



Chest radiograph in hospitalized children with COVID-19. A review of findings and indications

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HIGHLIGHTS

- COVID-19 clinical manifestations and radiological findings are milder and less specific in children.
- The presence of fever, and fever duration are clinical findings associated with pathological chest imaging.
- The most common pattern seen in pathological chest X ray were bilateral diffuse interstitial pattern followed by perihilar bronchial wall thickening.
- Consensual specific age-adjusted protocols regarding chest imaging indications in pediatric COVID-19, as the one developed, are needed.
- Imaging should not be used as a screening tool or a routine complementary test in pediatric hospitalized patients with COVID-19.

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ABSTRACT

Purpose: Many articles have been published regarding chest-imaging in COVID-19, but fewer studies have been published in pediatric populations. COVID-19 symptoms in children are generally milder and radiological tests have fewer positive findings. Indications for chest imaging in pediatric COVID-19 patients remain unclear. This study aims to describe the chest radiographs performed in COVID-19 patients in a pediatric hospital, to review the current chest X-ray indications and to develop an specific age-adjusted protocol for chest-imaging in children with COVID-19.

Methods: Retrospective study in hospitalized pediatric COVID-19 patients in Navarre, Spain. Between March and December 2020, 44 children were included (mean age 3.8-year-old, 50 % males). Demographic information, cause of admission, symptoms, and clinical evolution were described. Chest imaging technique performed, indications and findings were analyzed. A literature review was performed searching for current COVID-19 pediatric chest-imaging indications.

Results: Chest X-rays were performed in 35 patients (80 % of admissions) and most common indications were fever and respiratory symptoms. 53 % of the chest X-rays were considered "normal" and the classical bilateral diffuse interstitial pattern, described in adults, was only present in 22 %. All patients with pathological chest X-

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rays were symptomatic and reported fever (100 %) and fever tended to be longer (fever duration: 4.25 vs. 2.46 days $p:0.048$) in patients with pathological radiographs. We present a specific protocol for chest-imaging in pediatric COVID-19 cases.

Conclusions: COVID-19 clinical manifestations and radiological findings are milder and less specific in children. Imaging should not be used as a screening tool or a routine complementary test in pediatric COVID-19 patients, not even in hospitalized cases.

1. Introduction

It's only been a year since Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was identified in China as the responsible pathogen of COVID-19 [1]. Since then, cases keep rising worldwide, with more than 67,530,000 confirmed cases and over 1,545,000 deaths as of December 2020 [2]. The global pandemic, declared by the World Health Organization (WHO) in February 2020, is still on-going and in the last 12 months many changes and advances have been done in the prevention, diagnosis and treatment of this disease [3,4].

SARS-CoV-2 infection has very different clinical presentations, ranging from a mild common cold to a severe respiratory illness and death [1,5]. Children seem to have milder forms of the disease, with a wider spectrum of clinical findings, lower hospitalization rates and lower mortality [6–8]. Imaging techniques such as chest X-ray, Computed Tomography (CT), Ultrasound (US) or Magnetic Resonance Imaging (MRI), have been used in adults to diagnose SARS-CoV-2 pneumonia nevertheless, since children have different clinical presentations, imaging findings and indications may also differ [3,9–11]. Many articles have been published regarding the indications and utilizations of chest imaging in adults, the classical findings seen in adults, such as the peripheral bilateral diffuse infiltrates have been widely described, but fewer studies have been performed on pediatric population [12–17]. Descriptions of imaging findings in pediatric patients with COVID-19 are scarce and generally limited to case series [14,15,18], but according to first results, pediatric patients have less positive findings, and this fact, along with the negative effects of ionizing radiation in younger individuals, supports the idea that chest imaging should not be performed routinely in pediatric COVID-19 patients and that indications should be more restrictive [9,17,19–21]. According to the European Society of Pediatric Radiology recommendations on pediatric COVID-19, imaging should only be performed when expected to alter the management and always depending on the patient's symptoms and clinical evolution [22]. Lung US in adults has proven to be a useful tool in the early detection of pulmonary pathology, but its use in pediatric population is more scarce [23,24] and while CT has been widely used in adults with SARS-CoV-2 pneumonia, its high radiation exposure and the frequent need of sedation in pediatric make its use in children no so widespread [25–27].

