

Validity of Chest X-Ray in the Diagnosis of Airway Foreign Body; Analysis of 112 Cases

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ABSTRACT

Objective: To find out the validity of chest x-ray (CXR) in patients suspected of foreign body (FB) aspiration in our population considering bronchoscopy and/or thoracotomy as gold standards.

Study Design: A prospective validation study.

Place and Duration of Study: Departments of thoracic surgery, otorhinolaryngology, and diagnostic radiology from Combined Military Hospitals of Rawalpindi, Lahore, Malir, and Quetta and Pakistan Naval Ship Shifa, Karachi Pakistan, from Aug 2006 to Nov 2017.

Methodology: We included consecutive patients who underwent bronchoscopy and/or thoracotomy for suspected FB aspiration and recorded the findings observed on bronchoscopy and/or thoracotomy. The available radiological data pertinent to all included patients were recovered from the patients and the respective radiological departments. The CXRs were carried out in poster anterior or anteroposterior and lateral views and reviewed by consultant radiologists. All bronchoscopies were done using Karl Storz Ventilating Bronchoscopes.

Results: Out of 112 patients with FB aspiration, (mean age: 6 ± 7 years, range 1-45 years), 77 (68.8%) cases were male and 35 (31.3%) were females. Chest x-rays were normal in 27(24.1%) cases, while in 85 (75.9%) cases, a direct or indirect evidence of FB aspiration was observed. The commonest radiological finding was a radiopaque FB in 31(27.7%) cases. The sensitivity of CXR was 76.4%, while specificity was 50%, with positive predictive value of 98.8%, and negative predictive value of 3.7%. The accuracy rate was 76%.

Conclusion: Chest x-ray is a good screening tool for the diagnosis of airway FB but a normal CXR does not always rule out FB aspiration in patients with a positive clinical evaluation.

Keywords: Aspiration, Bronchoscopy, Chest x-ray, Foreign body, Validation.

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INTRODUCTION

Foreign body (FB) aspiration is the introduction of solid matter into the airway at the level of the glottal opening, larynx, trachea, or bronchi. It is the major cause of mortality and morbidity the world over. Morbidity associated with FB aspiration can be either instant or delayed. Instant morbidity usually occurs when the FB becomes lodged in the glottal opening, larynx, or trachea, partially or completely obstructing the movement of air to both lungs. Instant morbidity includes respiratory arrest, pulmonary edema, pneumothorax, pneumomediastinum, subcutaneous emphysema, hypoxic neurologic damage, and cardiac arrest. Delayed morbidity usually occurs when the FB lodges in one of the main or distal bronchi, obstructing airflow to the lung distal to the blockage. Delayed morbidity includes recurrent pneumonia, bronchiectasis, and pyelonephro-mothorax.

Timely diagnosis and management of FB aspira-

tion can prevent mortality and morbidity associated with FB aspiration. Since its inception, chest x-ray (CXR) has been in use for the diagnosis of unexplained respiratory symptoms and ailments including FB aspirations. It remained the only principal investigation of choice for FB aspiration cases till the advent of computerized tomographic (CT) scan. The multi-planar CT scan and virtual bronchoscopy have taken the initial evaluation of suspected FB aspiration to further heights. The significance of these investigations becomes critical in cases of small children and mentally retarded, intoxicated, and unconscious adults, where the clinical picture or presentation of FB aspiration is always dubious. Although bronchoscopy is the mainstay of diagnosis and treatment in these cases, it is a highly risky procedure and one has to be hundred percent sure of aspiration, location of FB, and at times, type of FB. Also, as the majority of the population in developing countries like Pakistan lives in areas where specialized procedures like bronchoscopy are unavailable, the only supportive investigation that is available is a CXR. So, the importance of CXR in suspected FB

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aspiration cannot be underestimated. In this study also, we tried to find out how valid a CXR is, in patients with suspected FB aspiration, based on results in the Pakistani population. The bronchoscopy and/or thoracotomy were considered the gold standard in our study

METHODOLOGY

This was a prospective validation study carried out in: Departments of thoracic surgery, otorhinolaryngology, and diagnostic radiology from Combined Military Hospitals of Rawalpindi, Lahore, Malir, and Quetta and Pakistan Naval Ship Shifa, Karachi, from Aug 2006 to Nov 2017.

