscopy copy       9 (10.23)       7 (89.7)       9 (70.2)         [CXR-bronchoscopy copy       9 (10.23)       7 (80.2)       9 (80.2)	Male	5 (9.80)	46 (90.20)	
Age(y)       0.84 9*         1 - 2       4 (10.26)       35 (89.74)         2 - 3       4 (14.3)       31 (88.57)         3 - 4       0 (00.0)       9 (00.00)         ≥ 4       1 (14.2)       6 (85.7)         Comotifity       0 (00.0)       6 (00.00)         No       9 (00.7)       75 (89.29)         No       9 (00.7)       75 (89.29)         Intersystem       0.040.**         More than 1-2 days       3 (27.27)       8 (72.73)         1 day or less       3 (27.27)       8 (72.73)         More than 1-2 days       5 (51.5)       28 (84.85)         3 - 7       1 (3.85)       25 (96.15)         7 days and more       0 (00.0)       1(00.00)         CXB-bronchoscopy       9 (10.2)       79 (89.7)         CXB-bronchoscopy       9 (00.0)       1 (100.00)         CXB-bronchoscopy       9 (00.0)       1 (100.00)         gapagascopy       9 (00.0)       1 (100.00)         Kith foreign body extraction       7 (11.86)       25 (88.14)         With out foreign body extraction       9 (10.8)       29 (93.5)         With out foreign body extraction       2 (64.5)       2 (93.5)         No       9	Female	4 (10.26)	35 (89.74)	
1·2       4(026)       35(89.74)         2·3       4(11.43)       31(88.57)         3·4       0(00.0)       9(100.00)         ≥ 4       0(00.0)       6(85.71)         Comorbidity       0.38*       0.38*         Yes       0(00.0)       6(100.00)         Iday or less       0(00.0)       6(100.00)         Iday or less       3(727)       8(72.73)         More than 1·2 days       5(15.15)       28(84.85)         3·7       1(3.85)       25(96.15)         7 days and more       0(00.0)       20(100.00)         CXR-bronchoscopy       9(10.23)       7(89.77)         CXR-bronchoscopy       9(10.23)       7(89.77)         With or forign body extraction       0(100.0)       1(100.00)         CXR-bronchoscopy       9(10.23)       7(89.77)         With or forign body extraction       7(18.60       2(84.43)         With or forign body extraction       7(18.60       2(84.81)         With or forign body extraction       7(18.60       2(84.81)         No       9(10.11)       32(85.14)         No       9(10.11)       30(89.89)	Age (y)			0.849 **
2-3       4 (1.43)       31 (88.57)         3-4       0 (00.0)       9 (100.00)         ≥ 4       1 (14.29)       6 (85.71)         OBSOURD SET	1-2	4 (10.26)	35 (89.74)	
$3.4$ 0(00.0)       9(10.00) $\geq 4$ 1(14.29)       6(85.71)         OBSON:         OBSON:         No       9(10.71)       75 (89.29)         Ves       0(00.0)       6(100.00)         Interval from aspiration to referral (day or less)       3(7.27)         1day or less       3(27.27)       8(72.73)         More than 1-2 days       5(15.15)       28(84.85)         3-7       1(3.85)       25(96.15)         7 days and more       0(00.0)       20(100.00)         Open **         QAR       0(00.0)       10(100.00)         CXR       0(00.0)         CXR       0(00.0)       1(100.00)         CAR-bronchoscopy-         of colspan="2">Open **         Veth foreign body extraction       7(1.86)       52(88.14)         With oreign body extractions       2(6.45)       29(93.55)         Open **         No       9(10.11)       80(89.89)         No       9(10.00)       1(100.00)	2-3	4 (11.43)	31 (88.57)	
≥ 4       1(14.29)       6(85.7)         Comorbidity       0.389*         No       9(10.7)       75(89.29)         Yes       0(00.0)       6(100.00)         Interval from aspiration to referral (days) $0(00.0)$ $6(100.00)$ Interval from aspiration to referral (days) $0(00.0)$ $8(72.7)$ $0.040*$ Iday or less $3(27.27)$ $8(72.73)$ $0.040*$ More than 1-2 days $5(5.15)$ $28(84.85)$ $0.040*$ Amore than 1-2 days $0(00.0)$ $20(100.00)$ $0.999*$ 7 days and more $0(00.0)$ $20(100.00)$ $0.999*$ Diagnostic-therapeutic measures $0.999*$ $0.999*$ CXR $0(00.0)$ $1(100.00)$ $0.999*$ Rothorchoscopy $9(10.2)$ $79(89.77)$ $0.416*$ Bron-bscopy result $0.000.0$ $1(100.00)$ $0.416*$ With foreign body extraction $7(11.86)$ $52(88.14)$ $0.999*$ No $9(10.11)$ $80(89.89)$ $0.999*$ No $9(10.10)$ $1(00.00)$ $0.999*$	3-4	0(00.0)	9 (100.00)	
Comorbidity       0389*         No       9(07)       75(89.29)         Yes       0(0.0)       6(100.00)         Intervalion aspiration to referral (days)       6(100.00)       0.040**         Iday or less       3(27.27)       8(72.73)       0.040**         More than 1-2 days       5(15.15)       28(84.85)       0.040         J-7       1(3.85)       25(96.15)       0.909**         Jay and more       0.000       200000       0.909**         CKR       0(0.0)       1(100.00)       0.909**         CKR-bronchoscopy       9(10.23)       79(89.7)       0.909**         Kebronchoscopy-scopy       0(0.00)       1(100.00)       0.416**         With foreign body extraction       7(18.6)       52(88.14)       0.416**         With foreign body extraction       2(64.5)       29(35.5)       0.99**         No       9(10.1)       8(198.98)       0.99**         No       9(10.1)       8(198.98)       0.99**	$\geq$ 4	1(14.29)	6 (85.71)	
