COVID-19 and lung ultrasound: reasons why paediatricians can support adult COVID-19 units during critical epidemiologic periods

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Since the beginning of the SARS-CoV-2 spread outside China, several hospitals have changed their organisation to increase critical care capacity and isolation areas to COVID-19 patients as well as to generate new flows to guarantee safety and care to non-COVID-19 patients. In addition, the paediatric practice has changed completely. SARS-CoV-2 rarely involves children, and most of the time, the paediatric COVID-19 disease is mild [1]. Moreover, parents have stopped routinely bringing their children to the hospital either because of the fear that their children might contract the infection or because of a lockdown-related drop of seasonal infectious diseases [2]. As a result, the workload of paediatricians has significantly reduced in the past few months [3], and therefore, their inclusion in COVID units should be considered by institutions.

Although not directly involved in adult care, paediatricians may play a significant role in managing COVID-19 patients for several reasons. From a clinical point of view, several common clinical scenarios can be included in COVID-19 adults that overlap with common paediatric conditions to which paediatricians, especially some categories of them, are already accustomed to their diagnosis and management (Table 1) [4, 5].

In the last few years, in several paediatric settings, lung ultrasound (LUS) has become the first-line imaging method in children evaluated for respiratory disease, allowing the real-time diagnosis and monitoring of lung involvement [6–13]. In recent years, several studies have shown that LUS is a useful and accurate tool for detecting pneumonia in children and it may be better than chest radiography in the diagnosis of community-acquired pneumonia [6–9, 13]. Other studies have shown that LUS can be used to predict more severe pneumonia and monitor antibiotic response, and recently, different LUS patterns have been used to differentiate viral from bacterial pneumonia by defining their etiology [6, 9, 13]. Many studies have described and validated LUS scores (based mainly on vertical artefacts and sub-pleural consolidations) in neonatal respiratory disorders [10] and bronchiolitis [11, 12].

Over the years, the development of LUS studies on the paediatric population and the use of LUS in paediatric clinical practice have become fundamental in references to studies performed on adults [14, 15], hence the translation of knowledge acquired from these studies in the clinical paediatric practice. However, true collaboration between paediatric and adult specialists is also fundamental, especially in the interpretation of some ultrasound findings, such as in the cases of vertical artefacts and ultrasound interstitial syndrome [7, 14, 15].

Since the outbreak of the pandemic, this sharing/collaboration of experiences and studies has assumed a greater force that takes shape every day in the fight against COVID-19. In particular, it is not a coincidence that of all medical professionals, a paediatrician not only suggested that the medical community use ultrasound more frequently in suspected COVID-19 patients but also described the first case of COVID-19 (an adult patient), diagnosed and managed with thoracic ultrasound [16–18].

Since then, LUS has played a key role in the management of patients with COVID-19 pneumonia. More importantly, the ultrasound patterns of viral pneumonia and bronchiolitis in children are similar to those seen in COVID-19 pneumonia patients (e.g. pleural line irregularities and vertical artefacts (B-lines) with patchy distribution, sub-pleural
Table 1  List of common clinical scenarios in COVID-19 adults that overlap with common pediatric conditions

