What is the accuracy of chest CT scan in diagnosing COVID-19 in children?
What are the common chest CT scan finding in children with COVID-19?

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This rapid review summarizes the available evidence on the accuracy of chest CT scan in diagnosing children with COVID-19. This may change as new evidence emerges.

KEY FINDINGS

A poor quality study showed 86.0% (95% CI 73.8, 93.0) sensitivity and 75.9% (95% CI 67.1, 83.0) specificity of chest CT scan in diagnosing COVID-19 in children. The most commonly reported chest CT scan patterns in these patients are ground glass opacities, patchy shadows, and consolidation.

- We found only one study that directly examined the diagnostic performance of chest CT scan in diagnosing COVID-19 in children compared to RT-PCR. It showed that its sensitivity and specificity is 86.0% (95% CI 73.8, 93.0) and 75.9% (95% CI 67.1, 83.0), respectively.
- Based from 39 observational studies, the pooled sensitivity of chest CT scan in diagnosing COVID-19 in children is 69.4% (95% CI 62.5, 76.3).
- Common chest CT scan findings in children with COVID-19 include the following: 1) ground glass opacities, patchy shadows, and consolidation, 2) lower lobe involvement, and 3) unilateral lung lesions.
- An International Expert Consensus on Chest Imaging in Pediatric COVID-19, the Philippine Pediatric Society and the Pediatric Infectious Diseases Society of the Philippines recommend against the use of chest CT scan as an initial diagnostic tool for children suspected to have COVID-19.

RESULTS

Diagnostic Accuracy of Chest CT scan

Only one study reported the accuracy of chest CT scan in diagnosing COVID-19 in children. This poor quality study was done in Wuhan, China and was published last April 2020. It showed that the sensitivity of chest CT scan in diagnosing COVID-19 is 86.0% (95% CI 73.8, 93.0), specificity is 75.9% (95% CI 67.1, 83.0), positive predictive value is 62.3% (95% CI 0.505, 0.728), and negative predictive value is 92.1% (95% CI 72.1, 84.7) [1].

Common Chest CT Scan Findings

Thirty-nine studies (11 case series [2-12], 1 multi-center prospective cohort [13]), and 27 retrospective cohort reviews [1, 14-40]) which characterize chest CT scan findings in pediatric patients with COVID-19 were included in this review. After screening, 11 of the 39 included studies were assessed to have good quality, 22 were of fair quality, and the remaining six have poor quality.

The pooled sensitivity of these 39 studies on chest of CT scan in diagnosing COVID-19 is 69.4% (95% CI 62.5, 76.3 I^2=89.89%).

The lower lobe was the most frequently reported lobe with pooled proportions from 13 studies on lower lobe involvement at 45.8% (95% CI 38.8,97.5, I^2=0).

The pooled proportions from 26 studies of unilateral lung involvement is 33.1% (95% CI 26.5,39.7, I^2=68.02%). On the other hand, 27 studies reported bilateral lung lesions, with pooled proportions of bilateral lung involvement at 31.2% (95%CI 23.5, 38.8), I^2=85.15%).

The most commonly reported pattern is ground-glass opacities with a pooled proportion from 32 studies of 43.1% (95%CI 34.5, 51.6, I^2=87.14%). Patchy shadows, reported in 7 studies, have a pooled proportion of 43.8% (95%CI 19.6, 67.9, I^2= 92.66%), while consolidations have a pooled proportion of 26.2% (95% CI 1.61, 36.3, I^2=85.13%) from 15 studies. Other reported findings on the CT scan are as follows: pleural effusion, halo sign, air bronchogram, pleural thickening, crazy paving sign, reverse halo sign, interstitial abnormalities, and lymphadenopathy.

An International Expert Consensus on Chest Imaging in Pediatric COVID-19, the Philippine Pediatric Society and Pediatric Infectious Disease Society of the Philippines do not recommend the use of chest CT scan as an initial diagnostic test in children with COVID-19 [41,42].

CONCLUSION

Studies which directly investigate the accuracy of chest CT scan in the diagnosis of COVID-19 pneumonia in children is very limited. At present, available studies on chest CT scan in children with COVID-19 are limited to cohort studies and case series.

While chest CT scan findings such as patchy shadows, ground glass opacities, and consolidation, are common in children with COVID-19, these may be similar to the imaging findings of other respiratory viral illnesses.

Limitations of these studies include small sample sizes and heterogenous populations with a wide spectrum of disease severity. Furthermore, there is a possibility of enrolment of the same participant/s in more than one of the included studies in our review.