A sample size of 112 was calculated using a sample size calculator¹ while using a sensitivity of 2 (60%), specificity of 2 (32%), expected prevalence of 46.9%³, desired precision of 0.1, and confidence level of 90%.

Inclusion Criteria: Consecutive patients who underwent bronchoscopy and/or thoracotomy for suspected FB aspiration.

After permission from the institutional ethical review committee and written informed consent from all patients or their caregivers, we recorded the findings observed on bronchoscopy and/or thoracotomy, along with the age and gender of the patient on a proforma. The available radiological data pertinent to all included patients were recovered from the patients and the respective radiological departments.

All the CXRs in posteroanterior (PA) or anteroposterior (AP) and lateral views were carried out using the Shimadzu R-20J x-ray system (Shimadzu Corporation, Kyoto, Japan) and GE 5135678-3 x-ray system (GE Hualun Medical Systems Company, Beijing, China). The CXRs were reviewed by consultant radiologists. All bronchoscopies were done using Karl Storz Ventilating Bronchoscope (Karl Storz SE & Co., Tuttlingen, Germany)

The Statistical Package for Social Sciences ver 20 (IBM Corp., Armonk, NY, USA) and Med Calc v 14.8.1 (MedCalc Software, Ostend, Belgium) were used for the statistical analysis. Means and standard deviations were calculated for quantitative variables and frequencies as well as percentages were calculated for the qualitative variables. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), were also calculated through the software. The accuracy of CXR for FB aspiration was estimated

through the following formula: Accuracy = $\frac{TP+TN}{TP+TN+FP+FN} \times 100$ Where;

TP: True positive (Positive on CXR and bronchoscopic and/or thoracotomy evaluation). FP: False positive (Positive on CXR and negative on bronchoscopic and/or thoracotomy evaluation). TN: True negative (Negative on CXR and bronchoscopic and/or thoracotomy evaluation). FN: False negative (Negative on CXR and positive on bronchoscopic and/or thoracotomy evaluation).

RESULTS

Out of 112 patients with FB aspiration, (mean age: 6 ± 7 years, range 1-45 years), 77 (68.8%) cases were male and 35 (31.3%) were females (male to female ratio: 2.2:1). Chest x-rays were normal in 27 (24.1%) cases, while in 85 (75.9%) cases, a direct or indirect evidence of FB aspiration was observed. The commonest radiological finding was a radiopaque FB in 31 (27.7 %) cases (Figure-1).

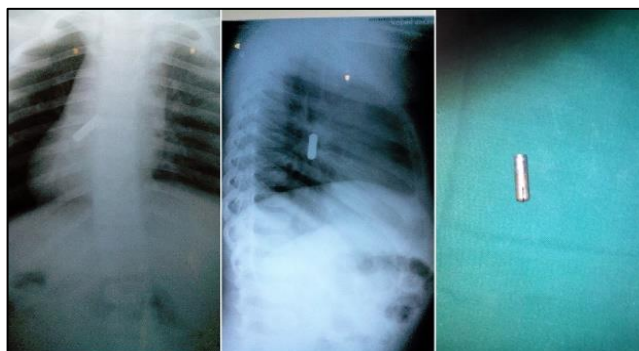


Figure-1: Figure showing radiopaque foreign body in chest x-ray.

This was followed by air trapping, 24 (21.4%) (Figure-2), segmental or lobar collapse, 12 (10.7%) (Figure-3), pneumonia 11 (9.8%), and non-specific infiltration, 7 (6.3%).

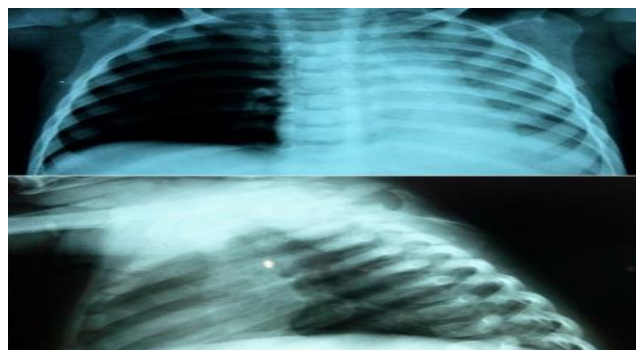


Figure-2: Chest x-ray showing right sided air trapping.

