The Impact of Indeterminate Pulmonary Findings in Chest CT Reports on Antibiotic Utilization

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Introduction

- Antimicrobial resistance (AMR) is an urgent global public health threat, associated with nearly 5 million deaths globally in 2019. In the U.S., more than 2.8 million AMR infections occur each year with 35,000 deaths in 2019[1].
- According to the CDC, the estimated national cost to treat infection caused by six multidrug-resistant microbes frequently found in healthcare is more than $4.6 billion per year[2].
- Findings indeterminate for pneumonia are commonly reported on chest CT scans with uncertain language, i.e. "infectious/inflammatory", which may lead to antibiotics overuse.

Objective

- To assess the impact of indeterminate pulmonary findings from chest CT scans on antibiotic utilization in the Emergency Department.

Materials and Methods

- The study population (n=1168) was comprised of a random subset of emergency department patients who underwent Chest CT during 2012-2022.
- Specific search terms were used to classify radiology reports into three groups: 1) **Negative**, 2) **Indeterminate**, and 3) **Positive** for pneumonia. Number of cases in each group were reduced as needed for balance among groups.
- Reports and CT images were reviewed, and patients in the Indeterminate or Positive groups were further characterized by CT findings (consolidation, tree-in-bud nodularity, ground glass opacities, and/or pulmonary nodules) and the extent of lung involvement (<5% (minimal), 5-10%, 10-25%, 25-50%, and >50%).
- Demographic, clinical symptoms, laboratory data, antibiotics administered within 24 hours of imaging, and imaging findings were collected.
- Multivariable logistic regression analysis was performed.

	Chest CT report outcome			
	Negative for pneumonia (n=457)	Indeterminate for pneumonia (n=386)	Positive for pneumonia (n=325)	p value
Female, no. (%)	256 (56%)	185 (48%)	166 (51%)	
Age, yr.	55.8	57.0	58.4	
Pulmonary symptoms	261 (57%)	144 (37%)	182 (56%)	
Temperature	97.9	97.9	98.0	
Pulse	81.9	81.3	83.3	
Respiratory Rate	18.1	18.2	18.5	
White Blood Cell Count	9.2	9.6	12.4	
Antibiotics utilization	121 (26%)	177 (46%)	256 (79%)	
Chest CT				
Extent of lung involvement				
<5% (minimal)		211 (55%)	33 (10%)	p<0.01
5-10%		75 (19%)	99 (30%)	p<0.01
10-25%		54 (14%)	131 (40%)	p<0.01
25-50%		20 (5%)	41 (13%)	p<0.01
>50%		20 (5%)	21 (6%)	p=0.47
Consolidation		51 (13%)	268 (82%)	p<0.01
Tree-in-bud Nodularity		142 (37%)	47 (14%)	p<0.01
Ground-glass Opacities		231 (60%)	166 (51%)	p=0.02
Nodules		102 (26%)	64 (20%)	p=0.03

Table 1. Patient demographic and clinical data.

Dependent: Antibiotics		0	1	OR (univariable)	OR (multivariable)
Minimal_Extent	0	134 (29.1)	327 (70.9)	-	-
	1	142 (57.5)	105 (42.5)	0.30 (0.22-0.42, p<0.001)	0.55 (0.38-0.81, p=0.002)
Consolidation	0	208 (53.5)	181 (46.5)	-	-
	1	68 (21.3)	251 (78.7)	4.24 (3.05-5.95, p<0.001)	2.75 (1.80-4.23, p<0.001)
Tree_in_bud	0	189 (36.5)	329 (63.5)	-	-
	1	87 (45.8)	103 (54.2)	0.68 (0.49-0.95, p=0.025)	0.87 (0.56-1.35, p=0.529)
Ground_glass_opacities	0	110 (35.5)	200 (64.5)	-	-
	1	166 (41.7)	232 (58.3)	0.77 (0.57-1.04, p=0.092)	0.91 (0.61-1.34, p=0.617)
Nodules	0	199 (36.9)	341 (63.1)	-	-
	1	77 (45.8)	91 (54.2)	0.69 (0.49-0.98, p=0.038)	0.91 (0.61-1.37, p=0.657)
Sex	Female	347 (57.2)	260 (42.8)	-	-
	Male	267 (47.6)	294 (52.4)	1.47 (1.17-1.85, p=0.001)	1.21 (0.86-1.70, p=0.277)
Age_Over_65	0	435 (55.6)	347 (44.4)	-	-
	1	179 (46.4)	207 (53.6)	1.45 (1.14-1.85, p=0.003)	1.18 (0.82-1.68, p=0.371)
Temp_Over_1004	0	596 (51.9)	552 (48.1)	-	-
	1	3 (60.0)	2 (40.0)	0.72 (0.09-4.36, p=0.719)	0.00 (NA-141709605393751744.00, p=0.971)
Pulse_Over_100	0	539 (54.3)	453 (45.7)	-	-
	1	61 (39.6)	93 (60.4)	1.81 (1.29-2.57, p=0.001)	1.44 (0.86-2.47, p=0.172)
Resp_Over_20	0	477 (55.5)	383 (44.5)	-	-
	1	123 (42.9)	164 (57.1)	1.66 (1.27-2.18, p<0.001)	1.49 (1.00-2.26, p=0.054)
WBC_Over_12	0	488 (59.0)	339 (41.0)	-	-
	1	114 (34.9)	213 (65.1)	2.69 (2.06-3.52, p<0.001)	1.73 (1.18-2.55, p=0.006)

Table 2. Multivariate logistic regression analysis of patients from either Indeterminate or Positive groups. Statistically significant variables are highlighted.

Results

- 457 patients were **Negative** for pneumonia, 386 were **Indeterminate** for pneumonia, and 325 were **Positive** for pneumonia (**Table 1**).
- The **Indeterminate** for pneumonia group on average had a WBC count similar to that of the **Negative** group (9.6 and 9.2, respectively), whereas the **Positive** for pneumonia group had a significantly higher WBC count (12.4).
- Antibiotics were administered in 46% of the **Indeterminate** group, significantly higher compared to the **Negative** group (26%) and lower compared to the **Positive** group (79%).
- Multivariable logistic regression analysis showed that **Indeterminate** results had an odds ratio (OR) of 2.35 for antibiotics administration, compared to an OR of 9.49 for **Positive** results (**Negative** group set as reference).
- Comparison of CT findings in the **Indeterminate** and **Positive** groups showed that antibiotics usage was significantly decreased when the extent of disease was minimal (OR=0.55, p< 0.01) and usage was increased when consolidations were present (OR=2.75, p< 0.01) (**Table 2**).
- Notably, antibiotics were administered in 71 (34%) patients in the **Indeterminate** group with minimal extent (subsegmental or smaller) of lung involvement.

Conclusion

- This study demonstrates the positive association between indeterminate CT findings for pneumonia and subsequent antibiotics utilization.
- Our data suggests that antibiotics are unnecessary when indeterminate CT findings involved a limited portion of lung parenchyma and in the absence of consolidations.
- Further studies are required to optimize antibiotics use when imaging features are not highly confident for infectious pneumonia.

1. National Infection & Death Estimates for Antimicrobial Resistance. Centers for Disease Control and Prevention. Available at: https://www.cdc.gov/drugresistance/national-estimates.html. Accessed March 17th, 2024.
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