No         9(0.7)         75 (89.29)           Yes         0(00.0)         6(100.00)           Interval from aspiration to referral (days)         0.040 **           1 day or less         3 (27.27)         8 (72.73)           More than 1-2 days         5 (15.15)         28 (84.85)           3 -7         1 (3.85)         25 (96.15)           7 days and more         0 (00.0)         20 (00.00)           7 days and more         0 (00.0)         20 (00.00)           CKR         0 (00.0)         1 (100.00)           CKR-bronchoscopy         9 (10.23)         79 (89.77)           CKR-bronchoscopy- esophagoscopy         0 (00.0)         1 (100.00)           Bronchoscopy result         7 (11.86)         52 (88.14)           With foreign body extraction         7 (11.86)         52 (88.14)           With foreign body extraction         7 (11.86)         29 (93.55)           Bronchoscopy result         2 (64.5)         29 (93.55)           No         9 (10.11)         80 (89.89)           No         9 (00.0)         1 (100.00)	Comorbidity			0.389*
Yes       0(00.0)       6(100.00)         Inter-y from aspiration to referral (days)       0.040**         1 day or less       3 (27.27)       8 (72.73)         More than 1-2 days       5 (55.5)       28 (84.85)         3 -7       1 (3.85)       25 (96.15)         7 days and more       0 (00.0)       20 (100.00)         Diagno-stic-therapeutic measures       0.999 **         CXR       0 (00.0)       1 (100.00)         CXR-bronchoscopy       9 (10.23)       79 (89.77)         CXR-bronchoscopy-       0 (00.0)       1 (100.00)         CXR-bronchoscopy-       0 (00.0)       1 (100.00)         Bron-to-scopy result       7 (11.86)       52 (88.14)         With foreign body extraction       7 (11.86)       52 (88.14)         With foreign body extraction       2 (6.45)       2 (9 (3.55)         Bron-to-scopy complications       9 (10.11)       80 (89.89)         No       9 (10.11)       80 (89.89)	No	9 (10.71)	75 (89.29)	
Interval from aspiration to referral (days)       0.040 **         1 day or less       3 (27.27)       8 (72.73)         More than 1-2 days       5 (15.15)       28 (84.85)         3 -7       1 (3.85)       25 (96.15)         7 days and more       0 (00.0)       20 (100.00)         Dagnostic-therapeutic measures       0.999 **         CXR       0 (00.0)       1 (100.00)         CXR-bronchoscopy       9 (10.23)       79 (89.7)         CXR-bronchoscopy- esophagoscopy       0 (00.0)       1 (100.00)         Bron-toscopy result       0 (00.0)       1 (100.00)         With foreign body extraction       7 (11.86)       52 (88.14)         With foreign body extraction       7 (11.86)       52 (88.14)         Without foreign body extraction       2 (645)       29 (93.55)         Bron-toscopy complications       0.999 **       0.999 **         No       9 (10.11)       80 (89.89)         No       9 (10.00)       1 (100.00)	Yes	0(00.0)	6 (100.00)	
1 day or less       3 (27.27)       8 (72.73)         More than 1-2 days       5 (15.15)       28 (84.85)         3 -7       1 (3.85)       25 (96.15)         7 days and more       0 (00.0)       20 (100.00)         Diagnostic-therapeutic measures         CXR       0 (00.0)       1 (100.00)         CXR-bronchoscopy       9 (10.23)       79 (89.77)         CXR-bronchoscopy.       0 (00.0)       1 (100.00)         CXR-bronchoscopy.       0 (00.0)       1 (100.00)         Bronc-boscopy.       0 (00.0)       1 (100.00)         With foreign body extraction       7 (11.86)       52 (88.14)         With out foreign body extraction       7 (11.86)       52 (88.14)         Bronc-boscopy complications       0.999 **         No       9 (10.11)       80 (89.89)         No       9 (00.0)       1 (100.00)	Interval from aspiration to referral (days)			0.040 **
More than 1-2 days       5 (15.15)       28 (84.85)         3 - 7       1 (3.85)       25 (96.15)         7 days and more       0 (00.0)       20 (100.00)         Diagnostic-therapeutic measures         CXR       0 (00.0)       1 (100.00)         CXR-bronchoscopy       9 (10.23)       79 (89.77)         CXR-bronchoscopy- esophagoscopy       0 (00.0)       1 (100.00)         CXR-bronchoscopy- esophagoscopy       0 (00.0)       1 (100.00)         Bronc-boscopy result       7 (18.6)       52 (88.14)         With foreign body extraction       7 (18.6)       52 (88.14)         Without foreign body extraction       2 (6.45)       29 (93.55)         Bronc-boscopy complications       0 (00.0)       100.00         No       9 (10.11)       80 (89.89)         Hypoxemia       0 (00.0)       1 (100.00)	1 day or less	3 (27.27)	8 (72.73)	