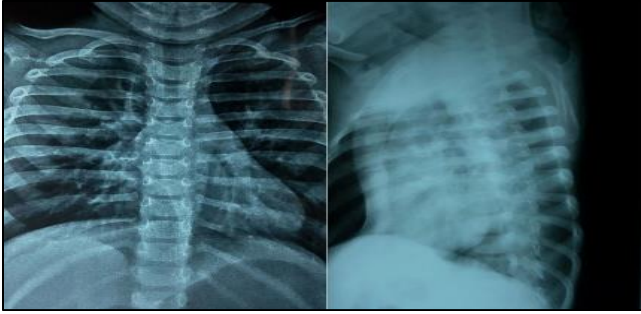


Figure-3: Chest x-ray showing lobar collapse in right lung.

Eighty-four radiologically positive patients had positive findings on bronchoscopy and/or thoracotomy, while one had a negative broncho-scopic evaluation (Table).

Table: Table showing cross-tabulation of positives and negatives on chest x-ray and bronchoscopy and/or thoracotomy.

Chest X-ray	Bronchoscopy/Thoracotomy	
	Positive	Negative
Positive	84	1
Negative	26	1

After analysis through the software, the sensitivity of CXR in the diagnosis of airway FB was 76.4%, while specificity was 50%, with PPV of 98.8%, and NPV of 3.7%. The accuracy rate calculated through the above-mentioned formula was 76%. The receiver operating characteristic curve interpreting sensitivity and specificity levels has been presented in Figure-4.

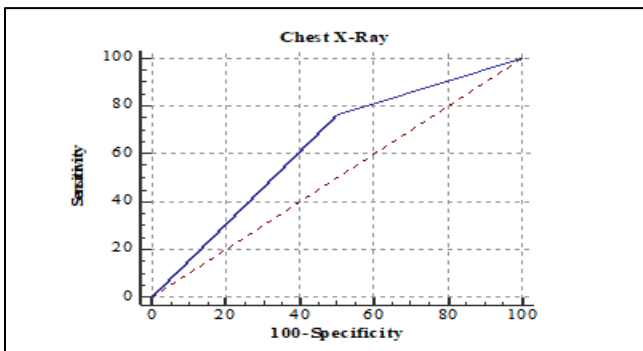


Figure-4: Receiver operating characteristic curve interpreting sensitivity and specificity levels among patients.

DISCUSSION

Diagnosis of FB aspiration begins with patient history and clinical examination and can be strengthened by radiological findings. Presenting symptoms for aspiration of a FB may be nonspecific and can include coughing, wheezing, shortness of breath, and fever. Eliciting a careful history of any episode of

choking, especially one associated with sudden onset of cough or shortness of breath, may prove important in not missing the diagnosis. Often the initial event lasts only for seconds to minutes and is followed by a period of no symptoms, misinterpreted as resolution by the patient and/or family. The re-emergence of symptoms of cough, wheeze, or dyspnea can often then be interpreted as acute pneumonia, asthma exacerbation, bronchiolitis, or croup. When examined, patients with FB aspiration may have focal wheezing or decreased air entry, but they might also have generalized wheezing or even a clear chest. If secondary pneumonia has developed, there may also be dullness to percussion or crackles on auscultation.

Radiographs are commonly performed in patients with suspected FB aspiration. Screening radiographic studies include AP and lateral imaging of the soft tissues of the neck, inspiratory and expiratory PACXRs, and lateral CXRs. Metallic FB are easily identified on CXRs; however, most inhaled FB are radiolucent and can be suggested only by secondary changes.² These include segmental or lobar collapse (Figure-2), air trapping (Figure-3), lobar or segmental infiltrates, or other chronic lung changes.² Nevertheless, these findings are nonspecific and are also found in patients without FB aspiration.

The male to female ratio of 2.2:1 was reported in our study. Similarly, male predominance was reported by other studies in the medical literature.^{4,6} The reason for male predominance remains unclear, however, some authors have attributed this to the more adventurous and impulsive nature of young boys.

