Pediatric SARS, H1N1, MERS, EVALI, and Now Coronavirus Disease (COVID-19) Pneumonia: What Radiologists Need to Know

OBJECTIVE. The purpose of this article is to review new pediatric lung disorders—including disorders that have occurred in recent years years such as severe acute respiratory syndrome (SARS), swine-origin influenza A (H1N1), Middle East respiratory syndrome (MERS), e-cigarette or vaping product use–associated lung injury (EVALI), and coronavirus disease (COVID-19) pneumonia—to enhance understanding of the characteristic imaging findings.

CONCLUSION. Although the clinical symptoms of SARS, H1N1, MERS, EVALI, and COVID-19 pneumonia in pediatric patients may be nonspecific, some characteristic imaging findings have emerged or are currently emerging. It is essential for radiologists to have a clear understanding of the characteristic imaging appearances of these lung disorders in pediatric patients to ensure optimal patient care.

The early 21st century has seen the emergence of several severe outbreaks of pediatric lung illnesses such as contagious viral epidemics, including three coronaviruses (i.e., severe acute respiratory syndrome coronavirus [SARS-CoV], Middle East respiratory syndrome coronavirus [MERS-CoV], and severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2]), swine-origin influenza A (H1N1), and cigarette or vaping product use–associated lung injury (EVALI). Because of their immature lung anatomy and developing immune systems, pediatric patients are often particularly susceptible to these public health crises. The ongoing SARS-CoV-2 outbreak, now deemed a global pandemic by the World Health Organization (WHO), has drawn attention to the importance of understanding the clinical and characteristic radiologic features of these lung disorders in the pediatric population.

Evaluation and diagnosis of pediatric lung disorders can be difficult because of the vague, overlapping nature of clinical symptoms, inability to communicate (in young or developmentally delayed infants and children), and nonspecific results often encountered during laboratory workup. Given the nonspecific nature of clinical presentation, imaging is an important component of diagnostic workup; thus, the radiologist plays an important role in initially detecting disease, evaluating response to treatment, and in some cases evaluating long-term sequelae of lung injury.

Although there are some overlapping imaging findings of these pediatric lung disorders, characteristic imaging features are currently emerging. This article provides an up-to-date review of the underlying causes, epidemiology, pertinent clinical presentation, and characteristic imaging findings of severe viral infections (i.e., SARS-CoV, MERS-CoV, SARS-CoV-2, and H1N1) and EVALI in pediatric patients with an emphasis on unique imaging features to help practicing radiologists accurately recognize and differentiate these novel lung disorders in the pediatric population.

Underlying Causes and Epidemiology
Coronaviruses: SARS-CoV, MERS-CoV, and SARS-CoV-2

First described in the 1960s as a cause for the common cold, human coronaviruses have become a global health threat in the 21st century after the emergence of severe respiratory syndromes associated with three coronaviruses: SARS-CoV, MERS-CoV, and SARS-CoV-2 [1, 2]. Coronaviruses are enveloped viruses with a single-stranded large RNA genome. The term “coronavirus” refers to the electron-microscopic appearance of the virions in which spike projections from the virus membrane resemble the appearance of a crown. Seven coronavi-
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The cell surface protein dipeptidyl peptidase transmission, acting as an intermediary [8]. are the only documented source for zoonotic SARS-CoV, with dromedary camels, which cleared; however, bats are favored to represent [4, 7]. The exact origin of the virus is still uncertain, virology and genetics research has suggested zoonotic transmission from bats to palm civets and subsequently to humans [5].

SARS-CoV was the first highly pathogenic coronavirus to infect humans and results in severe acute respiratory syndrome (SARS). It led to a pandemic of atypical pneumonia cases originating in Guangdong Province, China, in November 2002 [3]. The outbreak ultimately resulted in 8098 cases, 916 of which were fatal, across 29 countries in 2002–2003 before it was contained [4]. Although the exact causative origin of SARS-CoV remains uncertain, virology and genetics research has suggested zoonotic transmission from bats to palm civets and subsequently to humans [5].

SARS-CoV is spread predominantly through person-to-person contact via respiratory droplets. Once inside the respiratory tract, the virus binds to angiotensin-convert- ing enzyme 2 (ACE2) receptor expressed by the epithelial cells of the alveoli, trachea, and bronchi as well as by alveolar macrophages and monocytes. The virus subsequently leads to a marked inflammatory response and increased vascular permeability, which leads to pneumonia and in some cases respiratory failure [4, 6].

