Understanding COVID-19 Chest Radiograph Findings for Triage and Emergency Assessment

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Background

Although CT scan has been widely adopted in the evaluation and management of patients with COVID-19, the American College of Radiology (ACR) raises safety concerns regarding the rates of cross-contamination between patients and radiation hazards. As such, there is a need to explore the role of alternative imaging modalities such as Chest X-Ray (CXR) to mitigate these risks and promote patient safety. This review provides a meta-analysis on imaging findings in COVID-19 patients in order to equip healthcare professionals with understanding of the disease presentation on CXR so that we can better harness its utility as a faster, safer, cheaper imaging tool.

Methods/Materials

Twelve studies (N= 1948) met the inclusion criteria which consisted of: (1) published in English; (2) original study; (3) sample size ≥5 patients; (4) reporting clinical characteristics of COVID-19 patients and CXR imaging features; (5) reporting number of patients with each corresponding imaging feature. To perform the meta-analysis, a random-effects model calculated the pooled prevalence and 95% confidence intervals of abnormal CXR imaging findings.

Table 1
Basic clinical characteristics of studies in COVID-19 patients.

Reference	Country of Origin	Date Published (d/m/y)	Number of Participants	Gender Male: Female	Average Age	Method of Diagnosis	Patient Type	Symptom Severity	Onset of symptoms prior to radiograph taken
Arentz et al.	USA	28/4/2020	21	11:10	70	RT-PCR	Inpatient	SOB (76%), fever (52%), cough (48%)	3.5 days
Chen et al.	China	30/1/2020	99	67:32	55.5	RT-PCR (by WHO interim guidance)	Inpatient	Cough and fever (82%), SOB (30%)	–
Cozzi et al.	Italy	9/6/2020	234	153:81	66	RT-PCR	Inpatient	–	–
Guan et al.	China	30/4/2020	274	–	47.0	RT-PCR	Inpatient	Fever (88.7%), cough (67.8%)	4 days
Ippolito et al.	Italy	22/4/2020	468	328:140	64.7	RT-PCR	Inpatient	Fever (90.6%), cough (57.7%), dyspnea (56.8%)	>5 days for majority of patients (57.7%)
Kim et al.	Korea	6/4/2020	28	–	42.6	RT-PCR	Inpatient	Cough (28.6%), sore throat (28.6), fever, myalgia, and headache (25%)	–
Ng et al.	China	2/2/2020	5	–	56	RT-PCR	–	Fever (90%), cough (48%), sore throat (10%), diarrhea (10%)	3
Russel et al.	USA	–/5/2020	636	363:273	50	RT-PCR	–	–	–
Toussie et al.	USA	14/5/2020	338	210:128	39	RT-PCR	Inpatient	–	4 days
Vancheri et al.	Italy	30/5/2020	240	169:71	65	RT-PCR	Inpatient	–	–
Wong et al.	China	27/5/2020	64	26:38	56	RT-PCR	Inpatient	Fever (59%), cough (41%), asymptomatic (14%)	10–12 days
Yoon et al.	Korea	21/4/2020	9	4:5	54	RT-PCR	Inpatient	–	–

Table 2
Chest radiograph findings of studies in COVID-19 patients.