Few articles have been published about the different indications for chest imaging, or chest radiography in pediatric patients infected with SARS-CoV-2. Published indications are not specific and not age-adjusted, however, most authors agree that imaging tests should only be considered in pediatric patients with suspected COVID-19 presenting with moderate to severe acute respiratory illness [14,17]. The indications to perform chest imaging in pediatric COVID-19 remain unclear and there is an urgent need to develop specific guidelines and age-adjusted protocols for pediatric imaging. Most pediatric cases are non-severe, but children can also develop a multisystem inflammatory syndrome related to coronavirus (MIS-C) that might require a different diagnostic approach. As MIS-C clinical presentation is usually non-specific, imaging evaluation plays an important role in making an early diagnosis. Radiologists should be aware of the constellation of these imaging findings, that, although nonspecific, when combined with the classical presentation and the clinical history of exposure to SARS-CoV-2, might suggest the diagnosis of MIS-C [28,29].

The first objective of this study is to describe the indications and

findings of all the chest radiographs performed in pediatric patients admitted for SARS-COV-2 in a tertiary reference hospital in Navarre, Spain. The secondary objective is to review the pediatric chest X-ray indications published in the literature and to develop a protocol for chest-imaging indications in pediatric-COVID-19 patients.

2. Materials and methods

2.1. Epidemiology data

This is a single-center, retrospective article performed in hospitalized pediatric COVID-19 patients. The study period: March-December 2020 was selected to include the first (March - June) and the second (September - December) COVID-19 waves in Navarre. Navarre is located in the north-east of Spain, it has a total population of 660,887 (including 101,000 children younger than 15 year-old) and it has been one of the most affected European regions by the COVID-19 pandemic. According to the WHO, by December 2020, a total of 1,702,000 cases of SARS-CoV-2 and 46,646 related deaths have been confirmed in Spain, including 45,124 SARS-CoV-2 cases and 908 deaths in the community of Navarre [30,31]. The *Complejo Hospitalario de Navarre* (CHN Hospital) is the tertiary reference hospital of the community, located in Pamplona, the capital. All pediatric admissions during the first wave and the majority of the pediatric admission during the second wave (95.4 % of the total admissions) were admitted in the Pediatric CHN COVID-ward.

2.2. Study group

For this study, the inclusion criteria were any child (from 1 day- to 15-year-old), with confirmed COVID-19, admitted at the CHN pediatric COVID-ward. We considered as “confirmed COVID-19” children with a positive reverse transcriptase polymerase chain reaction (rRT-PCR) or a positive rapid antigen test. Our testing criteria and admission criteria changed many times during the study period, but for this analysis all laboratory confirmed cases, independently of the cause of admission, the presence of symptoms or the clinical evolution were included. A total of 5506 COVID-19 pediatric cases have been confirmed in Navarre, with no pediatric deaths. [2,30] During the study period (March-December 2020), 44 children (22 males, mean age 3.8-year-old) with confirmed COVID-19 were admitted in the CHN hospital. Among hospitalized cases 6 % were asymptomatic, 4 % developed severe COVID-19 or MIS-C and 89 % of children presented mild non-specific symptoms. Only 14 % of patients presented with the classical triad of cough, fever and respiratory distress.

2.3. Imaging

All chest-imaging techniques performed in the study population, including chest X-ray, and CT were registered (35 chest X-ray and 1 CT). The majority of the chest X-rays performed (34/35) were done at bedside with the portable chest X-ray. We retrospectively reviewed the medical history and registered the demographic information (sex, age, medical records and concomitant infections), the cause of admission, the symptoms and clinical evolutions of all patients. The chest radiographs performed were reviewed by a certified pediatric radiologist who evaluated the presence or absence of interstitial or focal opacities, the distribution and lung affection and the presence of complications.