3 · 7       1(3.85)       25 (96.15)         7 days and more       0 (00.0)       20 (100.00)         Diagnostic-therapeutic measures         CXR       0 (00.0)       1 (100.00)         CXR-bronchoscopy       9 (10.23)       79 (89.77)         CXR-bronchoscopy-esophagoscopy       0 (00.0)       1 (100.00)         Bronchoscopy result       0 (00.0)       1 (100.00)         With foreign body extraction       7 (11.86)       52 (88.14)         Without foreign body extraction       2 (6.45)       29 (93.55)         Bronchoscopy complications       0.909 **         No       9 (10.11)       80 (89.89)         Hypoxemia       0 (00.0)       1 (100.00)	More than 1 - 2 days	5 (15.15)	28 (84.85)	
7 days and more       0 (00.0)       20 (100.00)         Diagnostic-therapeutic measures       0.999 **         CXR       0 (00.0)       1 (100.00)         CXR-bronchoscopy       9 (10.23)       79 (89.77)         CXR-bronchoscopy- esophagoscopy       0 (00.0)       1 (100.00)         Bronchoscopy result       0 (00.0)       1 (100.00)         With foreign body extraction       7 (11.86)       52 (88.14)         Without foreign body extraction       2 (6.45)       29 (93.55)         Bronchoscopy complications       0.909 **         No       9 (10.11)       80 (89.89)         Hypoxemia       0 (00.0)       1 (100.00)	3-7	1 (3.85)	25 (96.15)	
Diagrostic-therapeutic measures       0.909 **         CXR       0(0.0.0)       1(100.00)         CXR-bronchoscopy       9(10.23)       79(89.77)         CXR-bronchoscopy-esophagoscopy       0(00.0)       1(100.00)         Bron-bscopy result       0.00.0)       1(100.00)         With foreign body extraction       7(11.86)       52 (88.14)         Without foreign body extraction       2(6.45)       29 (93.55)         Bron-bscopy complications       0.909 **         No       9 (10.11)       80 (89.89)         Hypoxemia       0 (00.0)       1 (100.00)	7 days and more	0(00.0)	20 (100.00)	
CXR       0 (00.0)       1 (100.00)         CXR-bronchoscopy       9 (10.23)       79 (89.77)         CXR-bronchoscopy-esophagoscopy       0 (00.0)       1 (100.00)         Bronchoscopy result       0 (00.0)       1 (100.00)         With foreign body extraction       7 (11.86)       52 (88.14)         Without foreign body extraction       2 (6.45)       29 (93.55)         Bronchoscopy complications       0.909 **         No       9 (10.11)       80 (89.89)         Hypoxemia       0 (00.0)       1 (100.00)	Diagnostic-therapeutic measures			0.999 **
CXR-bronchoscopy       9 (10.23)       79 (89.77)         CXR-bronchoscopy- esophagoscopy       0 (00.0)       1 (100.00)         Bronc-boscopy result       0 (00.0)       0.416*         With foreign body extraction       7 (11.86)       52 (88.14)         Without foreign body extraction       2 (6.45)       29 (93.55)         Bronc-boscopy complications       0.909 **         No       9 (10.11)       80 (89.89)         Hypoxemia       0 (00.0)       1 (100.00)	CXR	0(00.0)	1(100.00)	
CXR-bronchoscopy- esophagoscopy       0 (00.0)       1 (100.00)         Bronchoscopy result       0.416 *         With foreign body extraction       7 (11.86)       52 (88.14)         Without foreign body extraction       2 (6.45)       29 (93.55)         Bronchoscopy complications       0.999 **         No       9 (10.11)       80 (89.89)         Hypoxemia       0 (00.0)       1 (100.00)	CXR-bronchoscopy	9 (10.23)	79 (89.77)	
Bronchoscopy result         0.416*           With foreign body extraction         7(11.86)         52 (88.14)           Without foreign body extraction         2 (6.45)         29 (93.55)           Bronchoscopy complications         0.999**           No         9 (10.11)         80 (89.89)           Hypoxemia         0 (00.0)         1 (100.00)	CXR-bronchoscopy- esophagoscopy	0 (00.0)	1(100.00)	
With foreign body extraction         7 (11.86)         52 (88.14)           Without foreign body extraction         2 (6.45)         29 (93.55)           Bronchoscopy complications         0.999 **           No         9 (10.11)         80 (89.89)           Hypoxemia         0 (00.0)         1 (100.00)	Bronchoscopy result			0.416 *
Without foreign body extraction         2 (6.45)         29 (93.55)           Bronchoscopy complications         0.999 **           No         9 (10.11)         80 (89.89)           Hypoxemia         0 (00.0)         1 (100.00)	With foreign body extraction	7(11.86)	52 (88.14)	
Bronchoscopy complications         0.999 **           No         9 (10.11)         80 (89.89)           Hypoxemia         0 (00.0)         1 (100.00)	Without foreign body extraction	2 (6.45)	29 (93.55)	
No         9 (10.11)         80 (89.89)           Hypoxemia         0 (00.0)         1 (100.00)	Bronchoscopy complications			0.999 **
Hypoxemia 0 (00.0) 1 (100.00)	No	9 (10.11)	80 (89.89)	
	Hypoxemia	0(00.0)	1(100.00)	