Declaration of Conflict of Interest

No conflict of interest

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Table 1. Characteristics of included studies

No.	Title/Author	Study design	Country	Population	Age	Outcomes	Timing of Chest CT scan	Type of CT Scan
1	Clinical analysis of 25 COVID-19 infections in children Bai, K. et al. April 2020	Multi-center retrospective cohort study	Chongqing, China	25 children with laboratory-confirmed 2091 nCoV infection by RT PCR admitted from 4 designated hospitals in Chongqing from January 19 to March 12, 2020 14 males, 11 females	0.6-17 years (mean 11.0 years)	Clinical data and epidemiologic history	not stated	not stated
2	The early experiences of a single Italian emergency department treating COVID-19 in children Brisca, G, et. Al	Single center retrospective cohort study	Italy	24 patients admitted to the emergency department at IRCSS Gaslini Children's Hospital, Genoa, Italy from February 24 to April 16, 2020 11 males, 13 females	14 days to 18 years	Clinical data and course	not stated	Non contrast chest CT scan
3	Clinical Characteristics of 5 covid-19 case with Non-respiratory symptoms as the first manifestation in children Cai, X. et al. May 2020	Case Series	Wuhan, China	5 patients with non-respiratory symptoms as the first manifestation, later confirmed to have COVID-19 from January 23 to February 20, 2020 at the Wuhan Children's Hospital 4 males, 1 female	2 month- 5.6 years	clinical features of COVID19 with non-respiratory symptoms as first manifestation	Day 2-9 of symptom onset	not stated
4	Asymptomatic SARSCOV2 infection in children: a clinical analysis of 20 cases Chen, Jun et al. May 2020	Single center retrospective cohort study	Shenzhen, China	20 cases admitted to the Shenzhen Third People's Hospital from January 20 to March 4, 2020 7 males, 13 females	8 month-4 years	Main clinical manifestations, course of disease, treatment	after admission	High resolution chest CT scan
5	Clinical features of pediatric patients with COVID-19: a report of two family cluster cases Ji, Li-Na et al. March 2020	Case Series	Beijing, China	2 pediatric cases admitted January 25, 2020 and February 3, 2020 at Beinjing Tsinghua Changgung Hospital 2 males	9-15 years old	Epidemiological features, physical examinations, laboratory studies, and clinical outcome	Not stated	Unenhanced chest CT scan
6	CT image features analysis of 15 cases of novel coronavirus infection in children Kai, Feng et al.	Single-center retrospective cohort study	Shenzhen, China	15 cases of new coronavirus infection in children diagnosed by Shenzhen Center for Disease Control and Prevention from January	4-14 years old	Chest CT examination, clinical data	with fever: when they visit a doctor; asymptomatic: during the initial RT-PCR; then 3-5 days after admission	Unenhanced chest CT scab=n withToshiba 64-slice spiral CT 135 kV, pitch 0.8, matrix 512 x 512, FOV 320mm x 320mm, slice thickness 5.0mm, slice distance 5.0mm

				16,2020 to February 6, 2020 75 males, 10 females				
7	Computed tomography of the lungs in novel corona virus (COVID-19) infection Lai, W. et al. March 2020	Case Series	Guangdong, China	2 children diagnosed with COVID 19 2 males	12-16 years	Clinical and chest CT features	intial, repeat after 4,13,17 days	Unenhanced chest CT scan
8	Early CT findings of Coronavirus Disease 2019 (COVID-19) in Asymptomatic children: A single center experience Lan, L. et al. March 2020	Case series	Wuhan, China	all pediatric patients diagnosed with COVID19 and who underwent CT scan in Zhongnan Hospital of Wuhan University from January 20 to February 28, 2020 2 males, 2 females	7-13 years old	clinical and CT features	on admission	CT scan 120kV, 100-150mA, slice thickness 1mm, lung window -700, window width 1500HU
9	Radiographic and Clinical features of Children with Coronavirus Disease (COVID-19) Pneumonia Li, Bo et al. April 2020.	Single-center retrospective cohort study	Hubei, China	22 patients 12 males, 10 females	mean age 6 years	Clinical data, physical examination, laboratory data, radiographic features	not stated	Non-enhanced Chest CT Scan using a 16-row multi-detector CT scanner (Siemens Somatom), 120kVp, 140mA, 5mm collimation, 1.35:1 pitch,
10	Clinical and CT features of the COVID19 infection: comparison among four different age groups Li, W. et al July 2020	Single center retrospective cohort study	China	patients with chest CT examination and positive RT PCR from January 17 to February 21, 2020 at the Fifth Affiliated Hospital of Sun Yat-sen University 5 males, 1 female	mean 5 years	Clinical and chest CT features	Not stated	Non-enhanced chest CT scan
11	Chest computed tomography in children with COVID-19 respiratory infection Li, Wei et al.	Case Series	Zhuhai, China	5 children who tested positive on a reverse transcriptase- polymerase chain reaction for COVID-19 during the period January 28 to February 8, 2020 4 males, 1 female	10 months- 6 years	Clinical history, laboratory findings, and chest CT imaging	2-9 days after admission/ onset of symptoms; 5-7 days after initial CT scan	Non enhanced chest CT scan
12	Chest CT imaging characteristics of COVID-19 pneumonia in preschool children: a retrospective study Li, Yang et al.	Multi-center retrospective cohort study	Hubei, China	8 preschool children with laboratory-confirmed COVID-19 from 2 hospitals from January 26 to February 20, 2020 3 males, 5 females	1-5 years (median 2.5 years)	clinical, initial chest CT imaging data	At the time of admission	plain CT scan using multi-detector CT scanner, thickness of the slices 1mm, interslice gap 1mm matrix 512 mm x 512mm, tube voltage 80kV, current 200mA, pitch 0.813/HP 65.0