Radiologist had access to patients' information regarding, clinical presentation, previous medical conditions and previous radiographs. Chest X-rays were categorized as "normal" vs "pathological". For this study, only radiographs that included acute parenchyma alterations suggestive of COVID-19 infection were considered as "pathological". Other X-rays alterations, such as previous known pathologies or cardiac, mediastinal or thoracic-wall pathologies were evaluated, but not registered for the study as "pathological". According to previously published articles on chest X-rays findings, [19,32] we divided the pathological radiographs in 6 groups of possible parenchyma lesions: The first group included the typical adults' COVID-19 pneumonia findings (including bilateral diffuse interstitial pattern and bilateral pseudo-nodular opacities), other groups included: 2) perihilar bronchial wall thickening, 3) lobar consolidation, 4) unilateral interstitial pattern, 5) atelectasis and 6) other complications (including pleural effusion, pleural thickening, cavitation, or pneumothorax). Chest X-ray was the most common imaging technique, performed in 35 out of 44 patients. Following our MIS-C protocol, cardiac-USs were performed by a pediatric-cardiologist to all patients with confirmed or suspected MIS-C, but no lung-USs were performed. Thoracic CT scan was performed in only one patient (2 % of admitted patients) who presented a cardiac failure and a MIS-C and the CT scan was normal. NO MRIs were performed in our sample.

A literature review was performed in order to search for current publications regarding specific indications of chest-imaging in pediatric COVID-19 patients. Electronic searches of PubMed, Web of Science, Cochrane and Scopus database were conducted in December 2020, using a combination of medical subject heading terms (MESH-Terms). Two authors reviewed all selected publications (only articles in Spanish or English language were included).

2.4. Statistical analysis

Analyses were performed with the statistical program STATA.12. Continuous variables were presented as mean (M) and standard deviation (SD) and categorical variables as percentages (%) and total numbers. We described patients' characteristics and chest imaging indications and findings. We also compared children who had chest imaging vs those with no chest imaging performed. Pearson's Chi-squared test for qualitative values and Student's T test for quantitative variables were used. To compare changes in percentages, a two-sample test of proportion analysis was performed. All statistical analysis were performed with two tails and a p value of less than 0.05 was used as a point of statistical significance.

2.5. Ethical standards

The entire study has been performed according to the Declaration of Helsinki of 1975 (revision of October 2000), the local recommendation of the Spanish General Health Law on research and the ethical standards of the local Ethics Committee. Parental approval was obtained for each case and oral or written informed consent was obtained prior to inclusion in this study. The Ethics committee of Navarre Health department approved in May 2020 a study of the effects of Covid-19 on Navarre's pediatric patients. (*PI_2020/38: Estudio epidemiológico de las infecciones respiratorias por el nuevo Coronavirus SARS-CoV-2 en población pediátrica*).

3. Results

Among the 5506 COVID-19 pediatric cases in Navarre, 44 children were hospitalized (0.79 %), 2 patients required Intensive Care Unit (4.5 % of hospitalized cases and 0.03 % of total cases) and no mortality was registered. Mean hospital stay was 4.1 days (SD 2.3). Mean age of hospitalized patients was 3.8 years, 38 % were infants (<12-month-old), and 9 % were adolescents (>12-year-old). Most hospitalized children presented mild symptoms, and 7 % (9/44) were asymptomatic. [Table 1](#)

Table 1

Basal characteristics divided by age of the 44 hospitalized pediatric COVID-19 patients. CHN Hospital, Navarre, Spain. March – December 2020.

Variables	Infants <12-month-old	Children 1–12-year-old	Adolescents >12-year-old	p
n (%)	17	23	4	
Sex, n (% males)	9 (52.94 %)	12 (52.17 %)	1 (25 %)	0.576
Reported symptoms, n (%)	15 (88.24 %)	22 (95.75 %)	4(100 %)	0.558
Respiratory Symptoms, n (%)	12 (70.59 %)	9 (39.13 %)	3 (75 %)	0.098
Fever, n (%)	15 (88.24 %)	18 (78.26 %)	4 (100 %)	0.459
Fever duration (d), mean ± SD	1.9 (1,4)	3,8 (3.5)	4.3 (4)	0.117
Hospital stay (d), mean ± SD	4.2 (2,4)	4.0 (2.3)	6.0 (2.9)	0.334

shows the basal characteristics of the hospitalized pediatric COVID-19 patients divided by age. Among symptomatic patients, fever (>38 °C) was the most common symptom (37/41), with a mean duration of 3.11 days (SD 3.01). An epidemiological description of all pediatric patients with laboratory confirmed COVID-19 in Navarre, and a more detailed description of the CHN hospitalized patients have been performed [6,7,33]. No mortality, severe pulmonary complications or pulmonary emboli were detected in our study. No patient required intubation or mechanical ventilation. All the children were discharged without complications or sequelae.

