

# Community-Acquired Pneumonia Visualized on CT Scans but Not Chest Radiographs

## Pathogens, Severity, and Clinical Outcomes

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**e-Table 1.** Clinical characteristics of patients who underwent computed tomography (CT) and those who did not undergo CT. All included patients underwent chest x-ray (CXR).

	<b>CT Completed (n=748)</b>	<b>CT not Completed (n=1503)</b>	<b>p</b>
<i>Demographics</i>			
Age [years], median (IQR)	56 (46, 67)	59 (47, 73)	< 0.01
Female, n (%)	353 (53.0)	797 (47.2)	< 0.01
<i>Vital signs, median (IQR)</i>			
Heart Rate [beats/min]	101 (88, 114)	99 (86, 114)	0.11
Systolic blood pressure [mm Hg]	131 (116, 149)	132 (114, 149)	0.96
Respiratory rate [breaths/min]	20 (18, 22)	20 (18, 24)	0.74
Temperature [°F]	98.4 (97.3, 99.7)	98.6 (97.1, 100.3)	0.05
Oxygen saturation [%]	95 (93, 98)	95 (92, 97)	0.51
<i>Signs and Symptoms, n (%)</i>			
Cough with sputum production	348 (46.5)	658 (43.4)	0.22
Hemoptysis	91 (12.2)	106 (7.1)	<0.01
Shortness of breath	612 (81.8)	1140 (75.9)	<0.01
Chest pain	428 (57.2)	681 (45.3)	<0.01
Confusion	117 (15.6)	332 (22.1)	<0.01
Wheezing	317 (42.4)	657 (43.7)	0.55
<i>Comorbidities, n (%)</i>			
Asthma	181 (24.2)	401 (26.7)	0.21
Chronic Obstructive Pulmonary Disease	163 (21.8)	356 (23.7)	0.31
Chronic Heart Failure	115 (15.4)	315 (21.0)	<0.01
Diabetes mellitus	166 (22.2)	418 (27.8)	<0.01
Chronic kidney disease	94 (12.6)	259 (17.2)	<0.01
Chronic liver disease	43 (5.8)	82 (5.5)	0.78
Obesity (Body Mass Index $\geq 30$ kg/m <sup>2</sup> )	270 (36.1)	551 (36.7)	0.79
<i>Laboratory values, median (IQR)</i>			
White blood cell count [thous cells/ mL]	11.2 (7.7, 14.7)	11.5 (8.2, 15.0)	0.06
Blood urea nitrogen [mg/dL]	14 (10, 20)	16 (10, 25)	<0.01
Blood glucose [mg/dL]	114 (98, 139)	116 (99, 148)	0.10
Procalcitonin [ng/ml] *	0.13 (<0.05, 0.64)	0.16 (<0.05, 1.01)	0.01
<i>Pneumonia Severity Index risk class, n (%)</i>			
I-II (low risk)	366 (48.9)	654 (43.5)	0.02
III (moderate risk)	150 (20.1)	300 (20.0)	
IV-V (high risk)	232 (31.0)	549 (36.5)	
<i>CURB-65 score, n (%)</i>			
0-1 (low risk)	579 (77.4)	991 (65.9)	< 0.01
2 (moderate risk)	121 (16.2)	308 (20.5)	
3-5 (high risk)	48 (6.4)	204 (13.6)	
<i>ATS severe pneumonia criteria, n (%)</i>			
< 3 criteria (non-severe)	711 (95.1)	1380 (91.8)	0.01
$\geq 3$ criteria (severe)	37 (4.9)	123 (8.2)	

\* 520 patients did not have procalcitonin measured, including 162 (21.7%) with CT completed and 358 (23.9%) with CT not completed.

Abbreviations: CT computed tomography; CXR chest x-ray; n number; IQR interquartile range; min minute; mm millimeter; Hg mercury; F Fahrenheit; mL microliter; mg milligram; dL deciliter; ng nanogram; ml milliliter; CURB-65 confusion, uremia, respiratory rate, blood pressure, age  $\geq 65$  years; ATS American Thoracic Society.

**e-Table 2.** Pathogens detected among patients who underwent computed tomography (CT) and those who did not undergo CT.