								and dose lenth product 36-51 mGycm
13	Clinical and CT imaging features of the COVID-19 pneumonia: Focus on pregnant women and children Liu, Huanhuan et. al.	Case Series	Hubei, China	4 children with laboratory-confirmed and clinically-diagnosed COVID-19 pneumonia 2 males, 2 females	2 months to 9 years	Clinical and chest CT imaging data	Median of 2 days from onset of symptoms	non-enhanced chest CT examination, 64 section multidetector CT scanner 120kV, automatic tube current (120-380) mA, tickness 507mm, slice interval 5mm, rotation speed 0.5s, helical pitch 1:0875:1 or 1.375:1
14	High-Resolution Computed Tomography Manifestations of 5 Pediatric patients With 2019 Novel Coronavirus Liu, Mengqi et al.	Case Series	Chingqing, China	5 cases of pediatric patients with 2019 novel coronavirus 4 males, 1 female	7 months-13 years	Clinical and chest CT features	Initial and follow-up 5-13 days after admisison/ treatment	Unenhanced chest high resolution CT scan
15	Detection of COVID-19 in Children in Early January 2020 in Wuhan, China Liu, W. et al. March 2020	Case Series	Wuhan, China	6 patients detected with SARS-CoV-2 from January 2 to January 8 2 males, 4 females	1 to 7 years (median 3 years)	Clinical data and CT findings	Not stated	Not stated
16	SARS-COV2 infection in children Lu, X. et al. March 2020	Cohort	Wuhan, China	171 chidren with confirmed SARSCOV2 infection from January 28 to Feruary 26 104 males, 67 females	1 day to 15 years (median 6.7 years)	epidemiologic characteristics, clinical features, radiologic findings	Not stated	Not stated
17	Clinical characteristics and radiologic features of children infected with the 2019 novel coronavirus Lu, Y. et al. May 2020	Case Series	Guangzhou, China	9 children infected with the 2019-nCoV from January 22 to February 9, 2020 admitted to Guangzhou Women and Children's Medical Center 5 males, 4 females	2 month to 5 years	clinical characteristics and radiologic features	Not stated	64 section spiral CT system 120 kV tube 87 voltage, 50e70 mA tube current 0.5 s/rot bulb rotation 88 speed, and 0.2 mm slice thickness.
18	A single-center, retrospective study of COVID-19 features in children: a descriptive investigation Ma, Hujing et al.	Single center retrospective cohort study	Wuhan, China	158 children 16 years of age and under who had a family or social history of COVID-19 exposure, recruited from January 21-February 14, 2020 28 males, 22 females	0.9-7 years old	Demographic information, clinical symptoms, laboratory result, outcome data Chest CT without IV contrast features	Not stated	Chest CT without intravenous contrast was per- formed on all patients using a Siemens SOMATOM Definition AS128 or GE Optima CT 660 with a 1-mm or 0.625-mm slice thickness
19	Clinical features of children with SARSCOV2 infection: an analysis of 115 cases Ma, Yao-Ling et al. March 2020	Single-center retrospective cohort study	Wuhan, China	115 cases of outpatient diagnosis and emergency diagnosis of COVID-19 73 males, 42 females	51 days to 15 years old	Epidemiological contact, clinical symptoms, laboratory tests, and chest CT imaging findings of the lungs	Not stated	Not stated