Reference	Baseline			Lung Involvement			Consolidation (%)	Ground Glass Opacities (%)	Distribution			Zone Predominance			Other Atypical Features (%)
	Normal (%)	Abnormal (%)	Normal Turned Abnormal (%)	Right (%)	Left (%)	Bilateral (%)			Diffuse (%)	Peripheral (%)	Perihilar (%)	None (%)	Superior (%)	Basal (%)	
Arentz et al.	1 (4.8)	20 (95.2)	0 (0)	–	–	11 (52.4)	4 (19.0)	10 (47.6)	–	–	–	–	–	–	Pleural Effusion: 6 (28.6) Pulmonary Edema: 2 (9.5) Atelectasis: 1 (4.8)
Chen et al.	0 (0)	99 (100)	0 (0)	–	–	74 (74.7)	–	14 (14.1)	–	–	–	–	–	–	Pneumothorax: 1 (1)
Cozzi et al.	13 (5.6)	221 (94.4)	0 (0)	29 (12.4)	21 (9.0)	162 (69.2)	135 (57.7)	147 (62.8)	37 (16.5)	135 (60.5)	51 (22.8)	55 (24.6)	31 (13.9)	137 (61.4)	Cardiomegaly: 70 (29.9) Pleural Effusion: 39 (16.7) Pneumothorax: 5 (2.4)
Guan et al.	112 (40.9)	162 (59.1)	0 (0)	–	–	100 (36.5)	–	55 (20.1)	–	–	–	–	–	–	–
Ippolito et al.	–	–	–	–	–	301 (64.5)	245 (52.5)	335 (63.1)	–	292 (62.5)	–	–	–	335 (71.1)	Pleural Effusion: 57 (12.2)
Kim et al.	15 (53.6)	13 (46.4)	0 (0)	–	–	6 (21.4)	–	–	–	–	–	–	–	–	–
Ng et al.	2 (40.0)	3 (60.0)	0 (0)	–	–	2 (40.0)	3 (60.0)	–	–	–	–	2 (40.0)	0 (0)	1 (20.0)	–
Russel et al.	371 (58.3)	265 (41.7)	0 (0)	–	–	133 (20.9)	34 (5.3)	120 (18.9)	6 (0.9)	225 (35.4)	45 (7.1)	6 (0.9)	128 (20.1)	215 (33.8)	Pleural Effusion: 2 (0.3)
Toussie et al.	–	–	–	–	–	–	–	–	–	–	–	–	23 (6.8)	270 (79.9)	Pleural Effusion: 0 (0) Pneumothorax: 0 (0)
Vancheri et al.	60 (25.0)	180 (75.0)	0 (0)	24 (10.0)	24 (10.0)	132 (55.0)	71 (29.6)	124 (51.7)	71 (29.6)	89 (37.1)	20 (8.3)	–	66 (27.5)	158 (65.8)	Pleural Effusion: 12 (5.0)
Wong et al.	20 (31.3)	44 (68.8)	7 (10.9)	10 (15.6)	9 (14.1)	32 (50.0)	30 (46.8)	21 (32.8)	19 (29.7)	26 (40.6)	6 (9.4)	19 (29.7)	0 (0)	32 (50.0)	Pleural Effusion: 2 (3)
Yoon et al.	4 (44.4)	5 (55.6)	0 (0)	5 (55.6)	5 (55.6)	–	8 (88.9)	2 (22.2)	2 (22.2)	6 (66.6)	2 (22.2)	–	2 (22.2)	5 (55.6)	–

Results

Seventy-four percent (74%) (95% CI: 51–92%) of patients with COVID-19 had an abnormal CXR at the initial time of diagnosis or sometime during the disease course. The most common abnormalities are consolidation (28%, 95% CI: 8–54%) and ground-glass opacities (29%, 95% CI: 10–53%). The distribution is most frequently bilateral (43%, 95% CI: 27–60%), peripheral (51%, 95% CI: 36–66%), and basal zone (56%, 95% CI: 37–74%) predominant. In contrast to parenchymal abnormalities, pneumothorax (1%, 95% CI: 0–3%) and pleural effusions (6%, 95% CI: 1–16%) are rare.

Table 3
Compilation of pooled prevalence of chest radiograph imaging findings from each study.