Among hospitalized patients 80 % (35/44) had chest-imaging performed during admission (34 patients a chest X-ray and one patient a chest X-ray and a chest CT). Patients referred for a chest radiography tended to be more symptomatic (83 % vs 17 %) and to associate more respiratory symptoms (83 % vs 16 %) and more fever (86 % vs 13 %) than their peers with no chest-imaging performed. No differences were found regarding patients' age or sex distribution. ([Table 2](#)) The most common indications for chest imaging were clinically suspected pneumonia (fever with respiratory symptoms) followed by clinically suspected MIS-C. When follow-up radiographs were performed (25 %), they were all normal.

Of the chest radiographs performed, 54 % (19/35) were considered by a pediatric radiologist, according to the study methods, as "normal". The most common abnormal parenchyma finding was a bilateral diffuse interstitial pattern (8/35) followed by a unilateral diffuse interstitial pattern (3/35). One patient presented bilateral pseudo-nodular opacities, two patients presented perihilar bronchial wall thickening, unilateral lobar focal consolidation was seen in two patients and no atelectasis nor other complications were detected. [Figs. 1–5](#) include anteroposterior chest radiographs highlighting the most significant findings in our study. Finally, we analyzed the characteristics of children with pathological chest X-ray, compared with those with normal imaging. Among these 35

Table 2

Pediatric hospitalized COVID-19 patients characteristics according to chest imaging performance. CHN Hospital, Navarre, Spain. March-December 2020.

Variables	Total	Chest radiography	No chest radiography	p
n (%)	44	35 (80 %)	9 (20 %)	
Sex, n (% males)	22 (50 %)	15 (68 %)	7 (31.81 %)	0.062
Age (y), mean ± SD	3.84 (4.41)	4.42 (4.55)	1.59 (3.0)	0.086
Reported symptoms n (%)	41 (93.18 %)	34 (82.93 %)	7 (17.07 %)	0.041
Respiratory symptoms n (%)	24 (54.55 %)	20 (83.33 %)	4 (16.07 %)	0.048
Fever, n (%)	37 (83.4 %)	32 (86.49 %)	5 (13.5 %)	0.009
Fever duration (d), mean ± SD	3.11 (3.01)	3.57 (3.08)	1.33 (2.01)	0.046

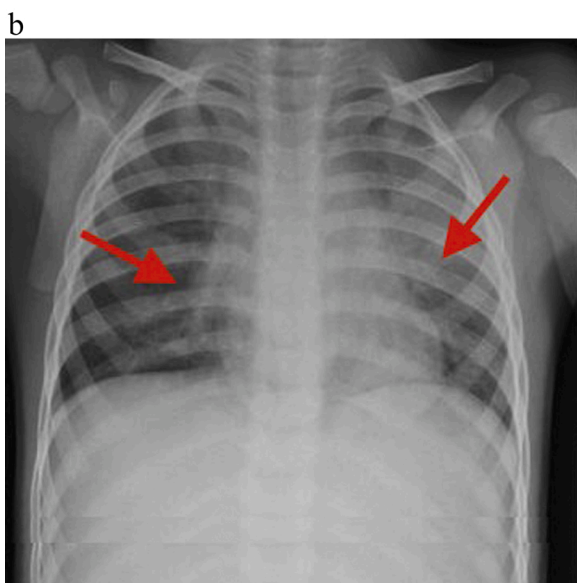
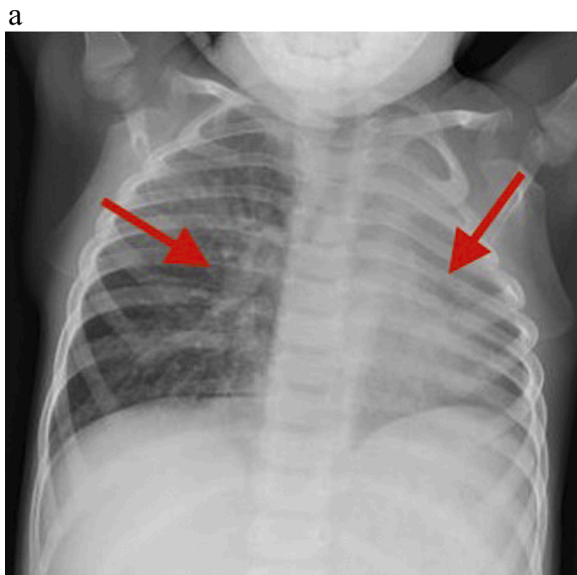