In our study, 27(24.1%) patients with suspicion of FB aspiration had normal CXR. The relevant medical literature has reported a wide range of the percentage of negative CXRs in suspected airway FB starting from 8.7% to as high as 60%^{4,18} Liang *et al*,¹⁹ have reported an unusually low percentage of 0.75% of negative CXRs in such cases. We found the sensitivity and severity of CXRs to be 76.4% and 50% respectively. Sattar and colleagues found the sensitivity and specificity of CXRs in FB detection as 66.6% and 50% respectively.¹⁸ Svedstrom and colleagues,²⁰ found that the diagnostic accuracy, sensitivity, and specificity of CXRs in the diagnosis of tracheobronchial FBs were 67%, 68%, and 67%, respectively. Normal CXR findings were obtained in 24% of patients who had bronchoscopically verified airway FB. Koşucu and the coworkers had found a sensitivity of 60% and a specificity of 32% respec-

tively.²In their study of patients with laryngotracheal FBs, Esclamado and colleagues,²¹ reported that 92% of neck radiographs showed an infraglottic density or swelling and therefore suggested that PA and lateral neck radiographs should be part of the radiographic workup when FB aspiration is a concern. In contrast, 58% of the patients in their study who had laryngotracheal FB had normal CXR findings. Thus, CXR may not be sufficiently sensitive nor specific for the diagnosis of FB aspiration. However, its importance in suggesting the type of bronchoscopy cannot be overlooked and, therefore, it has been included in the clinical algorithm for children with suspected FB aspiration.²²

The CXRs in the bulk (27.9%) of our sample showed a radiopaque FB making the diagnosis obvious on CXR, otherwise, a radiolucent FB could have become a great diagnostic dilemma inculcating a high index of suspicion. The second most common finding was air trapping seen in 21.6% of CXRs. Kaddah and Ahmed,⁸ and Liang and colleagues,¹⁹ also found radiopaque FB in most (78.8% and 67.5% respectively) of the sampled individuals. Yetim and colleagues,¹⁵ observed radiopaque FB in the majority (59.5%) of cases followed by air trapping observed in 19% of cases. Arif *et al*,¹¹ Mallick,²³ Ullah *et al*,¹⁷ Sattar *et al*,¹⁸ Dar *et al*,⁹ Kosucu *et al*,² Naragund *et al*,¹⁰ Janahi *et al*,²² and Memon *et al*,⁷ reported air trapping as the most common complication of FB aspiration seen on CXRs while Fraga *et al*,¹⁴ Sumanth *et al*,⁴ Jaswal *et al*,⁵ El dine Hamed *et al*,²⁴ and Shah *et al*,¹³ found segmental or lobar collapse as the most common finding in 38.8%, 34.7%, 41.65%, and 20.8% of the sample respectively. Sehgal *et al*,¹⁶ reported pneumonia in the CXRs of the maximum number (30.8%) of selected cases.

Though x-rays give some direct or indirect signs of FB aspiration, ultimately, the airways need to be examined directly in all cases. Because complications such as pneumonia, granulation tissue formation, and bronchiectasis increase if the diagnosis is delayed, moving toward bronchoscopy early in the evaluation is preferred. Flexible bronchoscopy is generally the investigation of choice. Flexible bronchoscopy allows a complete airway evaluation to find potential FBs. If there is no FB, then the complete examination and bronchoalveolar lavage will help determine the cause of the respiratory symptoms. In only very limited cases, with experienced hands, should FB removal be attempted with flexible bronchoscopy because grasping FBs with forceps out the end of a bronchoscope

could easily lead to dislodgement of the object and acute airway obstruction. If a FB is detected on flexible bronchoscopy, the patient should undergo rigid bronchoscopy for removal.²⁵ Rigid bronchoscopy allows ventilatory control of the airway, excellent visualization, and the ability to use a wide variety of forceps and other instruments to remove the FB. If the object becomes dislodged during rigid bronchoscopy, it is more easily retrieved while continuing to ventilate the child adequately.

If there has been the development of infection or airway obstruction with granulation tissue because of a FB, the child should be treated with appropriate antibiotics and steroids to decrease airway inflammation. Repeat evaluation of the airway may be necessary to ensure the removal of all foreign objects, to re-evaluate the development of granulation tissue, or to assess ongoing infection. Most children do well and recover fully, but having a high index of suspicion for FB aspiration will help resolve symptoms quickly and prevent complications.

CONCLUSION

Chest x-ray with a sensitivity of 76.4% and accuracy rate of 76% is a good screening tool for the diagnosis of airway FB but a normal CXR does not always rule out FB aspiration in patients with a positive clinical evaluation.

Conflict of Interest: None.

Author's Contribution

MR: Conception, data collection, manuscript writing, HS: Conception, data collection, SBA: Manuscript writing, data analysis, interpretation, IUB: Manuscript review, RH: Data analysis, FM: Manuscript writing.

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