MERS-CoV—First identified in Saudi Arabia in September 2012, Middle East respiratory syndrome (MERS) is a coronavirus-induced respiratory syndrome caused by MERS-CoV that resulted in an outbreak of atypical pneumonia and respiratory failure cases between 2012 and 2018. The pandemic led to 2254 cases of MERS and 800 deaths across 27 countries, although approximately 80% of the cases occurred in Saudi Arabia [4, 7]. The exact origin of the virus is still unclear; however, bats are favored to represent the natural host of MERS-CoV, similar to SARS-CoV, with dromedary camels, which are the only documented source for zoonotic transmission, acting as an intermediary [8].

Whereas SARS-CoV binds to the ACE2 receptor, MERS-CoV primarily binds to the cell surface protein dipeptidyl peptidase 4 (DDP4), which is abundant in the human respiratory tract including bronchial mucosa and alveoli. However, DDP4 is also expressed by epithelial cells in the kidneys, small intestines, liver, prostate, and activated leukocytes [4, 9]. MERS-CoV subsequently leads to immune dysregulation, which may then result in a delayed proinflammatory response in lung epithelial cells [4, 10].

SARS-CoV-2—Respiratory infection caused by the 2019 novel coronavirus (SARS-CoV-2) was first discovered in Wuhan, China, in December 2019. It has subsequently resulted in a global outbreak declared by the WHO to represent a pandemic on March 11, 2020 [11]. As of March 30, 2020, there have been 693,282 cases of coronavirus disease (COVID-19), the disease caused by SARS-CoV-2 infection, and 33,106 deaths across 202 countries and territories, including 122,653 cases and 2112 deaths in the United States [12].

Early data suggest that SARS-CoV-2 is more prevalent in male patients and that the highest levels of mortality occur in elderly patients and in those with preexisting comorbidities [13]. Health care workers are also at an elevated risk of SARS-CoV-2 infection, with up to 14.8% of 1716 confirmed cases in health care workers classified as severe or critical [14]. Children overall appear to be less severely affected than adults, with one study of 2143 children showing 94.1% of pediatric cases of COVID-19 to be asymptomatic, mild, or moderate [15]. The majority of pediatric COVID-19 cases affect children younger than 3 years old, with a slight male predominance [16]. The genetic sequence of SARS-CoV-2 is identical to more than 80% of the genetic sequence of SARS-CoV and 50% of the genetic sequence of MERS-CoV; zoonotic transmission with bats as the natural reservoir is favored to represent the origin of SARS-CoV-2, similar to both SARS-CoV and MERS-CoV [17].

Similar to SARS-CoV, SARS-CoV-2 has been shown to bind to ACE2 receptors within alveolar epithelial cells, leading to elevated levels of ACE2 and ultimately resulting in alveolar damage [13]. Elevated levels of proinflammatory cytokines in patients with COVID-19, greater in ICU patients than in non-ICU patients, suggest that immune dysregulation may also play a role in the disease pathogenesis [18].

H1N1

The H1N1 virus is a zoonotic virus that originated from pig-to-human transmission in Mexico in 2009 and consequently is also known as “swine-origin influenza A virus” or “S-OIV.” This respiratory virus resulted in a pandemic in 2009 involving 214 countries and overseas territories [19]. Although 18,500 deaths due to laboratory-confirmed H1N1 were reported worldwide, the actual number of deaths due to H1N1 is estimated to be substantially higher because of undersampling and the fact that the virus was no longer detectable at the time of death in some patients [20]. In a modeling study by Dawood et al. [20], the global mortality during the first 12 months of the H1N1 pandemic was estimated at 201,200 respiratory-related deaths (range, 105,700–395,600 deaths) and 83,300 cardiovascular-related deaths (range, 46,000–179,900 deaths). In the United States, the estimated disease burden was 60.8 million cases (range, 43.3–89.3 million cases), resulting in approximately 274,304 hospitalizations (range, 195,086–402,719 hospitalizations) and 12,469 deaths (range, 8888–18,306 deaths) [21].

Influenza A is an enveloped single-stranded negative-sense RNA virus belonging to the Orthomyxoviridae family, which is subtyped according to two cell surface glycoproteins: hemagglutinin (16 types) and neuraminidase (nine types) [22]. Influenza A spreads via contact with aerosolized respiratory droplets or respiratory fomites from an infected individual. In humans, the respiratory epithelium is the only site where the hemagglutinin molecule is cleaved, leading to generation of infectious viral particles [23]. The virus causes local inflammation and compromise within the respiratory epithelium from direct viral invasion and triggers lung inflammation caused by the host immune response.