Fig. 1. includes anteroposterior chest radiographs of two pediatric COVID-19 patients with the classical COVID-19 pneumonia, with a bilateral diffuse interstitial pattern.

patients no differences were found regarding previous medical history, age, sex, or hospital stay. Patients with pathological chest X-ray were more likely to have fever, longer fever duration and respiratory symptoms. 31 % of males vs. 40 % of females presented a pathological chest X-ray ($p:0.53$), and medium age was 3.81-year-old ($SD:4.71$) in children with pathological chest X-rays vs. 3.99-year-old ($SD:3.95$) in patients with normal chest X-rays ($p:0.91$). We did find that fever was highly associated with parenchyma alterations. In fact, in our sample all patients with a pathological chest X-rays reported fever. Among patients with fever 43 % had a pathological chest X-ray, whereas among afebrile patients all chest X-rays performed were normal ($p = 0.029$). Fever duration tended to be longer in patients with pathological radiographs; 4.25 days ($SD: 2.89$) vs. 2.46 days ($SD: 2.94$), $p:0.048$ and regarding respiratory symptoms 41 % of children presenting with respiratory symptoms had a pathological chest X-ray compared to 29 % of those without respiratory symptoms. ($p. 0.42$). Only 5 patients had concomitant co-infections detected. Two had positive hemocultures, one had a positive stool sample, and two had positive respiratory samples. Of those

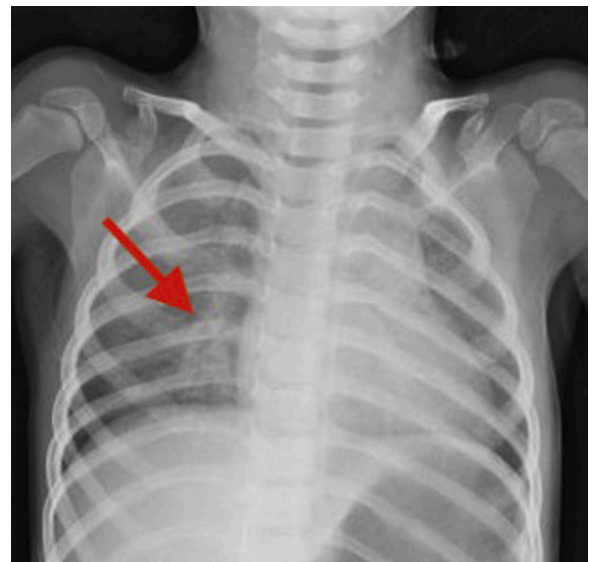


Fig. 2. shows an anteroposterior chest radiograph of a 3-year-old pediatric patient with COVID-19, with unilateral interstitial pattern in the right lower lobe.

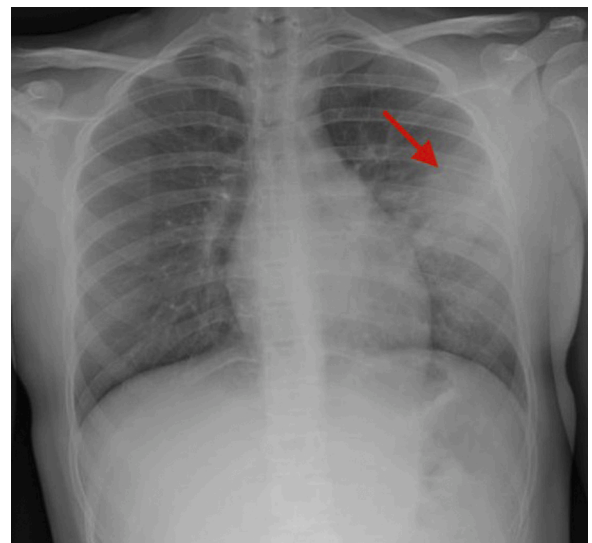


Fig. 3. is from a 13-year-old girl with fever, dyspnea and cough, diagnosed with COVID-19 pneumonia. Anteroposterior chest radiograph shows a focal consolidation in the left upper lobe.

