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Evaluation of the Accuracy of CT scan with the COVID-19 Protocol in Detecting the Location of Foreign Body Aspiration

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Abstract

Background: Ingestion of foreign body by children is one of the common problems that society and medical staff are always struggling with. Due to the fact that children put any nearby objects in their mouths during the phase of knowing the world around them, they are prone to swallowing a foreign object and getting it choked. It also happens during eating. The best method to diagnose and manage a foreign body aspiration is bronchoscopy, but this procedure has its own problems, such as the need for anesthesia.

Aim: In this study, we decided to investigate the accuracy of CT scan with the COVID-19 protocol in detecting the location of foreign body aspiration.

Methods: In this diagnostic study, all children with foreign body aspiration referred to Mofid Children Hospital from March 2018 to September 2021 were evaluated. Patients' information, including age, sex, locations of foreign body, radiographic report, bronchoscopy report, and CT scan report were checked and recorded. The diagnostic values of CT scan were compared with the diagnostic values of bronchoscopy results as a standard method.

Results: 193 children were evaluated. The mean age was 26.01 ± 21.83 months and 65.3% were boys. The sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of this method were 95.52%, 97.96%, 98.46%, 94.12%, and 96.55%, respectively.

Conclusion: CT-scan with the COVID-19 protocol is a good method to localize the location of the foreign body.

Conflicts of Interest: The Authors declare no conflicts of interest.
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Introduction

Foreign body aspiration is one of the important causes of death in children for anatomical and developmental reasons. Choking is usually defined as a swallowed foreign body, causing different amounts of airway obstruction. Obstruction can lead to problems in ventilation and oxygenation that makes complications or mortality. Materials that are mostly involved in aspiration in children include food, coins, toys and balloons. The main cause of death is hypoxic-ischemic brain damage and less common is alveolar hemorrhage (1-4).

In 2016, fatal choking in American children less than 5 years in the general population was 0.43 per 100,000. Another study that analyzed children under 14 years found a relatively higher rate of choking about 20.4 per 100,000. There was no statistical significant difference between sex in terms of choking (5, 6). Patients may be completely asymptomatic, and only

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some evidences of aspiration may be found during a history taking. However, it has been found that sudden starting cough, choking or shortness of breath are the most common symptoms.

A prospective study mentioned 91.1 % sensitivity and 45.2 % for choking and acute cough. Wheezing is a main physical finding and is recorded in one study in 60 % of cases. It has been observed that an abnormal physical examination has a sensitivity of 80.4% and a specificity of 59.5% for foreign body aspiration (7- 9).

Chest X-ray is often used as a primary evaluation for examining foreign body aspiration. Radiological findings in accordance with foreign body aspiration include atelectasia, pneumothorax and air trapping. However, numerous studies have shown that chest radiography is often normal (10-12).

CT scan is effective in detecting more foreign objects as well as helping to remove them by explicitly localizing the object in the tissue. The CT scan acts similar to radiography, but has an improved ability to differentiate tissue density and enables better visualization of inflammation, abscesses, and granulomas, most of which remain secondary clues to the foreign body. The added advantage of the CT scan is that it can provide a more accurate 3D location of the foreign body. A study showed 68 % sensitivity and 98 % feature to detect a variety of foreign objects using CT imaging. On the other hand, CT is also associated with increased cost and dose of beam for the patient and less diagnostic accuracy in some studies (13-17).

Recently, following the global outbreak of COVID-19, one of the methods used in a low-dose radiation is CT scan with the COVID-19 protocol for the diagnosis of pulmonary involvement of Coronavirus (18-19). The aim of this study was to evaluate the accuracy of CT scan with the COVID-19 protocol in the diagnosis of foreign body aspiration.

Methods

In this diagnostic study, all children with aspirations of foreign body who were referred to the Mofid Children Hospital (Tehran, Iran) from March 2018 to September 2021 were assessed. These children were evaluated by CT scans with the Corona protocol and then bronchoscopy. The inclusion criterion was a history and physical examination suggesting foreign body aspiration. The exclusion criteria were unwillingness to participate in the study, not performing bronchoscopies or CT scan.

The used protocol for CT scan included low dose of radiation, single phase (if possible), thin-section, and CT of the entire chest without IV contrast (apex to the base) (20).

Patient information including age, gender, location of foreign body, bronchoscopy and CT scan reports were reviewed and recorded. The CT scans results were compared with bronchoscopy results as the gold standard method (21). To evaluate the diagnostic value of the CT scan, bronchoscopy was considered as the golden standard. Sensitivity, Specificity, Accuracy, Negative Predictive Value (NPV), and Positive Predictive Value (PPV) were measured. An expert radiologist with over 5 years of experience in the center read and reported a CT scan of all patients in the study. Then, after 15 days, the radiologist reported the CT scans again. Also, all CT scans were read another time by another expert radiologist and all results were compared.