Abbreviation: CXR, chest X-ray.

observed in other cases; nevertheless, the success rate in the study conducted by Haddadi et al. was reported to be 95.5% (2), which can be a symptom for increasing levels of knowledge and awareness and suspicion of aspiration. In the present study, none of the samples required postoperative respiratory support. According to the results, respiratory complications occurred in 17.8% of the patients. These complications were often observed as pneumonia and, to a lesser extent, pleural effusion as the result of the immune system response. Only one patient developed hypoxemia. This complication rate was somewhat lower than the results of other studies. According to Samarei, 24% of the patients developed cardiac and respiratory complications, and the most common complication was reported to be pneumonia (3). The lower incidence of respiratory complications might be due to using total intravenous anesthesia and drugs with rapid metabolism.

In this study, mean heart rate values before and after

bronchoscopy were 137.76  $\pm$  12.79 and 131.63  $\pm$  12.47 beats per minute, respectively. Systolic and diastolic blood pressure was calculated to be 92.11  $\pm$  6.40 and 59.78  $\pm$  6.74 mmHg, respectively. Based on the findings, the heart rate changes were significant in terms of the ventilation type; accordingly, the changes in the patients with controlled ventilation were higher than in patients with spontaneous ventilation (P = 0.05, borderline significance). However, given the proximity between numbers in the two groups, the interpretation of the results should be made with caution. Moreover, repeating the study with a larger sample size can be helpful in obtaining more reliable results. The findings also showed that the lower heart rate in the patients without respiratory complications was significantly higher than in those who experienced these complications.