EVALI

Electronic cigarettes (e-cigarettes), also known as vapes, are battery-powered devices that can heat and aerosolize liquid combinations of nicotine, tetrahydrocannabinol, cannabidiol, and other additives (e.g., vitamin E) for inhalation. Increasingly popular among middle school–age children and high school–age adolescents, e-cigarettes have become the most commonly used tobacco product among U.S. teenagers and young adults since 2014 [24]. Unfortunately, EVALI cases spiked in late 2019, resulting in the Centers for Disease Control and Prevention deeming EVALI a national outbreak. As of February 18, 2020, there have been 2807 hospitalizations—including 68 deaths—due to EVALI across...
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TABLE I: Imaging Findings in New Pediatric Lung Disorders

<table>
<thead>
<tr>
<th>Lung Disorder</th>
<th>Chest Radiography</th>
<th>Chest CT</th>
<th>Helpful Imaging Features</th>
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<tbody>
<tr>
<td>SARS</td>
<td>Often normal findings; patchy opacities may be unilateral, especially during early stage; lower lung zone predominance; multifocal in one-third of cases</td>
<td>Unifocal or multifocal GGO, consolidation, or both; may be unilateral (early stage) or bilateral; peripheral or combined peripheral and central distribution; mid and lower lung zones</td>
<td>Initially unifocal; peripheral or combined peripheral and central distribution; pleural effusion absent</td>
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<tr>
<td>MERS</td>
<td>Unifocal GGO in mid and lower lung zones but may progress to be multifocal, bilateral, or both; fine interstitial reticular pattern; pneumothorax or pleural effusion more common in fatal cases</td>
<td>Bilateral GGO with or without consolidation; peripheral and lower lung zone distribution; pleural effusion more common in fatal cases</td>
<td>Unifocal and unilateral (early stage); fine interstitial reticular pattern; pleural effusion and pneumothorax</td>
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<td>COVID-19</td>
<td>May show normal findings; patchy bilateral GGO, consolidation, or both; peripheral and lower lung zone predominance</td>
<td>Bilateral multifocal GGO with or without consolidation, peripheral and subpleural distribution (often extending to pleural surface), possible halo sign; Central distribution, pleural effusion, and lymphadenopathy are rarely seen and should prompt consideration of other differential diagnoses</td>
<td>Periphera l and subpleural distribution (often extending to pleural surface), halo sign; Central distribution, pleural effusion, or lymphadenopathy suggests possible alternative diagnosis</td>
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<tr>
<td>H1N1</td>
<td>Often normal; in mild cases, bilateral hyperinflation and prominent peribronchial markings; in moderate and severe cases, one or more areas of GGO, consolidation, or both in bilateral symmetric distribution</td>
<td>Bronchovascular thickening; bilateral multifocal central lung–predominant GGO, consolidation, or both; possible pneumomediastinum</td>
<td>Bilateral hyperinflation and bronchovascular thickening (early stage); bilateral symmetric multifocal GGO, consolidation, or both (late stage); central distribution</td>
</tr>
<tr>
<td>EVALI</td>
<td>Bilateral multifocal GGO, consolidation, or both; symmetric; lower lung zones; possible subpleural sparing</td>
<td>Bilateral symmetric GGO with or without consolidation; subpleural sparing; mild lower lobe predominance; possible centrilobular nodules; possible atoll sign</td>
<td>Subpleural sparing; atoll sign</td>
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all 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands [24]. Although the exact pathophysiolo gy of EVALI is incompletely understood and is an active area of ongoing research, vitamin E acetate (VEA), also known as α-tocopherol acetate, an additive used as a carrier for drug delivery, is likely a contributor to the development of EVALI [25]. Strong support for this argument has been provided by Blount et al. [26], who evaluated bronchoalveolar lavage samples and found VEA in 48 of 51 samples from patients with EVALI compared with 0 of 99 healthy comparators including nonusers, nicotine-exclusive e-cigarette users, and cigarette smokers. Alterations in surfactant surface tension and production of the reactive compound ketene, which may serve as a lung irritant, during heating have been suggested as possible mechanisms of VEA-induced lung injury [26].