Statistical analysis

The mean, standard deviation, frequency, and percentage were used to describe the data. Cronbach's alpha and kappa statistics were used to check the agreement between the two methods. All analyzes were performed by SPSS 25.0 statistical software. P-value less than 0.05 was considered statistically significant.

Ethical consideration

The ethics of the research were respected and the information of all patients kept secret. This study obtained the ethics code from the Ethical

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Results

In this study, 193 patients, with a mean age of 26.01 ± 21.83 months (8 to 144 months), including 126 (65.3%) boys and 67 (34.7%) girls were evaluated. 182 (94.3%) patients had no underlying disease and 11 (5.7%) had underlying disease. The CT results were read twice by an experienced radiologist with a time gap and once by a second radiologist, and the results were the same. The CT scan results included three categories: normal cases, left lung involvement, and right lung involvement, while the bronchoscopy included two categories: right lung involvement and left lung involvement; because the inclusion criteria for bronchoscopy was proven involvement. For this reason, to calculate the Kappa index to determine the agreement between the two methods, only patients with diagnoses of right and left lung involvement were used in both methods. In other words, patients with normal diagnosis by CT method were ignored and then, Kappa agreement coefficient was calculated (Tables 1 and 2).

Table1. The frequency of detection of two methods

		CT scan involvement		Total
		Right lung	Left lung	
Bronchoscopy	Right lung	64	1	65
	Left lung	3	48	51
Total		**67**	**49**	**116**

The Kappa correlation coefficient was 0.93 (p- value <0.001) and it indicates the high level of agreement between the two methods in the diagnosis of foreign body.

The most common foreign body was food (88.1%) and the most common food was peanuts and then sunflower seeds. About other foreign bodies it was seen that organic foreign bodies in 5.2%, metal foreign bodies in 3.6%, and plastic foreign bodies in 3.1% were swallowed.

Table 2. The level of agreement in the diagnosis of the two methods

	Value	df	Asymptotic Significance (2-sided)	P-value (2-sided)	P-value (1-sided)
Pearson Chi-Square	100.392[a]	1	<0.001		
Continuity Correction	96.633	1	<0.001		
Likelihood Ratio	124.853	1	<0.001		
Fisher's Exact Test				<0.001	<0.001
Linear-by-Linear Association	99.526	1	<0.001		
Measure of Agreement, Kappa	0.930			P-value<0.001 Approximate T=10.02	

Table3. Diagnostic values of CT scan

sensitivity	95.52%	87.47% to 99.07%
Specificity	97.96%	89.15% to 99.95%
Positive Predictive Value	98.46%	90.19% to 99.78%
Negative Predictive Value	94.12%	84.10% to 97.98%
Accuracy	96.55%	91.41% to 99.05%

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In table 2 the diagnostic value of CT scan was assessed. We considered bronchoscopy as a gold standard and we compared CT findings with bronchoscopic findings.

Discussion

This study was conducted with the aim of investigating the diagnostic value of CT scan with the COVID-19 protocol in detecting foreign body aspiration. 193 children with the mean age of 26.01± 21.83 months (65.3% boys) were evaluated. The diagnostic values of CT scan were as following: the sensitivity was 95.52%, the specificity was 97.96%, and the accuracy of CT scan was 96.55%.

Children are prone to accidents due to their curiosity and taking any objects and materials and manipulating them. Due to the urgency and complications, foreign body incidents in the ear, mouth and throat, nose and airways are considered as one of the most important diagnostic and interventional issues in children. So that despite the progress of science and technology, one of the most important reasons for the death of children younger than five years old is airway obstruction due to the aspiration of a foreign body (22). In the United States of America, 2000 children under 5 years of age are admitted to the hospital due to ingestion and aspiration of foreign bodies, and foreign body aspiration is the cause of death in 7% of children under 4 years of age (23, 24). In children under five years old, 84% of cases of suffocation are caused by foreign body aspiration and 73% of these cases belong to children under three years old (25). In the current study, it was also seen that the mean age of the children was 26.01± 21.83 months and the most ingested foreign material was food (88.1%). It has also been seen in studies that the most swallowed foreign body that causes choking in children is food. The most common food that was aspirated was hotdog but in the present study it was peanut (26). In the study of Aras et al., it was seen that metal, glass and stone can be identified by X-ray radiography, CT scan, and ultrasound in all weights. In contrast, foreign bodies with low radio-opacity, which were detectable by CT, became less visible or almost invisible in muscle and interosseous tissue. Ultrasound performance is relatively better than CT for visualization of foreign bodies with low radiopacity. The conclusion was that ultrasound detects and localizes foreign bodies in surface (in neck) with low radiopacity in body tissues more effectively than CT and conventional plain radiography. However, CT is a more effective method for visualizing foreign bodies in Bronchi than ultrasound and conventional plain radiography (27). Aras et al.'s study did not evaluate the accuracy of CT scan, but emphasized that CT scan is a suitable method for detecting foreign bodies that are not located near the body surface. In fact, based on this study, it seems that when a swallowed foreign object passes through the neck lining and is lodged in the chest lining, CT scan works better than ultrasound. This issue was not investigated in our study, but it was seen that the diagnostic accuracy of CT scan for foreign body detection in children was 96.55%. Based on our study, the CT scan with COVID-19 protocol can detect the foreign bodies in lungs with high accuracy rate and its diagnostic accuracy is equal to bronchoscopy, approximately.