2 patients, one had Influenzae B and one *Achromobacter Xylooxidans* (positive PCR findings), and they both presented bilateral infiltrates in their chest X-ray. In these cases, the chest X-ray findings might have been related with these other pathogens instead of with SARS-CoV- 2 infection, but coinfection affected less than 5 % of our sample.

We performed a literature review and searched for previously published articles including age-adjusted indications for chest-imaging in COVID-19 pediatric patients. The international consensus [17] recommended that chest X-rays may be appropriate in patients with moderate to severe symptoms, and that it should not be used as a screening tool for symptomatic or asymptomatic pediatric patients. It also reinforced the use of this technique in patients with risk factors or bad clinical evolution [17]. An article evaluating the most common findings, highlighted that patterns in pediatric population were non-specific, and that they might superimpose on other viral pneumonias. they didn't established specific indications, but they did recommend the use of chest X-ray in

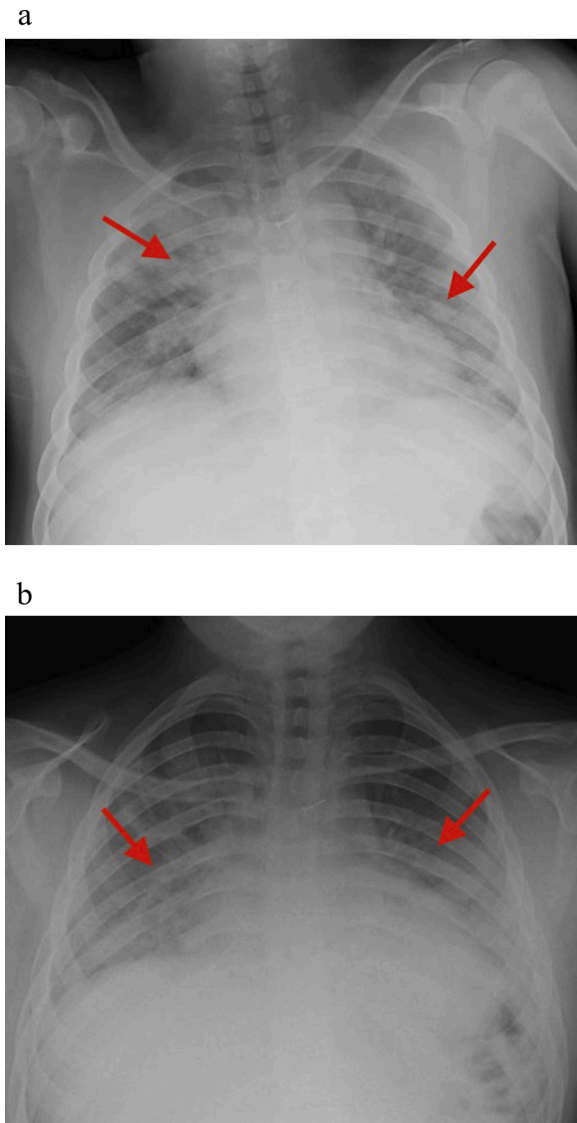


Fig. 4. Progression of parenchyma lesions. Bilateral interstitial infiltrates that change in location and distribution in the successive chest X-rays performed during hospital admission in a 5-year-old girl with fever, cough, and progressive dyspnea (Fig. 4A was performed at admission and Fig. 4B 48 h later).

neonates with fever and respiratory symptoms, in children with moderate to severe evolution and in patients with risk factors [14]. After analyzing our results, with the experience gained in the first two COVID-19 waves and based on the existing literature review we have performed a local protocol listing specific and age-adjusted indications for the performance of chest X-ray among pediatric patients with confirmed or suspected COVID. We prioritized in the indications the presence of symptoms and symptoms duration, specially fever, as it has already been published how chest X-ray sensitivity increases after 5 days of symptoms [34,35]. We also include specific indications for children with suspected MIS-C and for infants as they are known to present worst clinical evolutions [10]. Working in collaboration with a pediatric radiologist, an infectious disease pediatric specialist and a pediatric pneumologist we have elaborated a protocol (Table 3) with the specific chest X-ray indications, for pediatric COVID-19 cases in a hospital setting during a pandemic situation.