| Brain and nervous system  | COVID-19 patients | Pediatric practice |
|---------------------------|-------------------|-------------------|
| Encephalitis–Seizures–Loss of Consciousness | Viral encephalitis  | Epileptiform syndromes |
| Heart and cardiovascular system | Myocarditis/Pericarditis (by infectious, autoimmune, toxic causes) | Congenital Heart disease |
| (possibly direct attack by virus–lack of oxygen caused by acute respiratory failure–blood vessel constriction from infection or caused by systemic inflammation) | Acute Cardiac Injury | Supraventricular tachycardia–Wolff-Parkinson-White syndrome (WPW syndrome)–Long Q-T Syndrome (LQTS) |
| Arrhythmias | | DIC caused by septic shock |
| Inflammation in the blood vessels | Kawasaki disease | Infectious and autoimmune vasculitis |
| Blood Clots | Genetic conditions which caused thrombophilia (Factor V Leiden, Prothrombin gene mutation, or deficiencies of protein C, protein S, or antithrombin) | Chonic inflammation or reumatologic and autoimmune disorders (antiphospholipid antibody syndrome) |
| Disseminated Intravascular Coagulation (DIC)–Deep vein thrombosis (DVT)–Pulmonary embolism–Arterious thrombosis | Teens with risks factors as smoking, oral contraceptive, obesity | Trauma |
| Lungs and respiratory system | Viral respiratory disorders | Atypical Bacterial Pneumonia |
| Pneumonia–Acute Respiratory Distress Syndrome Acute Respiratory Failure | Bronchiolitis | Asthma |
| | Pulmonary Hypertension–Pulmonary edema | Pulmonary Hypertension–Pulmonary edema |
| Respiratory support | Respiratory disease in Neuromuscular Disorders | |
| Lung ultrasound | Used in common clinical practice by pediatricians for diagnosis, follow-up of acute and chronic respiratory diseases and their complications | |
| Gastrointestinal system (GUT) | Diarrhea (infectious, toxic, autoimmune causes) | Diarrhea (infectious, toxic, autoimmune causes) |
| (possibly from direct attack by virus on intestinal tissues or exacerbations of underlying GUT conditions) | Gastroesophageal reflux disease (GERD) | Gastroesophageal reflux disease (GERD) |
| Diarrhea | Exacerbations of Inflammatory bowel disease (IBD) | Exacerbations of Inflammatory bowel disease (IBD) |
| Gastroesophageal ulcers | Nutritional management–Parenteral and enteral nutrition in patients with endotracheal intubation | Nutritional management–Parenteral and enteral nutrition in patients with endotracheal intubation |
| Colitis | | Parenteral and enteral nutrition in children with neuromuscular and cognitive disabilities |
| Liver | Viral and bacterial infections–Hepatitis from toxic substances and drugs–Metabolic diseases–Autoimmune diseases–Hematological and vascular diseases | Viral and bacterial infections–Hepatitis from toxic substances and drugs–Metabolic diseases–Autoimmune diseases–Hematological and vascular diseases |
| (possibly from a direct attack by virus or underlying predisposing conditions or experimental hepatotoxic drugs) | Acute Liver Injury/ Hepatitis | Pre-renal injury from blood loss, surgery or shock |
| Acute Kidney Injury | Post-renal from a blockage in the urinary tract | Post-renal from a blockage in the urinary tract |
| Kidneys | Intoxications or medications | Intoxications or medications |
| (possibly from a direct attack by virus or underlying predisposing conditions or ventilator use or experimental drug or septic shock or rhabdomyolysis) | Hemolytic uremic syndrome | Hemolytic uremic syndrome |
| Acute Kidney Injury | Glomerulonephritis | Glomerulonephritis |
| Systemic inflammation | Advanced stage of chronic kidney disease: Alport syndrome, nephrotic syndrome, polycystic kidney disease | Advanced stage of chronic kidney disease: Alport syndrome, nephrotic syndrome, polycystic kidney disease |
| (caused by cytokine storm) | Primary haemophagocytic lymphohistocytosis (HLH) | Primary haemophagocytic lymphohistocytosis (HLH) |
| Macrophage Activation Syndrome-Like Disease | Secondary haemophagocytic lymphohistocytosis (malignant and non-malignant diseases as viral infections, rheumatologic and autoimmune disease) | Secondary haemophagocytic lymphohistocytosis (malignant and non-malignant diseases as viral infections, rheumatologic and autoimmune disease) |
| Pediatric multisystem inflammatory syndrome (PMIS) | Use of biological drugs | Commonly used in pediatric clinical practice in rheumatological, autoimmune and neoplastic diseases |
| Anti Interleukin-6 drugs | | |

Pediatricians routinely take care of patients with viral conditions and acute respiratory distress (e.g. bronchiolitis, asthma) and that’s why are confident in diagnosis and treatment. The usual management of these situations provides expertise in blood-gas analysis evaluation and in the use of devices for respiratory support, such as high-flow nasal cannula and continuous positive airway pressure (CPAP). In addition, recent evidence is pointing out that adult COVID-19 resembles systemic inflammatory syndromes [4] and pediatricians are not new to such conditions. For instance, Kawasaki disease is one of the most common systemic conditions in children and, not rarely, biological agents are required to treat it, not to mention the new identity of pediatric inflammatory multisystem syndrome temporally associated with COVID-19 (PIMS-TS) [5]. Similarly, macrophage activation syndromes, as well as other rheumatologic conditions, do occur in secondary and tertiary level settings increasingly requiring pediatricians to be trained in managing biological agents.
consolidations, and white lung areas), making it easier for paediatricians to detect pathological LUS patterns in adults with COVID-19 (Fig. 1). In general, the basic LUS semiotics of COVID-19 pneumonia does not differ between adults and children [19–21].

To allow the comparison of the severity of COVID-19 pneumonia in different patients, limiting the subjectivity and operator dependence of the exam as well as standardising the ultrasound semiotics of COVID-19 pneumonia and the LUS score of severity of COVID-19 pneumonia have been proposed; moreover, a paediatrician (DB) actively participated in the drafting of this research [19, 20] Although paediatricians could face several obstacles while dealing with adult patients, their tendency to manage complex patients with multi-systemic diseases and poly-pharmacological therapies gives them an important source of strength to contribute to the management of adult COVID-19 patients. All these strengths could also help to reduce the anxiety, stress, and uncertainty of doctors who find themselves working in relatively unfamiliar fields.

