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THE INTERRELATIONS OF RADIOLOGIC FINDINGS AND MECHANICAL VENTILATION AND ADMISSION TO INTENSIVE CARE UNIT IN PNEUMONIA PATIENTS IN DAMASCUS HOSPITAL

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ABSTRACT

Background: Chest X-rays (X-Ray) and Computed Tomography (CT) scans are essential tools for diagnosing lung disease in critically ill patients admitted to intensive care units. These studies provide valuable information about the type and severity of lung injury. One of the most common findings in these examinations is consolidation, which appears as areas filled with fluid or pus instead of the normal air-filled alveoli in the lungs. The size and distribution of these consolidations can vary. In bronchopneumonia, a common pattern seen in ICU patients, multiple lobes of the lungs are often affected. In contrast, lobar pneumonia appears more localized, affecting an entire lobe. As the infection progresses and lung damage worsens, ICU patients may exhibit additional distinctive findings. Pleural effusion, which is accumulation of fluid between the lung and chest wall, and may restrict lung expansion. In some cases, CT scans may reveal air pockets within lung tissues, a condition known as cavitation. While specific radiographic features can help identify the causative agent of pneumonia, these common abnormalities—consolidations, pleural effusion, and cavitation—are often the first indicators alerting doctors to the presence of critical pulmonary infection that requires intensive treatment. **Methods:** This retrospective cohort study included cases of pneumonia reviewed in Damascus hospital in Damascus, Syria. Samples were collected from patient records in the Pulmonary Internal Medicine Department. The Chi-Square test was used to assess whether there was a relationship between radiological findings and clinical outcomes. Relative Risk (RR) was calculated for statistically significant variables. **Results:** Among 205 pneumonia cases, the ICU admission rate was 29.8%, while the mechanical ventilation rate was 14.1%. Consolidation was the most common radiological finding on simple chest radiography, observed in half of the cases. Only 26 patients underwent CT scanning, with consolidation being the most common finding (69.2%), followed by ground-glass opacity (23.1%). Half of the cases showed bilateral injury. Among ICU-admitted patients, 68.9% had bilateral injury on simple chest radiography. Among ICU-admitted patients who underwent CT scanning, ground-glass opacity was diagnosed in more than half, with a statistically significant relationship ($P<0.05$). Additionally, most of them had bilateral injury on CT scan (58.7%) with a statistically significant relationship ($P<0.05$). Among mechanically ventilated patients who underwent CT scanning, three-quarters (75%) had ground-glass opacity, with a statistically significant relationship ($P<0.05$). **Conclusion:** The results of this study reveal potential associations between radiological findings on simple chest radiography and CT scan and the need for ICU admission and mechanical ventilation in pneumonia patients. Further studies are needed to support and generalize these findings.

KEYWORDS: Radiography, Thoracic, Pneumoniae, Imaging, Critical care.

INTRODUCTION

Pneumonia poses a significant challenge in intensive care units (ICUs), contributingto high morbidity and mortality rates. Early diagnosis and appropriate management are crucial for improving patient outcomes. While clinical symptoms play a key role, radiological findings, particularly from chest X-rays and computed tomography (CT) scans, are essential tools for diagnosis and guiding treatment decisions.

This discussion delves into the realm of radiological findings in ICU-admitted pneumonia patients. There is a spectrum of chest radiographic manifestations associated with various types of pneumonia, including bacterial, viral, fungal, and aspiration pneumonia. Computed tomography (CT) imaging plays a crucial role in providing detailed images of pulmonary injury, aiding in distinguishing pneumonia from other conditions that mimic its symptoms.

Understanding the language of these radiological findings enables physicians to make informed decisions regarding treatment strategies, improving potential outcomes for critically ill pneumonia patients.

Pneumonia is an inflammatory condition of the lungs primarily affecting the microscopic air sacs known as alveoli. It is characterized by symptoms such as cough, fever, difficulty breathing, and chest pain. Pneumonia can be caused by various infectious agents, including bacteria, viruses, fungi, and parasites.[1]

Pneumonia can be classified based on several factors, including the causative agent, setting of infection, and disease severity.

Common types include

Community-acquired pneumonia (CAP): Occurs outside healthcare facilities or within 48 hours of hospital admission.[2]

Hospital-acquired pneumonia (HAP): Develops more than 48 hours afterhospital admission.[3]

Ventilator-associated pneumonia (VAP): Occurs in patients mechanicallyventilated for more than 48 hours.[3]

Aspiration pneumonia: Caused by inhalation of foreign substances such as food, liquids, or vomit into the lungs.[4]

Methods

Study Design and Setting

A retrospective study was conducted.