20	Clinical and radiological characteristics of pediatric patients with COVID-19: focus on imaging findings Mohammadi, A. et al. June 2020	Single center retrospective cohort study	Urmia, Iran	27 pediatric patients with COVID-19 pneumonia between January 23 to March 25, 2020 10 males, 17 females	mean 4.7 years	clinical and radiologic findings of pediatric patients with COVID-19 pneumonia	initial day of hospitalization	Siemens SOMATOM, Toshiba Alexion: low dose mode, automatic tube current modulation with a voltage of 120 kVp, matrix size of 512 × 512, increment and thickness of 1.5–2 mm
21	Clinical and epidemiological features of 36 children with coronavirus disease 2019 (COVID-19) in Zhejiang, China: an observational cohort study Qiu, H. et al. March 2020.	Multi-center retrospective cohort study	Zhejiang, China	36 children infected with SARSCOV2 infection from January 17 to March 1, 2020 in 3 hoospitals in Zhejiang, China 23 males, 13 females	1-16 years old	epidemiologic data and clinical features	Not stated	Not stated
22	Novel coronavirus infection in children outside of Wuhan, China Shen, Q. et al. March 2020 (38)	Single center retrospective cohort study	Hunan, China	9 hospitalized patients diagnosed with COVID-19 between January 8 to February 19, 2020 3 males, 6 females	1-12 years old (median 8 years old)	epidemiologcial, clinical, laboratory, and radiologic characteristics	Not stated	Not stated
23	Pediatric coronavirus disease 2019 (COVID-19): An insight from west of Iran Soltani, J. et al. May 2020	Multi-center prospective cohort study	Iran	30 children diagnosed as probable or confirmed COVID19 cases from March 1 to April 15, 2020 in Hamadan and Kurdistan province 14 males, 16 females	1 day to 15 years (mean 6, median 5.5 years)	clinical, laboratory, radiological characteristics	Not stated	Not stated
24	CT features of coronavirus disease (COVID-19) in 30 pediatric patients Steinberger, S. et al. May 2020	Multi-center retrospective cohort study	China	30 pediatric patients with laboratory confirmed COVID-19 who were at six centers in China from January 23, 2020 to February 8, 2020 15 males, 15 females	10 months-18 years (median 10 years)	clinical characteristics and CT features	Not stated, 11 had follow-up CT scan	Non-contrast chest CT scan, slice thickness of 1-5mm
25	Clinical features of pediatric patients with coronavirus disease Song, Wenliang et al. April 2020	Single-center retrospective cohort study	Xiangyang City, Hubei, China	16 children diagnosed with COVID-19 at Central Hospital of Xiangyang City between Janurary 31, 2020 and March 17, 2020	11.5 month-14 years (median 8.5 years)	Clinical features, laboratory testung and imaging	on the day or 1 day after the RT-PCR	Not stated
26	Clinical features of severe pediatric patients with coronavirus disease 2019 in Wuhan: a single center's observational	Single-center retrospective cohort study	Wuhan, China	8 severely or critically ill patients with COVID-19 who were treated at the Intensive Care Unit, Wuhan Children's Hospital	2 months to 15 years	Clinical characteristics and chest imaging results	Not stated	Not stated