Characteristic Imaging Findings

Although the clinical symptoms and imaging findings of these new pediatric lung disorders may be nonspecific, some characteristic imaging features have emerged or are currently emerging. These imaging findings are summarized by lung disorder in Table 1.

SARS

Pediatric patients with SARS tend to have a milder clinical course than adults with SARS, with up to 35% of pediatric patients with SARS found to have normal findings on chest radiographs [27]. In pediatric SARS cases with a radiographic abnormality, the most frequently observed findings are patchy ground-glass opacities (GGOs) and areas of consolidation predominantly in lower lung zones, with multifocal involvement in up to one-third of affected patients [27, 28] (Figs. 1A and 1B). Cavitation, pleural effusion, and lymphadenopathy are generally absent [29–31].

CT is more sensitive than radiography for the detection of parenchymal abnormalities in patients with SARS and frequently shows parenchymal abnormalities when initial chest radiographs show normal findings [29]. In pediatric patients, the most common CT findings during the acute period of SARS are unifocal or multifocal central or peripheral consolidations and GGOs [27] (Fig. 1C). The extent of parenchymal injury visible on CT is often greater than that appreciated radiographically. Chu et al. [32] evaluated the delayed manifestations of SARS in 47 pediatric patients 6 and 12 months after SARS-CoV diagnosis and found that the majority of patients (66%) had no imaging abnormalities at 6 months. The most common abnormalities observed at 6 months were persistent GGOs, air trapping, and small parenchymal scars. By 12 months after SARS-CoV diagnosis, GGOs had improved or resolved in all cases, but lower lobe–predominant subsegmental and subpleural air trapping and small parenchymal scars persisted in all cases [32].

MERS

MERS has a nonspecific presentation of fever, difficulty breathing, and cough among the most common clinical symptoms. Chest radiography is an important tool both in initial evaluation and in tracking disease progression because mean chest radiographic score is an independent predictor of mortality. Furthermore, a static radiographic pattern of lung changes over time is associated with the highest rate of pulmonary fibrotic change, and a progressive radiographic pattern has been associated with a higher mortality rate [33, 34].

The most frequently observed chest radiography findings in patients with MERS are unifocal GGOs in the mid and lower lung zones, which may eventually progress to multifocal and bilateral airspace opacities as the disease
progresses [33, 35, 36] (Fig. 2). Although less frequently observed, pneumothorax or pleural effusion is significantly more common in fatal cases of MERS and, consequently, is an important observation for the radiologist to make [33]. Very few pediatric cases of MERS have been reported in the literature; however, a fine interstitial reticular pattern of interstitial inflammation has been described [37].

On CT, the most frequently observed pattern is GGOs alone or in combination with consolidation in a peripheral and basilar distribution involving multiple lung segments, often bilaterally [38, 39] (Fig. 3). The observation of multisegmental or bilateral involvement on CT likely relates to the CT examination being performed mainly in more seriously ill patients and often several days into the course of illness. Interlobular septal thickening and pleural effusion have also been described, the latter of which was observed in only fatal cases in one study [38].

Coronavirus Disease (COVID-19)
The clinical presentation of COVID-19 is relatively nonspecific with fever, cough, myalgia, and fatigue representing the most common presenting features. Similarly, laboratory values overall have proven relatively nonspecific, although multiple studies have reported lymphopenia, leukopenia, thrombocytopenia, elevated C-reactive protein, and elevated erythrocyte sedimentation rate [40–45]. Thus, chest imaging, whether chest radiography or cross-section imaging such as CT, plays an important role in the diagnostic workup of suspected COVID-19. Furthermore, both the limited supply of reverse transcription–polymerase chain reaction (RT-PCR) tests for detecting SARS-CoV-2 and somewhat high false-negative rate of RT-PCR tests for detecting SARS-CoV-2 can lead to delayed treatment. Chest CT has been shown to have a significantly higher rate of sensitivity in detection of SARS-CoV-2 than the initial RT-PCR test [46, 47]. In fact, during the peak outbreak in China, chest CT findings were added as major evidence for confirmed clinical diagnosis [48].