- Hospital approval was obtained to access patient records.
- Data were collected from the medical records of patients in the pulmonary internal department at the hospital.
- An electronic questionnaire was created using Google Forms.
- Data were archived using Microsoft Excel 2019.
- The study included 205 patients diagnosed with pneumonia who were admitted to the Pulmonology internal department.

Exclusion criteria

- Archiving errors.
- Cases with incomplete data that were not suitable for study.

Ethical considerations

The study protocol was approved by the Research Ethics Committee at the Syrian Private University.

Statistical analysis

Patient data were tabulated and entered into a computer. Statistical Package for the Social Sciences (SPSS) version 26 was used for data analysis. The following statistical methods were employed:

1. Descriptive statistics: Frequency distributions of categorical study variables(gender, age group, etc.) were analyzed.
2. Analytical statistics (inferential): This part of the analysis aimes to present, interpret the results and infer them in order to reach the goal of the study by conducting the Chi Square (independence test) to study whether a relationship exists between two descriptive variables by applying the Chi Square statistic. Relative Risk (RR) was calculated for statistically associated variables. Statistical significance was considered at a level of 0.05, which is standard in studies. Therefore, statistical significance was determined based on the P-value as follows: if the P-value is greater than0.05, there are no significant differences or relationships. If the P-value is less than 0.05, there are statistically significant differences or relationships.

RESULTS

Part One: Descriptive analysis of study variables.

Patient characteristics

Among 205 cases of pneumonia, the majority of patients were male (62%), and most were adults (48.3%) or children (39.5%). Chronic diseases were prevalent in 37% of the sample, while infectious histories accounted for 5.9% of the sample, and respiratory diseases approximately 11% of the sample. Cough was the most prominent symptom at 73.7%, followed by respiratory distress and chest tightness at 71.2%. Viral pneumonia diagnosis was predominant at 38.5%, while absence of sputum was also notable at 68.3%. Bloody sputum constituted 3.4% of the sample. The admission rate to intensive care units was 29.8% of the sample, while the rate of mechanical ventilation requirement was 14.1% of the sample. (Table 1) (Figures 1-12).

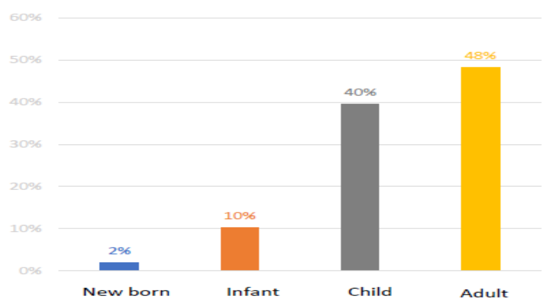

Figure 1: Gender distribution of sample.

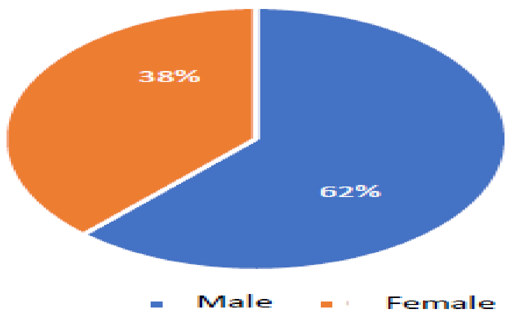

Figure 2: Age distribution of sample.

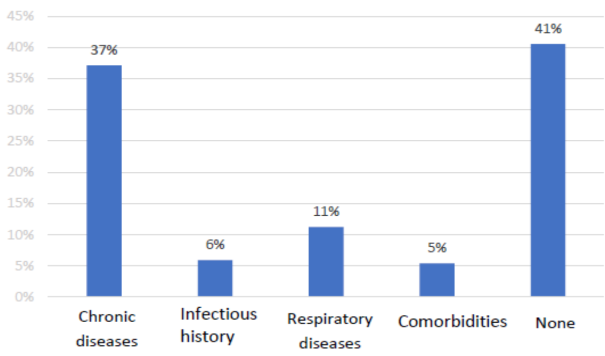

Figure 3: Sample distribution according to the presence of medical history.