<b>Pathogens Detected, n (%)</b>	<b>CT completed (n=748)</b>	<b>CT not Completed (n=1503)</b>
Any pathogen	256 (34.2)	593 (39.5)
Co-detection of $\geq 1$ pathogen	31 (4.1)	79 (5.3)
Any Bacteria	89 (11.9)	216 (14.4)
<i>Streptococcus pneumoniae</i>	32 (4.3)	82 (5.5)
Group A Streptococcus	4 (0.5)	3 (0.2)
Viridans group Streptococci	7 (0.9)	1 (0.1)
Other Streptococci species	4 (0.5)	4 (0.3)
<i>Staphylococcus aureus</i>	10 (1.3)	27 (1.8)
<i>Haemophilus influenzae</i>	5 (0.7)	8 (0.5)
<i>Escherichia coli</i>	7 (0.9)	10 (0.7)
<i>Pseudomonas aeruginosa</i>	2 (0.3)	6 (0.4)
<i>Klebsiella pneumoniae</i>	6 (0.8)	6 (0.4)
<i>Mycoplasma pneumoniae</i>	6 (0.8)	37 (2.5)
<i>Chlamydia pneumoniae</i>	2 (0.3)	7 (0.5)
<i>Legionella pneumophila</i>	7 (0.9)	25 (1.7)
Other bacteria	5 (0.7)	0 (0)
Any Virus	167 (22.3)	423 (28.1)
Influenza	36 (4.8)	94 (6.3)
Parainfluenza virus	21 (2.8)	46 (3.1)
Coronavirus	17 (2.3)	36 (2.4)
Human metapneumovirus	25 (3.3)	63 (4.2)
Respiratory syncytial virus	17 (2.3)	51 (3.4)
Human rhinovirus	53 (7.1)	140 (9.3)
Adenovirus	9 (1.2)	23 (1.5)

Abbreviations: n number; CT computed tomography; CXR chest x-ray

**e-Table 3.** Clinical outcomes among patients who underwent computed tomography (CT) and those who did not undergo CT.

<b>Clinical Outcome</b>	<b>CT-completed (n=748)</b>	<b>CT not Completed (n=1503)</b>
In-hospital death, n (%)	16 (2.1)	33 (2.2)
Hospital length-of-stay (days) among survivors, median (IQR)	4 (2-7)	3 (2-5)
ICU admission, n (%)	166 (22)	316 (21)
Invasive mechanical ventilation, n (%)	45 (0.6)	72 (4.8)
Vasopressor-dependent septic shock, n (%)	35 (4.7)	52 (3.5)
Moderate-severe ARDS, n (%)	24 (3.2)	66 (4.4)

**e-Table 4.** Clinical characteristics at hospital presentation, with the CXR pneumonia group subclassified based on CT results: CXR pneumonia / CT not done (CXR+/CT not done); CXR pneumonia / CT pneumonia (CXR+/CT+); CXR pneumonia / CT no pneumonia (CXR+/CT-).

	CXR pneumonia			CT-only pneumonia (CXR-/CT+) (n=66)
	CXR+/CT not done (n=1503)	CXR+/CT+ (n=652)	CXR+/CT- (n=30)	
<i>Demographics</i>				
Age [years], median (IQR)	59 (47-73)	56 (47-67)	63.5 (55-73)	53 (40-63)
Female, n (%)	797 (53)	299 (45.9)	15 (50)	39 (59.1)
<i>Vital signs, median (IQR)</i>				
Heart Rate [beats/min]	99 (86-114)	101 (88-114)	103 (78-123)	100 (88-118)
Systolic blood pressure [mm Hg]	132 (114-139)	130 (115-147)	133 (124-149)	140 (126-157)
Respiratory rate [breaths/min]	20 (18-24)	20 (18-22)	20 (18-22)	20 (18-24)
Temperature [°F]	98.6 (97.1-100.3)	98.4 (97.3-99.7)	97.7 (96.3-99.2)	98.4 (97.3-100.3)
Oxygen saturation [%]	95 (92-97)	95 (93-98)	95 (93-98)	96 (94-98)
<i>Signs and Symptoms, n (%)</i>				
Cough with sputum production	845 (56.2)	344 (52.8)	17 (56.7)	39 (59.1)
Hemoptysis	106 (7.1)	84 (12.9)	2 (6.7)	5 (7.6)
Shortness of breath	1140 (75.9)	537 (82.4)	26 (86.7)	49 (74.2)
Chest pain	681 (45.3)	365 (55.8)	20 (66.7)	44 (66.7)
Confusion	332 (22.1)	99 (15.2)	7 (23.3)	11 (16.7)
Wheezing	657 (43.7)	260 (39.9)	20 (66.7)	37 (56.1)
<i>Comorbidities, n (%)</i>				
Asthma	401 (26.7)	149 (22.9)	11 (36.7)	21 (31.8)
Chronic Obstructive Pulmonary Disease	356 (23.7)	135 (20.7)	14 (46.7)	14 (21.2)
Chronic Heart Failure	315 (21)	100 (15.3)	7 (23.3)	8 (12.1)
Diabetes mellitus	418 (27.8)	137 (21)	8 (26.7)	21 (31.9)
Chronic kidney disease	259 (17.2)	81 (12.4)	4 (13.3)	9 (13.6)
Chronic liver disease	82 (5.5)	37 (5.7)	3 (10)	3 (4.6)
Obesity (Body Mass Index $\geq 30$ kg/m <sup>2</sup> )	551 (36.7)	228 (35)	10 (33.3)	32 (48.5)
<i>Laboratory values, median (IQR)</i>				
White blood cell count [thous cells/ mL]	11.5 (8.2-15)	11.3 (7.9-14.8)	8.9 (5.5-11.9)	11.1 (6.9-14.2)
Blood urea nitrogen [mg/dL]	16 (10-25)	14 (10-20)	14 (12-17)	12 (9-19)
Blood glucose [mg/dL]	116 (99-148)	113.5 (98-139)	114 (102-136)	120 (102-144)
Procalcitonin [ng/ml] *	0.16 (<0.05 - 1.01)	0.15 (<0.05- 0.64)	<0.05 (<0.05- <0.05)	<0.05 (<0.05- 0.11)