In most institutions, chest radiography is the first imaging study performed in patients with clinically suspected COVID-19. Despite this fact, the studies in the literature on chest radiography findings in patients with COVID-19 are relatively scarce. Yoon et al. [49] reported patchy, bilateral, peripheral lower lung zone–predominant consolidations and, to a lesser extent, GGOs on chest radiographs in three of nine adult patients with laboratory-confirmed SARS-CoV-2 in-
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Fig. 4—16-year-old girl with coronavirus disease (COVID-19) and known history of tuberous sclerosis who presented with acute hypoxic respiratory distress. Reverse transcription–polymerase chain reaction testing confirmed diagnosis of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).

A, Frontal chest radiograph obtained at initial presentation shows bilateral lower lung zone–predominant consolidations and, to lesser extent, ground-glass opacities. B, Frontal chest radiograph obtained 2 days after hospital admission shows interval increase in consolidation in bilateral lower lung zones. C, Frontal chest radiograph obtained 6 days after hospital admission and treatment shows interval improvement in consolidations in bilateral lower lung zones.

Fig. 5—16-year-old girl with coronavirus disease (COVID-19) who presented with shortness of breath. Reverse transcription–polymerase chain reaction testing confirmed diagnosis of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).

A–D, Axial (A and B), coronal (C), and sagittal (D) lung window setting CT images show posterior subpleural ground-glass opacity with small component of consolidation within left lower lobe.

(Fig. 5 continues on next page)
a large number of H1N1 cases [60–64]. In adults with H1N1 who are found to have a radiographic abnormality, the most common findings are bilateral patchy and nodular opacities in the mid and lower lung zones [61, 64–66]. In mild cases of H1N1 in pediatric patients, the most frequently observed imaging abnormalities are prominent peribronchial markings and hyperinflation (Fig. 6). Chest radiographs of pediatric patients with H1N1 who require hospitalization may reveal one or more areas of consolidation or GGO, typically in a bilateral symmetric distribution without a zonal preference [62] (Fig. 7). Bilateral peribronchovascular opacities and consolidative opacity or GGO in an asymmetric or lower lung–predominant distribution have also been described [63, 67].

CT of the chest in adult patients with H1N1 typically shows peribronchial thickening, bilateral GGOs or consolidation, and nodular opacities in a central and peripheral peribronchovascular or diffuse distribution [60, 61, 64, 68]. Interlobular septal thickening, reticulation, pleural effusions, and mediastinal lymphadenopathy may be observed in nearly one-fourth of patients [69]. CT examinations are performed in pediatric patients less frequently than in adults, likely because of a combination of less severe clinical course in pediatric patients and concerns regarding radiation exposure. When chest CT is performed, the most common findings in pediatric patients with H1N1 are bilateral, multifocal, central lung–predominant consolidation or GGOs and bronchovascular thickening [70]. In addition, it is interesting that pneumomediastinum has been observed in several H1N1 cases in pediatric patients [63, 70, 71].

**EVALI**

EVALI is an important differential consideration in the pediatric population given that up to 50% of EVALI cases occur in patients younger than 21 years old. Furthermore, the clinical presentation, which typically includes constitutional, respiratory, and gastrointestinal symptoms, is nonspecific and overlaps with symptoms observed in other infectious entities. The radiologist may be the first to raise this diagnostic possibility, which can lead to acquisition of a more detailed social history and, in some cases, to altered management.

Chest radiographs of both pediatric and adult populations typically show bilateral multifocal GGO or consolidation in a symmetric pattern predominantly in the lower lung zones [72–75]. Sparing of the subpleural and pericardiac region may be observed [75]. Pneumomediastinum and pneumothorax have also been reported in a few cases [72, 76, 77].

Chest CT of adult patients with EVALI most often shows bilateral multifocal GGOs, consolidation, or both, frequently with subpleural sparing [75, 77]. However, multiple distinct imaging patterns have been reported, including acute eosinophilic pneumonia, diffuse alveolar damage, organizing pneumonia, hypersensitivity pneumonitis, lipoid pneumonia, diffuse alveolar hemorrhage, and, in at least one case, giant cell interstitial pneumonia [73–75, 78–82]. In pediatric patients, CT often shows bilateral symmetric GGOs with or without consolidation with subpleural sparing and a slight lower lobe predominance [72, 83]. Centrilobular ground-glass nodules may also be observed [72, 83]. Although not present in all cases, the “atoll” sign (i.e., central GGO surrounded by dense consolidation of crescentic shape) has been described in up to 36% of
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Future Directions