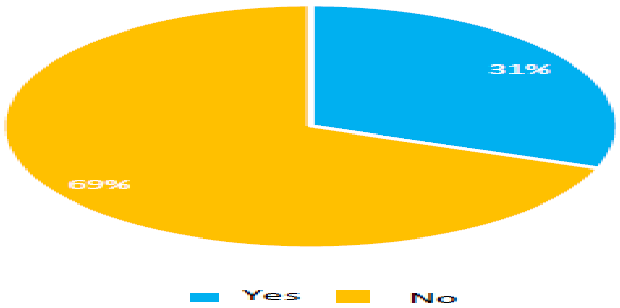

Figure 4: Distribution of sample by surgical history.

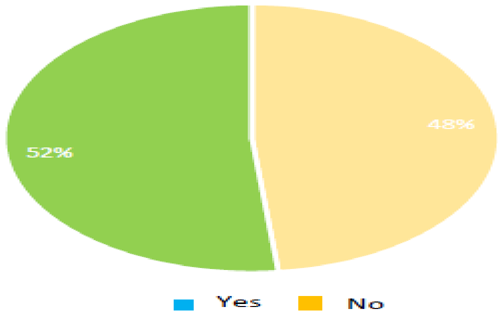

Figure 5: Sample distribution by drug history.

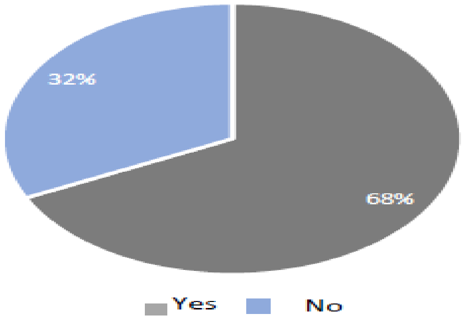

Figure 6: Sample distribution by presence of fever.

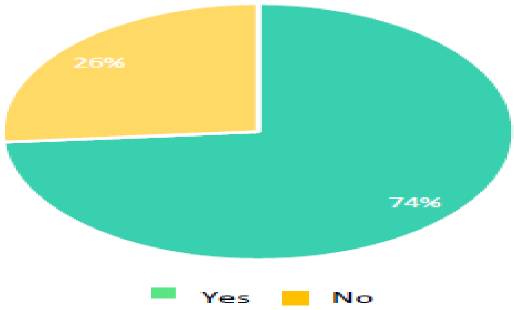

Figure 7: Sample distribution by Presence of Cough.

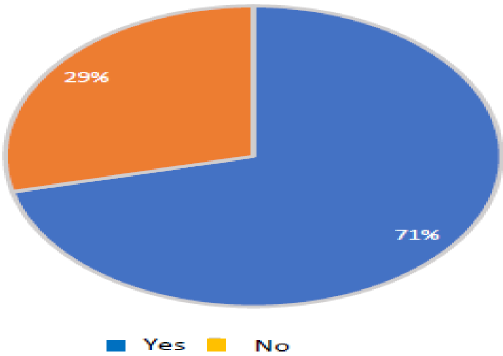

Figure 8: Sample distribution based on the presence of respiratory.

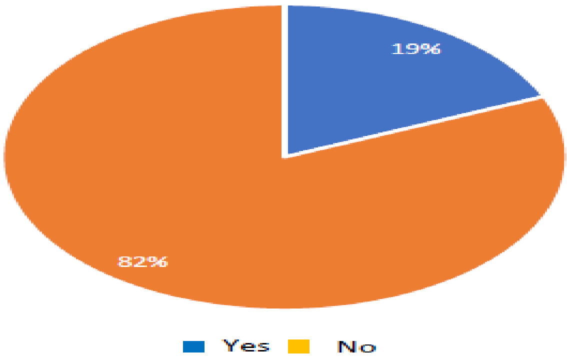

Figure 9: Distribution of the sample based on the presence of chest pain Distress.

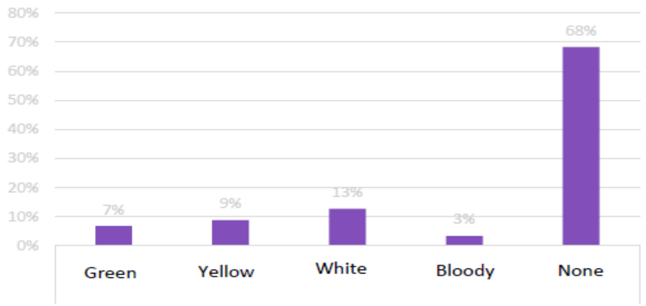

Figure 10: Sample distribution according to sputum color.