<i>Pneumonia Severity</i>				
<i>Index risk class, n (%)</i>				
I-II (low risk)	654 (43.5)	316 (48.5)	9 (30)	41 (62.1)
III (moderate risk)	300 (20)	131 (20.1)	8 (26.7)	11 (16.7)
IV-V (high risk)	549 (36.5)	205 (31.4)	13 (43.3)	14 (21.2)
<i>Index score, median (IQR)</i>				
<i>CURB-65 score, n (%)</i>				
0-1 (low risk)	991 (65.9)	503 (77.2)	23 (76.7)	53 (80.3)
2 (moderate risk)	308 (20.5)	109 (16.7)	5 (16.7)	7 (10.6)
3-5 (high risk)	204 (13.6)	40 (6.1)	2 (6.7)	6 (9.1)
<i>ATS severe pneumonia criteria, n (%)</i>				
< 3 criteria (non-severe)	1387 (92.3)	619 (94.9)	30 (100)	63 (95.5)
≥ 3 criteria (severe)	116 (7.7)	33 (5.1)	0 (0)	3 (4.5)
<i>Antibiotics within six hours</i>	1284 (85.4)	501 (76.8)	26 (86.7)	39 (59.1)

Abbreviations: CT computed tomography; CXR chest x-ray; n number; IQR interquartile range; min minute; mm millimeter; Hg mercury; F Fahrenheit; mL microliter; mg milligram; dL deciliter; ng nanogram; ml milliliter; CURB-65 confusion, uremia, respiratory rate, blood pressure, age ≥ 65 years; ATS American Thoracic Society.

**e-Table 5.** Pathogens detected, with the CXR pneumonia group sub-classified based on CT results: CXR pneumonia / CT not done (CXR+/CT not done); CXR pneumonia / CT pneumonia (CXR+/CT+); CXR pneumonia / CT no pneumonia (CXR+/CT-).

Pathogens Detected, n (%)	CXR pneumonia			CT-only pneumonia (CXR-/CT+) (n=66)
	CXR+/CT not done (n=1503)	CXR+/CT+ (n=652)	CXR+/CT- (n=30)	
Any pathogen	593 (39.5)	225 (34.5)	4 (13.3)	27 (40.9)
Co-detection of ≥ 1 pathogen	79 (5.3)	29 (4.5)	0 (0)	2 (3.0)
Any Bacteria	216 (14.4)	80 (12.3)	1 (3.3)	8 (12.1)
<i>Streptococcus pneumoniae</i>	82 (5.5)	29 (4.5)	0 (0)	3 (4.6)
Group A	3 (0.2)	4 (0.6)	0 (0)	0 (0)
Streptococcus Viridans group	1 (0.1)	7 (1.1)	0 (0)	0 (0)
Streptococci Other Streptococci species	4 (0.3)	4 (0.6)	0 (0)	0 (0)
<i>Staphylococcus aureus</i>	27 (1.8)	10 (1.5)	0 (0)	0 (0)
<i>Haemophilus influenzae</i>	8 (0.5)	5 (0.8)	0 (0)	0 (0)
<i>Escherichia coli</i>	10 (0.7)	6 (0.9)	0 (0)	1 (1.5)
<i>Pseudomonas aeruginosa</i>	6 (0.4)	1 (0.2)	0 (0)	1 (1.5)
<i>Klebsiella pneumoniae</i>	6 (0.4)	4 (0.6)	0 (0)	2 (3.0)
<i>Mycoplasma pneumoniae</i>	37 (2.5)	6 (0.9)	0 (0)	0 (0)
<i>Chlamydia pneumoniae</i>	7 (0.5)	1 (0.2)	0 (0)	1 (1.5)
<i>Legionella pneumophila</i>	25 (1.7)	7 (1.1)	0 (0)	0 (0)
Other bacteria	0 (0)	4 (0.6)	1 (3.3)	0 (0)
Any Virus	423 (28.1)	144 (22.1)	3 (10)	20 (30.3)
Influenza	94 (6.3)	32 (4.9)	0 (0)	4 (6.1)
Parainfluenza virus	46 (3.1)	18 (2.8)	2 (6.7)	1 (1.5)
Coronavirus	36 (2.4)	17 (2.6)	0 (0)	0 (0)
Human metapneumovirus	63 (4.2)	21 (3.2)	0 (0)	4 (6.1)
Respiratory syncytial virus	51 (3.4)	17 (2.6)	0 (0)	0 (0)
Human rhinovirus	140 (9.3)	41 (6.3)	1 (3.3)	11 (16.7)
Adenovirus	23 (1.5)	8 (1.2)	0 (0)	1 (1.5)