On the other hand, a major barrier could be represented by medico-legal concerns as common comorbidities and complications of adult patients are far from those in daily paediatric practice. A safe and effective strategy for COVID wards could be, once again, a multidisciplinary team. Close collaboration between paediatricians and

Fig. 1 Lung ultrasound findings in children with viral lower respiratory tract infection (a, c) and in a woman with COVID-19 pneumonia (a, d), performed by the same paediatrician. a Lung ultrasound images of a 4-year-old boy with viral pneumonia—caused by coronavirus (non-COVID-19), bocavirus, and metapneumovirus coinfection—requiring respiratory assistance with high-flow nasal oxygen at the paediatric department; the lung ultrasound shows areas of white lung with multiple, coalescent vertical artefacts (B-lines, black arrowhead). A similar lung ultrasound pattern (multiple vertical artefacts, B-lines, black arrowhead) was found in a 42-year-old woman with COVID-19 pneumonia and moderate respiratory distress (b). c Lung ultrasound images of a 2-year-old boy with H1N1 influenza pneumonia requiring respiratory assistance with high-flow nasal oxygen at the paediatric department, showing sub-pleural consolidations (hypoechoic areas, black arrow); below, areas of white lung are evident. A similar lung ultrasound pattern (sub-pleural consolidations, black arrow, with areas of white lung) was found in a 31-year-old pregnant woman with COVID-19 pneumonia and acute respiratory failure requiring admission to the intensive care unit (d)
Internists (even mixing more and less experienced doctors) could help to reintroduce the former to adult patients and to ensure mutual clinical support.

Given their skills in paediatric infectious diseases and LUS, paediatricians DB and LP as well as many of their colleagues have been included in the management of adults with COVID-19 in institutions in Italy. In Bologna, two internists, two paediatricians (including LP), one endocrinologist, and a group of mixed paediatric and internist residents managed a COVID ward for five weeks, from March 16, 2020, to April 17, 2020. It was a 30-bed ward with two negative-pressure rooms for patients on CPAP. In those five weeks, a total of 145 patients were managed on oxygen therapy and CPAP. Three other paediatricians have been integrated in three other COVIDequivps. Many specialists were involved in the COVID wards, but only the paediatricians actively supported the internists in the management of patients. The success of this collaboration was derived from a common way of thinking in dealing with patients and multi-systemic diseases. Even if a paediatrician is not confident with adults’ common pathologies, their tendency to look at the patient as a whole helped to recognise worsening signs early and to facilitate discussions about the patients. These equal views also helped to reduce stress in a highly stressful situation, which could have been worse in a context where internists would have to carry the whole task by themselves while other specialists would feel too frustrated to manage risky and unfamiliar situations.

In Rome, a paediatrician (DB) became responsible for the LUS evaluation of pregnant women with respiratory conditions so as to reduce the routine use of chest X-rays and computed tomography (CT) scans in this specific group, reserving these tools to selected cases [22, 23]. In particular, since March 2020, 62 pregnant women who tested positive for COVID-19 have been evaluated via chest ultrasound. No COVID-19–positive pregnant woman has undergone a chest CT scan so far, and LUS has become the first-level tool to diagnose pneumonia.

The past, current, and projected scales of distress among healthcare professionals, while understandable, have been and are of grave concern [9]. The short- and long-term negative effects of this disease have both physical and psychological consequences that can significantly impact the quality of life of both the health worker and their family. The existing risks to the well-being of healthcare professionals are compounded under these high-pressure conditions [24].

Concomitantly, the whole world is facing a severe shortage of personal protective equipment, [3] which contributes to the high number of infections and deaths among healthcare workers worldwide. Altogether, these factors determine an increasing shortage of doctors worldwide, including the richest countries. Having adequate numbers of health workers and establishing collaboration among different specialists will be critical to winning the battle against COVID-19.

Growing evidence highlights that COVID-19 is a systemic condition that requires doctors with multiple areas of expertise [25]: general support measures, experience in managing antivirals, antibiotics, and biological agents, respiratory support, imaging interpretation, and experience in point-of-care ultrasound. Considering the issues of staff shortage in every country, the complexity of COVID-19, the rare and mild involvement of SARS-CoV-2 in children, [1] and reduced access to paediatric health facilities, [2] paediatricians may represent an important source of ready and skilled specialists who can quickly translate the paediatric practice in COVID-19 care.

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