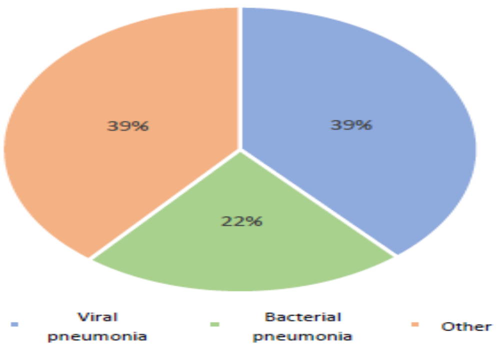

Figure 11: Sample distribution by the diagnosis of pneumonia.

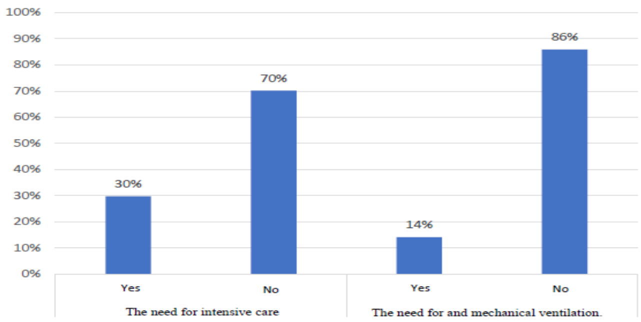

Figure 12: Sample distribution according to the need forintensive Care and Mechanical ventilation.

"Table 1: Patient Characteristics (N=205): n(%)"		
127 (62)	Men	Sex
78 (38)	Female	
4 (2)	Newborn	Age
21 (10.2)	Infant	
81 (39.5)	Child	
99 (48.3)	Adult	
76 (37.1)	Chronic illnesses	Medical history
12 (5.9)	Infectious history	
23 (11.2)	Respiratory diseases	
11 (5.4)	Co-morbidities	
83 (40.5)	no medical history	
99 (48.3)	Yes	Medication history
106 (51.7)	No	
63 (30.7)	Yes	Surgical history
142 (69.3)	No	
Symptoms of Pneumoina		
151 (73.7)	Yes	Cough
54 (26.3)	No	

139 (67.8)	Yes	Fever
66 (32.2)	No	
146 (71.2)	Yes	Respiratory distress and chest tightness
59 (28.8)	No	
38 (18.5)	Yes	Chest pain
167 (81.5)	No	
	Yes	Loss of consciousness
	No	
Pulmonary characteristics		
14 (6.8)	Green	Sputum color
18 (8.8)	Yellow	
26 (12.7)	White	
7 (3.4)	Bloody	
140 (68.3)	None	
79 (38.5)	Viral pneumonia	Diagnosis
46 (22.4)	Bacterial pneumonia	
80 (39)	Other	
61 (29.8)	Yes	Requirement for intensive care
144 (70.2)	No	
29 (14.1)	Yes	Need for mechanical ventilation
176 (85.9)	No	

Radiographic findings

On chest X-ray, consolidation was the most common radiographic finding at a rate of 50%, followed by pleural effusion and hilar enlargement at approximately 38% each, andnearly the same rate for interstitial infiltrates at 37.6% of the sample. Bilateral injury was present in more than half of the cases (53.7%), while injury of more than two lobes in one lung was found in 23.9% of patients. (Table 2); (Figure 13). Out of 205 cases, only 26 underwent CT scans. Consolidation was the most common finding at a rate of 69.2%, while ground-glass opacity accounted for 23.1%. Half of the cases showed bilateral injury. (Table2); (Figure14).

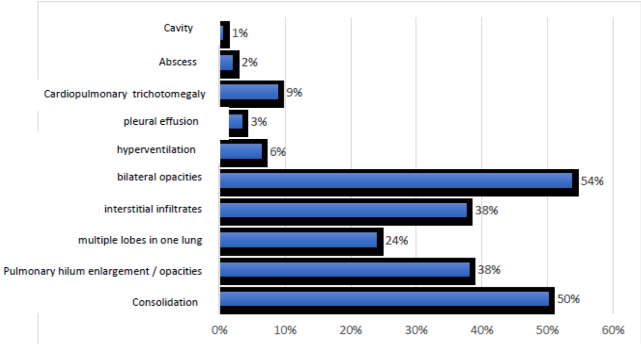

Figure 13: Sample distribution by radiological findings on plain chest X-ray.