In the study by Gibbons et al., which was conducted with a method almost similar to the current study, it was seen that there was 100% sensitivity, 98% specificity for the CT scan as a diagnostic method for detection of foreign body aspiration. The conclusion was that CT is an accurate and reliable diagnostic tool in foreign body evaluation (28). In the current study, it was seen the sensitivity was 95.52% and the specificity in correct diagnosis was 97.96%. These findings were similar to the findings of Gibbons et al's study. Based on these two studies it can be said that CT scan is a good method for detection of the location of foreign bodies in lungs. Based on our study, the CT scan with the COVID-19 protocol can be used

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widely for foreign body aspiration diagnosis because it has low level of radiation and can be safer for children.

In the study by Pitiot et al., NPV for CT was 99.2% and PPV was 83.8%. The conclusion was that the use of CT scanning with multilevel reconstruction in suspected foreign body aspiration is a safe alternative to endoscopy under general anesthesia, especially in asymptomatic patients (29). In our study, it was seen that the NPV for CT was 94.12% and PPV was 98.46%. Our findings were similar to Pitiot et al.'s study, although the methods of CT scanning were different between the two studies. In the present study the CT scans were performed with COVID-19 protocol but in the Pitiot et al.'s study, the CT scans were done with the multiplanar reconstruction method. Of the benefits of CT scanning with COVID-19 protocol is that children receive low dose of radiation with this protocol and it can be preferred by physicians.

In Gordon et al.'s study, data of 136 children were collected. It was seen that the effective doses used in ultra-low-dose CT examinations were lower compared to conventional methods ($p < 0.001$). The mean dose for CT was 0.04 mSv compared to 0.1 mSv for conventional procedures. Sensitivity and specificity for ultra-low-dose CT were higher than conventional methods (100% and 98% vs. 33% and 96%) and also positive and negative predictive values (90% and 100% vs. 60% and 91%). It was concluded that ultra-low-dose CT can be used as the imaging of choice in the diagnosis of airway foreign body aspiration in the emergency setting (30).

In the current study, CT scan was performed with very low dose radiation, which was similar to the study by Gordon et al.'s study. In Gordon et al.'s study, CT scan with low dose was compared to CT scan with a normal dose, while in our study CT scan with low dose was compared to bronchoscopy as the gold standard. This was one of the differences between the two studies. In our study it was seen that sensitivity was 95.52%, specificity was 97.96%, PPV was 98.46% and NPV was 94.12%. Based on our findings the specificity, negative and positive predictive values were higher in CT scanning with COVID-19 protocol than ultra-low-dose CT protocol. Comparison between these two studies shows COVID-19 protocol has better diagnostic values than ultra-low-dose CT protocol. Gordon et al concluded that ultra-low-dose CT can be used as the imaging of choice in the diagnosis of airway foreign body aspiration in the emergency setting. Based on our findings, it can be said that CT scan with COVID-19 protocol is preferable method for diagnosis of foreign body aspiration than ultra-low-dose CT scanning because the specificity, negative and positive predictive values were higher in CT scanning with COVID-19 protocol and in emergency department it can be used as a routine method for the diagnosis of the location of foreign body in lungs.

Conclusion

It is concluded that CT scan with the COVID-19 protocol is effective in children who have a complaint of foreign body aspiration. This method's sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy are 95.52%, 97.96%, 98.46%, 94.12%, and 96.55%, respectively. CT scan with the COVID-19 protocol can be used in children with the complaint of foreign body aspiration instead of bronchoscopy because it has no need to general anesthesia compared to bronchoscopy and has low dose of radiation and also it has diagnostic values near to bronchoscopy.

It is suggested that in the future, studies with a larger statistical population be conducted to evaluate the accuracy of CT scanning in the diagnosis of foreign body aspiration in children and adults.

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Conflicts of Interest

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Ethics

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