Meta-Analyses: Pooled Prevalence of CXR Imaging Findings (95% CI)															
Reference	Baseline			Lung Involvement			Consolidation	Ground Glass Opacities	Distribution			Zone Predominance			Pleural Effusion
	Normal	Abnormal	Normal Turned Abnormal	Right	Left	Bilateral			Diffuse	Peripheral	Perihilar	None	Superior	Basal	
Arentz et al.	0.05 (0.00, 0.24)	0.95 (0.76, 1.00)	0.00 (0.00, 0.16)	–	–	0.52 (0.30, 0.74)	0.19 (0.05, 0.42)	0.48 (0.26, 0.70)	–	–	–	–	–	–	0.29 (0.11, 0.52)
Chen et al.	0.00 (0.00, 0.04)	1.00 (0.96, 1.00)	0.00 (0.00, 0.04)	–	–	0.75 (0.65, 0.83)	–	0.14 (0.08, 0.23)	–	–	–	–	–	–	–
Cozzi et al.	0.06 (0.00, 0.09)	0.94 (0.91, 0.97)	0.00 (0.00, 0.02)	0.12 (0.08, 0.17)	0.09 (0.06, 0.13)	0.69 (0.63, 0.75)	0.58 (0.51, 0.64)	0.63 (0.56, 0.69)	0.16 (0.11, 0.21)	0.58 (0.51, 0.64)	0.22 (0.17, 0.28)	0.24 (0.18, 0.29)	0.13 (0.09, 0.18)	0.59 (0.52, 0.65)	0.17 (0.12, 0.22)
Guan et al.	0.41 (0.35, 0.47)	0.59 (0.53, 0.65)	0.00 (0.00, 0.01)	–	–	0.36 (0.31, 0.43)	–	0.20 (0.15, 0.25)	–	–	–	–	–	–	–
Ippolito et al.	–	–	–	–	–	0.64 (0.60, 0.69)	0.52 (0.48, 0.57)	0.72 (0.67, 0.76)	–	0.62 (0.59, 0.67)	–	–	–	0.72 (0.67, 0.76)	0.12 (0.09, 0.15)
Kim et al.	0.54 (0.34, 0.72)	0.46 (0.28, 0.66)	0.00 (0.00, 0.12)	–	–	0.21 (0.08, 0.41)	–	–	–	–	–	–	–	–	–
Ng et al.	0.40 (0.05, 0.85)	0.60 (0.15, 0.95)	0.00 (0.00, 0.52)	–	–	0.40 (0.05, 0.85)	0.60 (0.15, 0.95)	–	–	–	–	0.40 (0.05, 0.85)	0.00 (0.00, 0.52)	0.20 (0.01, 0.72)	–
Russel et al.	0.58 (0.62, 0.54)	0.42 (0.38, 0.46)	0.00 (0.00, 0.01)	–	–	0.21 (0.18, 0.24)	0.05 (0.04, 0.07)	0.19 (0.16. 0.22)	0.01 (0.00, 0.02)	0.35 (0.32, 0.39)	0.07 (0.05, 0.09)	0.01 (0.00, 0.02)	0.20 (0.17, 0.23)	0.34 (0.30, 0.38)	0.00 (0.00. 0.01)
Toussie et al.	–	–	–	–	–	–	–	–	–	–	–	–	0.07 (0.04, 0.10)	0.80 (0.75, 0.84)	0.00 (0.00. 0.01)
Vancheri et al.	0.25 (0.20, 0.31)	0.75 (0.69, 0.80)	0.00 (0.00, 0.02)	0.10 (0.07, 0.15)	0.10 (0.07, 0.15)	0.55 (0.49, 0.61)	0.30 (0.24, 0.36)	0.52 (0.45, 0.58)	0.30 (0.24, 0.36)	0.37 (0.31, 0.44)	0.08 (0.05, 0.13)	–	0.28 (0.22, 0.34)	0.66 (0.59, 0.72)	0.05 (0.02, 0.09
Wong et al.	0.31 (0.20, 0.44)	0.69 (0.56, 0.80)	0.11 (0.05, 0.21)	0.16 (0.08, 0.27)	0.14 (0.07, 0.25)	0.50 (0.37, 0.63)	0.47 (0.34, 0.60)	0.33 (0.22, 0.46)	0.30 (0.19, 0.42)	0.41 (0.29, 0.54)	0.09 (0.04, 0.19)	30 (0.19, 0.42)	0.00 (0.00, 0.06)	0.50 (0.37, 0.63)	0.03 (0.00, 0.11)
Yoon et al.	0.44 (0.14, 0.79)	0.56 (0.21, 0.86)	0.00 (0.00, 0.34)	0.56 (0.21, 0.86)	0.56 (0.21, 0.86)	–	0.89 (0.52, 1.00)	0.22 (0.03, 0.60)	0.22 (0.03, 0.60)	0.67 (0.30, 0.93)	0.22 (0.03, 0.60)	–	0.22 (0.03, 0.60)	0.56 (0.21, 0.86)	–
Overall I^2	98.18%	98.18%	70.54%	76.22%	91.48%	97.54%	99.03%	99.14%	97.19%	95.67%	91.07%	98.01%	92.14%	97.79%	97.41%
Overall *p*	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Conclusion

- These results provide information that enhances the utility of CXR in the evaluation and management of patients diagnosed with COVID-19. CXR may be used to triage patients, guide admission criteria, and follow response to treatments.
- This is especially important in the fast-paced, high-stakes and resource-limited setup that the pandemic has imposed on healthcare systems where there is a need for evidence-based alternatives such as CXR to provide safe, efficient and high-quality patient care.