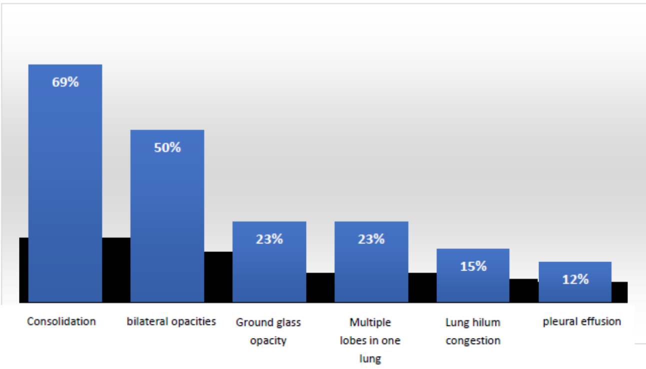

Figure 14: Sample distribution according to radiological findings on the CT scan.

Table 2: Radiographic findings.	
Radiographic findings on plain X-ray (N=205): n (%)	
113 (50.1)	Consolidation
78 (38)	Pulmonary hilum enlargement / opacities
49 (23.9)	Multiple lobes in one lung
77 (37.6)	Interstitial infiltrates
110 (53.7)	Bilateral opacities
13 (6.3)	Hyperventilation
7 (3.4)	Pleural effusion
18 (8.8)	Cardiopulmonary trichotomegaly
4 (2)	Abscess
1 (0.5)	Cavity
Radiological findings on axial imaging: (n=26)	
18 (69.2)	Condensation
13 (50)	Bilateral findings
6 (23.1)	Ground glass opacity
6 (23.1)	More than two lobes in one lung
4 (15.4)	Lung hilum congestion
3 (11.5)	Lateral effusion

Part two: Semantic analysis of the study variables.
First - The relationship between radiographic findings on chest X-rays andthe need for admission to the ICU.

When studying the relationship between radiographic findings on chest X-ray and the need for admission to the intensive care unit (ICU), the results showed a statistically significant association as follows: among patients requiring ICU admission, the majority, at 68.9%, had bilateral injury on chest X-ray with a statistically significant relationship (P<0.05). (Figure 15). No statistically significant relationship was found between other radiographic findings and the need for ICU admission (P>0.05). (Table 3).

Table 3: Relationship between radiological findings on Plain X-RAYS and The need for intensive care admission(N=205): N(%)

P-value	The need for intensive care unit admission		**Radiographic Findings on plain chestx-ray**	
	No	Yes		
0.618	81 (56.3)	32 (52.5)	Yes	Consolidation
	63 (43.8)	29 (47.5)	No	
0.051	61 (42.4)	17 (27.6)	Yes	Pulmonary hilum enlargement / opacities
	83 (57.6)	44 (72.1)	No	
0.197	50 (34.7)	27 (44.3)	Yes	Interstitialinfiltrates
	94 (65.3)	34 (55.7)	No	
0.355	37 (25.7)	12 (19.7)	Yes	Multilobar
	107 (74.3)	49 (80.3)	No	
0.005	68 (47.2)	42 (68.9)	Yes	Bilateral
	76 (52.8)	19 (31.1)	No	
0.586	10 (6.9)	3 (4.9)	Yes	Hyperventilation
	134 (93.1)	58 (95.1)	No	
0.944	5 (3.5)	2 (3.3)	Yes	Pleural effusion
	139 (96.5)	59 (96.7)	No	
0.728	12 (8.3)	6 (9.8)	Yes	Pulmonary trichotomegaly
	132 (91.7)	55 (90.2)	No	