According to the results of this study, the percentage of respiratory complications was observed to be signifi-

/ariables	Heart Rate Changes	Median	P Value
Gender			0.282
Male	$-6.55\pm7.27$	-7.00	
Female	$-5.56\pm9.82$	-5.00	
lge (y)			0.522
1-2	-6.56 $\pm$ 7.24	-7.00	
2-3	$-5.37\pm5.56$	-5.00	
3 - 4	$-10.11 \pm 17.19$	-7.00	
$\geq$ 4	$-2.29 \pm 10.36$	-7.00	
Comorbidity			0.222
No	$-6.35\pm8.54$	-6.50	
Yes	$-3.00\pm6.48$	-5.00	
nterval from aspiration to referral days)			0.149
1 day or less	$-8.82\pm4.19$	-7.00	
More than 1 - 2 days	$-6.85 \pm 10.03$	-7.00	
3-7	$-5.56\pm9.49$	-7.00	
7 days and more	$\textbf{-4.05} \pm \textbf{5.07}$	-5.00	
ype of ventilation			0.051
Spontaneous respiration	$-9.11 \pm 4.17$	-9.00	
Controlled respiration	$-5.79 \pm 8.73$	-6.00	
iagnostic-therapeutic measures			0.356
CXR-bronchoscopy	$-6.16\pm8.47$	-6.00	
CXR-bronchoscopy- esophagoscopy	-3.00 ± 0	-3.00	
Bronchoscopy result			0.267
With foreign body extraction	-5.69 ± 7.49	-6.00	
Without foreign body extraction	$\textbf{-6.94} \pm \textbf{10.07}$	-7.00	
Respiratory complications			0.031
No	$-7.05 \pm 8.23$	-7.00	
Yes	$-1.81 \pm 8.24$	-5.00	
Bronchoscopy complications			0.489
No	$-6.15 \pm 8.48$	-6.00	
Hypoxemia	$-4.00\pm0$	-4.00	

Abbreviation: CXR, chest X-ray.

<sup>a</sup> Values are expressed as mean  $\pm$  SD unless otherwise indicated.

cant in terms of foreign body extraction by bronchoscopy; accordingly, those with successful bronchoscopy accompanied by foreign body extraction were eight times more likely to have complications (P = 0.009), which is probably due to further manipulation of the airways for foreign body extraction; nonetheless, these complications have no significant relationship with the ventilation type. On the other hand, the relationship between arterial oxygen saturation and bronchoscopy complications was observed to be significant (P = 0.022). This finding was also followed by the manipulation of the airway for bronchoscopy and the occurrence of respiratory complications, which can be followed up by further studies. In a study by Mashhadi et al. oxygen saturation in patients with spontaneous ventilation was higher than in patients with controlled ventilation (18). According to Liu et al. oxygen saturation was not significant in a variety of spontaneous and controlled ventilation methods during rigid bronchoscopy; nevertheless, the prevalence of laryngospasm and duration of bronchoscopy in controlled ventilation were reported to be lower (16). However, in some other studies, such as Sadeghi et al.'s study no significant difference was observed between the two groups with spontaneous and controlled ventilation in terms of anesthesia duration, bronchoscopy time, intensive care unit stay duration, recovery time, and complications (17).

The current evidence does not show a preference for either controlled ventilation or spontaneous respiration, although laryngospasm has a lower incidence when controlled ventilation is performed (16). Liu et al. performed a meta-analysis to compare controlled ventilation and spontaneous respiration with respect to complications, operation duration, and anesthesia recovery time. They studied 423 subjects that received controlled ventilation in comparison to 441 subjects that received spontaneous respiration. There was no significant difference in the incidence of desaturation between controlled ventilation and spontaneous respiration [odds ratio (OR) = 0.70; 95% CI: 0.30 -1.63]. However, the incidence of laryngospasm was lower when controlled ventilation was performed (OR = 0.27; 95% CI: 0.10 - 0.76). The operation time (mean difference = -9.07 minutes; 95% CI: -14.03 to -4.12) was shorter in the controlled ventilation group (16). The results of the aforementioned study are similar to the conclusion of the present study. Finally, Liu et al. recommended that additional clinical studies are required to substantiate this issue (16).