4. Discussion

In this study we retrospectively reviewed the chest imaging

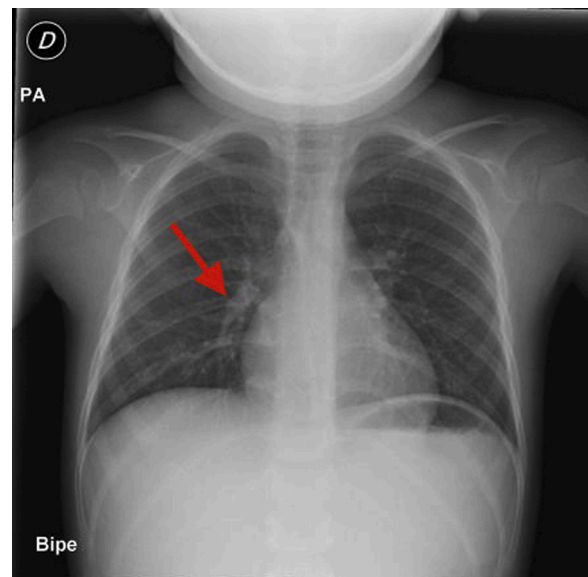


Fig. 5. shows a chest radiograph of a 4-year-old pediatric patient with COVID-19, presenting with prolonged fever. A perihilar bronchial wall thickening was detected.

Table 3

Chest X-ray indications in pediatric population with laboratory confirmed or clinically suspected COVID-19. CHN Hospital, Navarre, Spain.

Chest X-ray indications in pediatric population with laboratory confirmed or clinically suspected COVID-19
Infants <u>younger than 1 month</u> with fever (>38°C)
Infants <u>younger than 12 months</u> with respiratory distress (with or with-out fever)
Pediatric patients with clinical suspicion or confirmed MIS-C
Pediatric patients with <u>fever (>38 C°)</u> and <u>one</u> of the following:
• Persistent fever (> 5 days)
• Persistent cough (> 5 days)
• Fever not controlled with usual antipyretic drugs
• Respiratory distress
• Tachypnea
• Hypoxemia (Sat O2 < 92 %)
• Chest pain
• Pathological lung auscultation
• Comorbidities (immunodeficiency, heart disease, chronic lung disease, neuromuscular diseases, tracheotomy, severe asthma, cystic fibrosis, bronchopulmonary dysplasia...)
Pediatric patients with <u>analytical alterations</u> : CBC with leukocytosis (>20.000/mm ³), increase of acute phase reactants (procalcitonin >0.5 ng/mL) or severe alterations in coagulation.

techniques performed in pediatric patients hospitalized with COVID-19 from March 1st to December 31st, 2020 in a tertiary reference children's hospital in Navarre, Spain. From 5506 children with confirmed COVID-19 in Navarre, only 44 were admitted into hospital, and only 35 had a chest radiograph performed (6 % of all SARS-CoV-2 pediatric cases and 80 % of hospitalized children). In our review, chest radiograph was the most common imaging technique used to diagnose pneumonia or respiratory tract infection in children and, while in adults CT is very commonly used, only one pediatric patient required a chest CT [34]. Even though chest X-ray remains the principal technique imaging recommended, lung ultrasound, is a non-invasive, easily repeatable useful diagnosing tool. It requires a portable device and trained personal but due to its multiple advantages it should be considered both to diagnose and to monitor the evolution of lung disease in children when available [24].