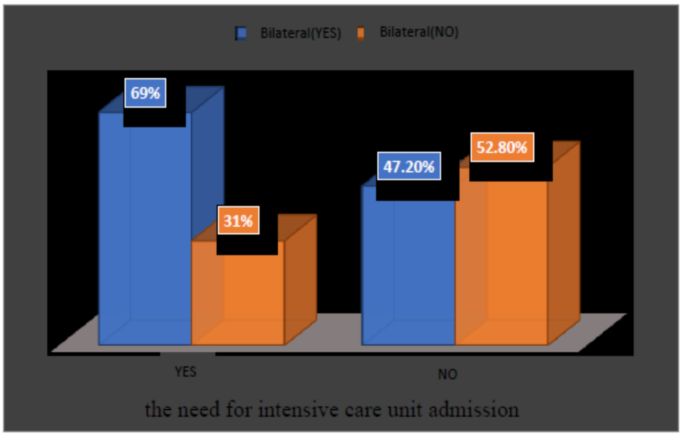

Figure 15: Relationship between bilateral lung injury on plain imaging and the need for intensive care unit admission.

Secondly - The relationship between radiological findings on chest X-ray and the need for mechanical ventilation:

When studying the relationship between radiological findings on chest X-ray and the need for mechanical ventilation, the results did not show any statistically significant relationship(P > 0.05). Although most patients requiring mechanical ventilation had bilateral injury (69%), this relationship was not statistically significant (P = 0.07). Similarly, nearly half of the patients requiring mechanical ventilation had consolidation on plain chest X-ray (51.7%), with no statistically significant relationship (P = 0.691). (Table 4)

Table 4: Relationship between radiographic findings on plain chest X-RAY and The need for mechanical ventilation (N=205): N(%)

P-value	The need for mechanical ventilation		Radiographic findings on plainchest X-RAY	
	No	Yes		
0.691	98 (55.7)	15 (51.7)	Yes	Consolidation
	78 (44.3)	14 (48.3)	No	
0.21	70 (39.8)	8 (27.6)	Yes	Pulmonary Hilum Enlargement /opacities
	106 (60.2)	21 (72.4)	No	
0.433	68 (38.6)	9 (31)	Yes	Interstitialinfiltrates
	108 (61.4)	20 (69)	No	
0.616	41 (23.3)	8 (27.6)	Yes	Multilobar
	135 (76.7)	21 (72.4)	No	
0.07	90 (51.1)	20 (69)	Yes	Bilateral
	86 (48.9)	9 (31)	No	
0.89	11 (6.3)	2 (6.9)	Yes	Hyperventilation
	165 (93.8)	27 (93.1)	No	
0.99	6 (3.4)	1 (3.4)	Yes	Pleural effusion
	170 (96.6)	28 (96.6)	No	
0.74	15 (8.5)	3 (10.3)	Yes	Pulmonary trichotomegaly
	161 (91.5)	26 (89.7)	No	

Third - The relationship between radiographic findings on CT scansand the need for ICU admission

When studying the relationship between radiographic findings on CT scans and the needfor ICU admission, the results showed a statistically significant relationship as follows: among the patients who required ICU admission and underwent CT scans, ground-glass opacities were diagnosed in more than half, with a statistically significant relationship (P<0.05). (Figure 16). Additionally, most of them had bilateral injury on CT (58.7%), with a statistically significant relationship (P<0.05). (Figure 17). There were no statistically significant relationships for the other findings (P>0.05). (Table 5).

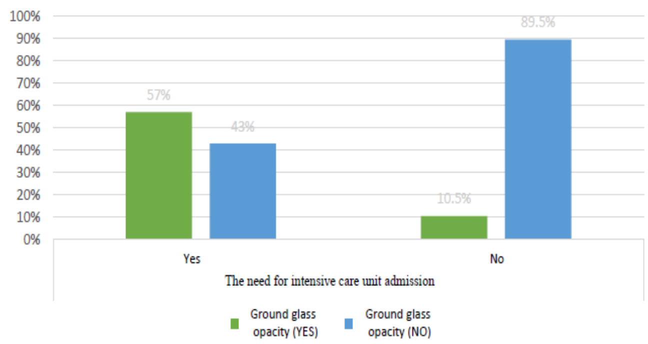

Figure 16: Relationship between ground glass opacity on axial imaging and the need for intensive care unit admission.

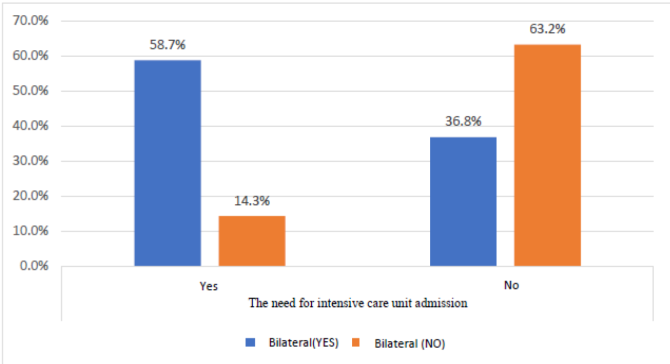

Figure 17: Relationship between bilateral injury on axial Imaging and The need for intensive care unit admission.