Early recognition of imaging characteristics of specific pediatric lung disorders, including severe viral infections and EVALI, is key to making a timely and accurate diagnosis. These lung disorders are often difficult to study in children given that the affected pediatric patient population may be small. In the future, a multicenter effort to increase sample size and allow improved characterization during the early phase of disease development is essential. Therefore, close communication and collaboration among international pediatric thoracic radiologists is important. In addition, collaboration with other pediatric specialists, such as pediatric surgeons who can perform lung biopsy in patients with suspected EVALI and pediatric pathologists who can provide histologic correlation, is imperative to gain a better understanding of the pathogenesis of the imaging abnormalities observed in these disorders. Cross-sectional imaging, such as chest CT, can provide improved characterization of lung abnormalities in pediatric lung disorders; however, the studies in the literature describing the CT findings in pediatric patients are scarce, presumably because of the concerns about the harmful effects of ionizing radiation [84]. Fortunately, there have been substantial improvements in lung MRI technique in recent years with motion correction and parallel imaging [85–87]. Lung MRI may be helpful and can provide additional structural and functional information without associated ionizing radiation; however, future studies are needed to assess the utility of MRI in identifying markers for pediatric lung disorders.

Conclusion

The clinical presentation and laboratory evaluation of pediatric patients presenting with several relatively new lung disorders are often nonspecific with a great deal of overlap. A clear understanding of the imaging manifestations of these pediatric lung disorders is essential so that the radiologist can make a timely and accurate diagnosis (Table 2). Although there are some overlapping imaging features of these disorders, careful evaluation of the distribution, lung zone preference, and symmetry of the abnormalities with an eye for a few unique differentiating imaging features, such as the halo sign seen in COVID-19 and subpleural sparing and the atoll sign seen in EVALI, can allow the radiologist to offer a narrower differential diagnosis in pediatric patients, leading to optimal patient care.

### TABLE 2: What Radiologists Need to Know About Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS), Coronavirus Disease (COVID-19), Swine-Origin Influenza A (H1N1), and E-Cigarette or Vaping Product Use–Associated Lung Injury (EVALI)

<table>
<thead>
<tr>
<th>Lung Disorder</th>
<th>Imaging Characteristics</th>
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<tr>
<td>SARS</td>
<td>Often initially presents with unifocal GGO, consolidation, or both in the lower lung zone in a peripheral or combined peripheral and central distribution</td>
</tr>
<tr>
<td>MERS</td>
<td>May initially present with unifocal GGO, consolidation, or both in a peripheral and lower lung zone distribution; pleural effusion or pneumothorax may be observed and is suggestive of a more severe clinical course</td>
</tr>
<tr>
<td>COVID-19</td>
<td>Frequently presents with bilateral multifocal GGO, often with associated consolidation, in a peripheral and subpleural distribution; halo sign may also be seen; central distribution, pleural effusion, and lymphadenopathy are rare and, when present, should lead to a broadened differential diagnosis</td>
</tr>
<tr>
<td>H1N1</td>
<td>Mild cases typically present with normal findings on chest radiography or hyperinflation with prominent bilateral symmetric peribronchial markings; severe cases show bilateral central lung–predominant GGO, consolidation, or both</td>
</tr>
<tr>
<td>EVALI</td>
<td>Most commonly presents with multifocal bilateral symmetric GGO, consolidation, or both, frequently with subpleural sparing; “atoll” sign may be seen and, when present, can help narrow the differential diagnosis</td>
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Note—GGO = ground-glass opacity.
30. Chu WC, Li AM, Ng AWH, et al. Thin-section CT 12 months after the diagnosis of severe acute respiratory syndrome in pediatric patients. AJR 2006; 186:1707–1714
37. Ajaian AM, Ahayd RA, Jamjoom LG, Alharthy A, Madani TA. Middle East respiratory syndrome coronavirus (MERS-CoV) infection: chest CT findings. AJR; 2014; 203:782–787
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60. Schoen K, Horvat N, Guerreiro NFC, de Castro I, de Giassi KS. Spectrum of clinical and radiographic findings in patients with diagnosis of H1N1 and correlation with clinical severity. BMC Infect Dis 2019; 19:964

61. Agarwal PP, Cinti S, Kazerooni EA. Chest radiographic and CT findings in novel swine-origin influenza A (H1N1) virus infection. AJR 2009; 193:1488–1493


84. Sodhi KS, Lee EY. What all physicians should know about the potential radiation risk that computed tomography poses for paediatric patients. Acta Paediatr 2014; 103:807–811


AJR:215, September 2020