Abbreviations: n number; CT computed tomography; CXR chest x-ray

**e-Table 6.** Clinical outcomes, with the CXR pneumonia group sub-classified based on CT results: CXR pneumonia / CT not done (CXR+/CT not done); CXR pneumonia / CT pneumonia (CXR+/CT+); CXR pneumonia / CT no pneumonia (CXR+/CT-).

Clinical Outcome	CXR pneumonia			CT-only pneumonia (CXR-/CT+) (n=66)
	CXR+/CT not done (n=1503)	CXR+/CT + (n=652)	CXR+/CT - (n=30)	
In-hospital death, n (%)	33 (2.2)	15 (2.3)	1 (3.3)	0 (0)
Hospital length-of-stay (days) among survivors, median (IQR)	3 (2-5)	4 (2.5-7)	3 (2-6)	3.5 (2-5)
ICU admission, n (%)	316 (21)	143 (21.9)	8 (26.7)	15 (22.7)
Invasive mechanical ventilation, n (%)	72 (4.8)	41 (6.3)	0 (0)	4 (6.1)
Vasopressor-dependent septic shock, n (%)	52 (3.5)	32 (4.9)	0 (0)	3 (4.6)
Moderate-severe ARDS, n (%)	66 (4.4)	23 (3.5)	0 (0)	1 (1.5)

Abbreviations: CT computed tomography; CXR chest x-ray; n number; IQR interquartile range; ICU intensive care unit; ARDS acute respiratory distress syndrome

**e-Table 7.** Timing of in-hospital antibiotics.

	CT-only pneumonia (n = 66)	CXR pneumonia (n = 2185)
Antibiotics ≤ 6 hours, n (%)	39 (59%)	1815 (83%)
Antibiotics ≤ 12 hours, n (%)	58 (88%)	2046 (94%)
Antibiotics ≤ 24 hours, n (%)	64 (97%)	2106 (96%)
Median (IQR) time to first antibiotics, hours	4.7 (2.6, 6.8)	2.9 (2.0, 4.5)



**e-Table 8.** Among patients with CT-only pneumonia [n=66], pathogens detected in patients with probable or definite pneumonia on CT and an elevated PCT ( $\geq 0.25$  ng/ml) [n=5] and patients not meeting these criteria. Fourteen patients could not be classified by these criteria due to missing procalcitonin (PCT) values; these patients are displayed separately in the table.

	Probable/definite pneumonia on CT and PCT $\geq 0.25$ ng/ml (n = 5)	Probable/definite pneumonia on CT and missing PCT (n = 14)	Possible pneumonia on CT and/or PCT $<0.25$ ng/ml (n = 47)
Any pathogen detected, n (%)	2 (40)	6 (43)	19 (40)
Bacterial pathogen, n (%)	1 (20)	3 (21)	4 (9)
Bacterial pathogens detected	<i>E. coli</i>	<i>S. pneumoniae</i> <i>K pneumoniae</i> <i>C. pneumoniae</i>	<i>S. pneumoniae</i> x 2 <i>K pneumoniae</i> <i>P. aeruginosa</i>
Viral Pathogen, n (%)	1 (20)	3 (21)	16 (34)
Viral pathogens detected	HPMV	HRV x 2 Flu A	HRV x 8 HMPV x 3 Flu A x 3 PIV AdV

Abbreviations: CT: computed tomography; PCT: procalcitonin; HPMV: human metapneumovirus; HRV: human rhinovirus; Flu A: influenza A virus; PIV: parainfluenza virus; AdV: adenovirus