Table 5: Relationship between radiographic findings on axial Imaging and The need for intensive care unit admission (N=26): N(%)

P-value	The need for intensive care unit admission		Radiological findings on axial imaging	
	No	Yes		
0.418	14 (73.7)	4 (57.1)	Yes	Consolidation
	5 (26.3)	3 (42.9)	No	
0.012	2 (10.5)	4 (57.1)	Yes	Ground glass opacity
	17 (89.5)	3 (42.9)	No	
0.686	4 (21.1)	2 (28.6)	Yes	Multilobar
	15 (78.9)	5 (71.4)	No	
0.027	7 (36.8)	6 (58.7)	Yes	Bilateral
	12 (63.2)	1 (14.3)	No	

Fourthly - Relationship between Radiological Findings on CTImaging and Need for Mechanical Ventilation

When studying the relationship between radiological findings on CT imaging and the need for mechanical ventilation, the results showed a statistically significant relationship as follows: among patients who required mechanical ventilation and underwent CT imaging, ground-glass opacity (GGO) was diagnosed in three-quarters of the patients (75%), with a statistically significant relationship (P<0.05) and a relative risk ratio (RR) of 10 (CI95%= 1.26,79.3). (See Figure 18). There were no statistically significant relationships for the other findings (P>0.05). (See Table 6).

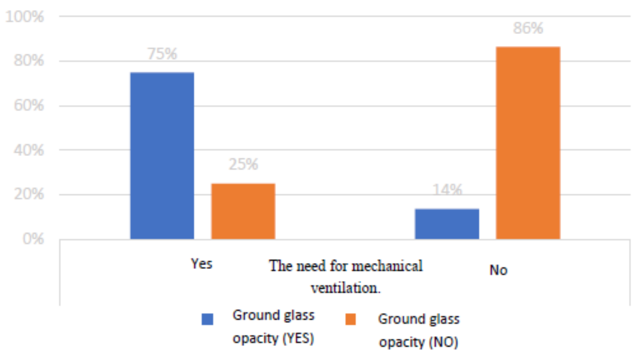

Figure 18: Relationship between Ground-Glass Opacity (GGO) on CT Imaging and Need for Mechanical Ventilation.

Table 6: Relationship between radiological findings onaxial Imaging and The need for mechanical ventilation(N=26): N(%)

P-value	The need for mechanical ventilation		Radiological findings on axial imaging	
	No	Yes		
0.365	16 (72.7)	2 (50)	Yes	Consolidation
	6 (27.3)	2 (50)	No	
0.007	3 (13.6)	3 (75)	Yes	Ground glassopacity
	19 (86.4)	1 (25)	No	
0.234	6 (27.3)	0	Yes	Multilobar
	16 (72.7)	4 (100)	No	
1	11 (50)	2 (50)	Yes	Bilateral
	11 (50)	2 (50)	No	

DISCUSSION

The presence of opacities or consolidation on chest radiography in a patient with compatible clinical syndrome is the gold standard for diagnosis and is recommended by both the American Thoracic Society and the Infectious Diseases Society of America guidelines.[5] High-resolution computed tomography (HRCT) is more sensitive for detecting lung pathology compared to plain radiography and can be useful in better characterizing and identifying complications.H6 Several studies, though limited, have discussed the relationship between chest radiographic findings in patients with pneumonia and clinical outcomes such as mortality or the need for mechanical ventilation,especially during the recent COVID-19 pandemic.[7,8,9]

This retrospective study evaluated the relationship between chest radiographic findings, both on plain radiography and CT scans, and the need for intensive care unit (ICU) admission or mechanical ventilation. In the current study, approximately one-third of patients required ICU admission at Damascus Hospital, and approximately 14% were placed on mechanical ventilation. Unfortunately, only 12% of the study sample underwent CT imaging. This may be attributed to difficulties in performing chest CT scans for unstable individuals or patients with acute respiratory distress, and possibly due to limited available resources. Therefore, comparing all outcomes between plain chest radiography and CT scans yielded inconclusive results.