	Sun, Dan et al.			from January 24 to February 24, 2020 6 males, 2 females				
27	SARS-CoV2 infection in infants under 1 year of age in Wuhan City, China Sun, Dan et al. June 2020	Single center retrospective cohort study	Wuhan, China	36 infants with SARSCOV2 infection in Wuhan Children's Hospital from January 26 to March 22, 2020 22 males, 14 females	2-12 months (mean 6.43 month)	clinical features, chest imaging findings, laboratory test results, and clinical outcomes	Not stated	Not stated
28	Epidemiological and Clinical Characteristics of 10 Children with Coronavirus Disease 2019 in Changsa, China Tan, Yu-pin et al. April 2020	Single-center retrospective cohort study	Changsa, China	10 children with confirmed COVID-19 from January 27 to March 10,2020 in the First Affiliated Hospital of Hunan Normal University 3 males, 7 females	1-12 years (mean 7 years)	Epidemiological and demographic information, signs and symptoms on admission, laboratory results, coinfection, CT findings, treatment and outcome	Not stated	Not stated
29	A retrospective study of the clinical characteristics of COVID-19 infection in 26 children Tang, Anjue et. al. March 2020	Single-center retrospective cohort study	Shenzhen, China	26 cases of children (>1 year old and <14 years old) In the Third People's Hospital of Shenzhen from January 16 to February 8, 2020 9 males, 17 females	1-13 years old	Clinical manifestations, laboratory results, chest CT, treatment methods and outcomes	Not stated	Not stated
30	Clinical analysis of 31 cases of 2019 new coronavirus infection in children from six provinces (autonomous regions) in northern China Wang, Duan et al.	Multi-center retrospective cohort study	Shaanxi, Ningxia, Hebei, Henan, and Shandong provinces, China	30 cases of children with 2019-nCoV infection in 21 hospitals from January 25 to February 21, 2020 15 males, 15 females	6 months to 17 years old	Clinical manifestations, laboratory examination, imaging examinations, and treatment	Not stated	Not stated
31	Epidemiological and Clinical Characteristics of Children with Coronavirus Disease 2019 Wu, Qin et al.	Multi-center retrospective cohort study	China	74 pediatric cases admitted to 2 hospitals from January 20 to February 27, 2020 44 males, 30 females	Median of 6 years	Baseline information, clinical manifestations, laboratory and radiologic findings, treatment, and outcome	Not stated	Not stated
32	Clinical and CT features in pediatric patients with COVID-19 infection: different points from adults Xia, Wei et al.	Single-center retrospective cohort study	Wuhan, China	20 pediatric inpatients with COVID-19 infection from January 23 to February 8, 2020 13 males, 7 females	1 day to 14 days (median 2 years and 1.5 months)	Clinical and laboratory data, chest CT findings	Initial, Advanced, Critical, Recovery	Noncontrast chest CT studies were performed on SOMATOM Definition AS 128 unit with the following parameters 12 0 Kv 100 to 150 mA, 0.5mm collimation, and 1:! Pitch
33	A follow-up study of children infected with SARS-COV2 from Western China	Multi-center retrospective cohort study	4 provinces in Western China	32 children confirmed with SARS-CoV-2 infection	mean 10 years	History of exposure, demographic characteristics, laboratory	Not stated	Not stated

	Xu, Hongmei et al.			between January 24 and February 12, 2020 17 males, 15 females		findings, radiologic findings and clinical outcomes		
34	The clinical and epidemiological features and hints of 82 confirmed COVID-19 pediatric cases age 0-16 in Wuhan, China Yu, Hui et al.	Single-center retrospective cohort study	Wuhan, China	82 children infected with COVID-19, on February 1-20, 2020 at Wuhan Children's Hospital 51 males, 31 females	3 days-16 years	Symptoms, laboratory results, chest radiography and CT findings	Not stated	Not stated
35	Clinical characteristics of 34 Children with Coronavirus Disease-2019 in the West of China Zhang, Che et al.	Multi-center retrospective cohort study	China	34 admitted children with laboratory-confirmed SARS-CoV-2 from 4 hospitals during January 1 to February 23, 2020 14 males, 20 females	1-144 months (media 33 months)	Demographic information, medical and exposure history, CT scan, therapeutic information	Not stated	Not stated
36	Clinical Characteristics of Children with Coronavirus Disease 2019 in Hubei, China Zheng, Fang et. al.	Multi-center retrospective cohort study	Wuhan, China	24 children aged 1 month -14 years admitted to hospitals with COVID-19 between February 1 to February 10, 2020	1 month -14 years (media 3 years)	Clinical and laboratory data, radiological characteristics, treatments and outcomes	on admission	Not stated
37	Chest CT findings and clinical features of coronavirus disease 2019 in children Zhong, Zheng et al.	Single center retrospective cohort study	Hunan province, China	laboratory confirmed pediatric COVID19 patients 4 males, 5 females	3 months-12 years	clinical history, laboratory results, and epidemiological characteristics, CT scan results	same day as being diagnosed and on follow-up (2-3 days after treatment)	Not stated
38	Clinical features and chest CT manifestations of 2019 coronavirus in infants Zhou, Yun et al.	Single-center retrospective cohort study	Shenzhen, China	9 infants (0-3 years old) patients diagnosed with COVID-19 from January 20 to February 10,2020 4 males, 5 females	0-3 years old (median age 1 year)	Clinical data and chest CT data	Same day or 1 day after the throat swab	64-slice spiral CT scan: tube voltage 80-120 kV, FOV 200x200mm, reconstruction layer thickness 0.8mm
39	Clinical characteristics of a case series of children with coronavirus disease 2019 Zhu, Li et al. March 2020	Case Series	Jiangsu, China	10 children ahed from 1 to 18 years with confirmed COVID19 from 3 designated hospitals in 3 cities of Jiangsu province 5 males, 5 females	1 year 7 months to 17 years old	Demographic, epidemiological, and clinical data	On admission	Not stated