In our pediatric population more than half of the chest X-rays performed were normal, and we found high variability in the radiographic findings, with a 22 % of bilateral diffuse interstitial pattern, an 8 % of

unilateral diffuse interstitial pattern, a 5% of perihilar bronchial wall thickening and a 5% of lobar focal consolidations. Similar results have been previously published [15,32], with perihilar bronchial wall thickening (a common presentation of viral respiratory tract infection in children), being the most common pattern. In our study, even though only 5% of chest X-rays were categorized as bronchial wall thickening, this finding was also present in most of the radiographs categorized as diffuse interstitial pattern. Therefore, chest imaging findings in COVID-19 pediatric patients are nonspecific, and very similar to those seen in other viral infections. On other published case series, most children had normal chest radiographs, but in our study 46% of the radiographs were abnormal. We believe this is due to the fact that we only included hospitalized patients, and that our center did not request chest X-ray for all COVID-19 admissions. Also in our study most patients were symptomatic, as it was performed on a hospital setting, while a high percentage of COVID-19 pediatric patients are asymptomatic [10], and in these asymptomatic children imaging is more frequently normal [14,15]. According to the literature, in our study the presence of symptoms, specifically the presence of fever, was clearly associated with the presence of acute parenchyma alterations in the radiographs. We did not find in our study statistically significant differences regarding respiratory symptoms, even though children with pathological chest X-ray tended to have more respiratory symptoms, probably this is caused by the limited sample size.

Our study has several strengths and limitations that should be addressed. One strength is that Navarre has a very well-developed and centralized digital clinical history, allowing effective retrospective data revision and a second strength is that all pediatric COVID-19 hospitalized cases agreed to collaborate in the study. Another strength is that, as far as we know, this is the first article creating a specific protocol describing chest imaging indications adjusted for age and symptoms for pediatric population. Possible study limitations are the limited sample size, the interobserver variability when interpreting pediatric chest radiographs, and the common misinterpretation of increased central peribronchovascular markings, as normal exams. To avoid this bias all COVID-19 CHN hospitalized pediatric patients were included, and all the radiographs were interpreted by a pediatric pneumologist and a highly experienced pediatric radiologist. Finally, another possible study limitation is that the protocol created with the specific indications for the performance of chest X-ray in COVID-19 children was elaborated based in our current local situation (a reference hospital setting in a developed country), but different scenarios with different resources, different settings or different pandemic situations may need to adjust these indications.

5. Conclusions

Pediatric COVID-19 is different from adult COVID-19; therefore, it requires the development of protocols and indications specifically created for pediatric populations.

Based on our study results and on the literature search and review, we can conclude that COVID-19 clinical manifestations and radiological findings are milder and less specific in children. Imaging should therefore not be used as a screening tool or a routine complementary test in all pediatric patients with COVID-19, not even in all hospitalized children, it should be restricted to clinical indications. When needed, chest radiograph should be the first imaging option and even though radiograph findings are non-specific the diffuse interstitial pattern and the increase in central peribronchovascular wall thickening are commonly present. Chest X-ray should be performed only in symptomatic children and based on clinical criteria and age. CT should only be performed in cases with bad clinical evolution, to detect possible complications or in cases with previous medical pathologies.

The findings and indications of chest-imaging in pediatric COVID-19 patients are clearly not the same as in adult population, therefore larger and multicenter studies are needed to better describe and categorize

these findings, to specify the pediatric imaging indications, and to clarify the role of CT and US in children with SARS-CoV-2 infection.

CRedit authorship contribution statement

Andrea Ilundain: contributed to conception and design, analysis, and writing the original draft of the manuscript. **Cristina Jiménez:** contributed to conception and design, and reviewed all the chest X rays. **Mercedes Herranz:** contributed to acquisition and analysis, and draft of the manuscript. **Natividad Viguria:** contributed to acquisition and critical revision of the manuscript. **Beatriz Ramos:** contributed to acquisition, writing and reviewing of the manuscript. **Maria Urretavizcaya:** contributed to acquisition, writing and reviewing of the manuscript. **Laura Echeverría:** contributed to acquisition, writing and reviewing of the manuscript. **Maria del Mar Pina:** contributed to acquisition, writing and reviewing of the manuscript. **Marcos García:** contributed to acquisition, writing and reviewing of the manuscript. **Alejandro Fernández:** contributed to the methodology, software, formal analysis. **Laura Moreno:** contributed to the conceptualization, writing the original draft and supervision. All authors have agreed to submit this article in the present form. Each has participated sufficiently in the conception and design of the work. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Ethical approval

The local ethics committee approved on May 2020 the study “Comité de Ética del Complejo Hospitalario de Navarra” (CHN: PI_2020/38: Estudio epidemiológico de las infecciones respiratorias por el nuevo Coronavirus SARS-CoV-2 en población pediátrica).

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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