Consolidation was the most common radiographic finding on plain chest radiography, occurring in half of the cases, and similarly on CT scans where it constituted 69%. Intersitial infiltrates were present in over one-third of patients on plain chest radiography. Cavitation and lung abscesses were rare in this study, possibly explained by the predominant viral lung pathology observed. Bilateral injury was positive in over half of thesample in both plain chest radiography and CT scans, respectively. The prevalence of consolidation as the most common finding aligns with previous studies, with varying proportions.

In a referenced Turkish study, consolidation was present in the majority of patients, with rates of 89% on chest radiography and 80% on CT scans.[10] Our results similarly confirmed the rarity of pneumothorax and cavitations with bilateral injury (50%)comprisinga quarter of the sample in the comparative study.[10]

The relationship between radiographic findings on both chest X-rays and CT scans and the need for ICU admission has been assessed. Studies examining the correlation between radiographic findings and clinical outcomes in patients with pneumonia are limited and almost exclusively focus on COVID-19 patients, creating a gap when comparing results. In a previous study on COVID-19 patients, the ICU admission rate was 45%,[11] while it is approximately one-third in this study. Additionally, previous studies on the correlation with specific radiographic findings (such as consolidation or bilateral injury) are even more limited, as most prior studies evaluated the relationship with radiographic scores like the CXR score.[11,12]

In this study, patients with bilateral lesions identified on chest X-rays were almost twice as likelyto be admitted to the ICU, and those with bilateral lesions identified on CT scans were six times more likely to be admitted 6 (95% CI = 0.83, 43.1), with a statistically significant relationship (P<0.05). Furthermore, patients with ground-glass opacities identified on CT scans were 4.4 times more likely to be admitted to the ICU (1.35, 14.5), with a statistically significant relationship (P<0.05). These findings are consistent with those presented in previous studies.

Previous studies have reported differences in the nature and severity of initial lung lesions in patients admitted to the ICU compared to less severe patient groups. More severe disease is associated with bilateral injury of lung lesions in either subpleural or central regions of the lung parenchyma, as well as the number of affected lobes. Finally, diffuse ground-glass opacities andconsolidations are indicative of higher severity.[13]

Further, a previous study investigated the prognostic role of lung findings in a cohort of 168 ICU patients with COVID-19. Most patients had multifocal and bilateral ground-glass opacities (GGOs), which were significantly associated with the SOFA score upon admission and with comorbidities such as cardiovascular diseases. In the same previous study, no significant association was observed between radiographic findings and mortality.H6 It is noteworthy that the current study did not evaluate this correlation.

The relationship between chest radiographic findings on both plain radiography and CT scans and the need for mechanical ventilation was assessed. In this study, there was nostatistically significant relationship found between chest radiographic findings on plain radiography. Although most patients who required mechanical ventilation had bilateral lung injury on plain chest radiography at a rate of 69%, the significance level was marginally non-significant (P=0.07). However, the likelihood of needing mechanical ventilation was nearly doubled among patients with bilateral lung injury on plain chest radiography (RR=1.9, CI95%= 0.91,1.01). For findings on CT scans, the relationship withthe presence of ground-glass opacity (GGO) and the need for mechanical ventilation wasstatistically significant with a relative risk rate of 10 (CI95%= 1.26,79.3). Furthermore, our study results are consistent with previous limited studies, although our findings are limitedto mechanical ventilation rather than other non-invasive means. Few studies have assessed the mutual relationships between radiographic outcomes and the need for mechanical ventilation in patients admitted with pneumonia.

The Turkish study found that patients with bilateral lung injury often require non-invasive ventilation, while those with multi-lobe injury often require invasive ventilation.[10] It is worth noting that multi-lobe injury did not show a statistically significant value in this study.

Additionally, in a 2022 American study, a statistically significant relationship was found between radiographic outcomes and disease severity indicators, including the need for mechanical ventilation, but their study sample included COVID-19 patients, while the relationship with radiographic findings was not precisely evaluated[7] The Turkish study recommends that while the current results suggest predicting the need for mechanical ventilation through radiographic findings, adherence to the current clinical outcome-based protocol is necessary. Radiographic evaluation that surpasses clinical outcomes in predicting the need for mechanical ventilation should undergo further assessment with a large series of patients.[10] These study results support the aforementioned recommendation.

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