Sadeghi et al. studied the ventilation of patients undergoing rigid bronchoscopy and concluded that patients with spontaneous respiration and controlled ventilation during rigid bronchoscopy have a similar outcome during and after the procedure. However, the authors of the present study strongly recommend further investigations in this regard (17). Sadeghi et al. also strongly recommend further investigations in this regard (17). The results of the aforementioned study are similar to the results of the present study regarding the same outcome between two types of ventilation. Mashhadi et al. performed a clinical trial and investigated the type of ventilation during bronchoscopy. Mashhadi et al. found that the controlled ventilation group had significantly fewer complications, and surgeon comfort was significantly higher in this group. Oxygen desaturation was significantly more prevalent in the spontaneous ventilation group during laryngoscopy and bronchoscopy (P < 0.001)(18). Although in the current study, no preference was observed between spontaneous and controlled ventilation during rigid bronchoscopy in the patients with foreign body aspiration.

In the present study, the average length of hospital stay was 1.89  $\pm$  1.60 days. According to the results, the length of hospital stay was significant in terms of respiratory complications; accordingly, the subjects with respiratory complications were hospitalized longer (P < 0.001). The type of ventilation was also significant in terms of the interval from foreign body aspiration to referral to the hospital. Therefore, the percentage of spontaneous ventilation in the individuals who delayed the referral for less than a day (27.27%) was higher than in others, which could be a symptom of unstable clinical conditions and the presence of more symptoms and respiratory problems prior to bronchoscopy. No deaths were reported in any of the studied cases. In this regard, Bakal et al. also showed a higher prevalence of complications in individuals who were re-

ferred more than 24 hours after aspiration (4). Foreign bodies in the airways lead to inflammatory reactions by stimulating the immune system and can be emerged as pneumonia, pleural effusion, and pulmonary abscesses in chronic cases. Therefore, in children with recurrent pneumonia, foreign body aspiration should be regarded as one of the differential diagnoses for physicians.

# 5.1. Limitations

One of the most important limitations of this study was that most patients were brought to the operating room urgently, thereby making it difficult to take a history, perform a physical examination, and obtain complete file information.

#### 5.2. Conclusions

According to the results of this study, foreign body aspiration occurred more frequently in male subjects younger than 2 years. The most common clinical signs were cough and wheezing, and the most common findings in examinations were wheezing and unilateral decreasing breathing sounds. Bronchoscopy was successful, accompanied by foreign body extraction in 65.6% of the patients who experienced more pulmonary complications. The relationship of the ventilation method was not significant with changes in blood pressure, length of hospital stay, pulmonary complications, and oxygen saturation; however, individuals with spontaneous ventilation were referred in shorter intervals from the aspiration and experienced fewer heart rate changes. No deaths were reported in any of the participants.

According to the results of this study and the currently available data in the literature, there was no preference between spontaneous and controlled ventilation during rigid bronchoscopy in patients with foreign body aspiration. However, the ventilation method should be planned based on medical history, clinical signs and symptoms, and diagnostic imaging. In addition, there is a need for further studies to introduce a definitive recommendation on the choice of controlled or spontaneous ventilation in the management of foreign body aspiration in children.

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#### Footnotes

Authors' Contribution: Study concept and design, Haddadi, Parvizi, and Babaei; Acquisition of the data, Haddadi, Parvizi, and Babaei; Analysis and interpretation of the data, Kazem Nejad; Drafting of the manuscript, Haddadi, Parvizi, Babaei, Nemati, and Kazem Nejad; Critical revision of the manuscript for important intellectual content, Haddadi and Parvizi; Statistical analysis, Kazem Nejad; Administrative, technical, and material support, Haddadi, Parvizi, and Kazem Nejad; Study supervision, Haddadi and Parvizi.

**Conflict of Interests:** Authors declare no conflict of interests.

**Ethical Approval:** IR.GUMS.REC.1398.333 (ethics.research.ac.ir/EthicsProposalViewEn.php?id=86500)

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**Informed Consent:** This was a retrospective study, and there was no informed consent.

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