Radiology

Seeing Is Believing: COVID-19 Vaccination Leads to Less Pneumonia at Chest CT

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One of the tenets of survival training is the rule of threes (1). In general, you can survive for 3 minutes without air, 3 hours in extreme heat or cold, 3 days without water, and 3 weeks without food. The exact survival times vary depending on the circumstances. However, lack of carbon dioxide exchange in the blood for oxygen in the alveoli is an urgent problem for any animal. It is quite simply a matter of life and death.

Viral pneumonia during pandemics has been uniquely aggressive. These viral lung infections may progress to adult respiratory distress syndrome (ARDS), which results in death if not aggressively treated. The Spanish flu of 1919 (H1N1) killed an estimated 17 to 50 million persons (numbers vary depending on the source), with case fatality rates greater than 2.5% (2). Despite the many medical advances over the past 100 years, there has been more than 329 million confirmed cases of COVID-19; 5.6 million people have died, resulting in a global fatality rate of 1.7%.

The case fatality rates for SARS-CoV-2 vary depending on several factors, but the most important preventive factor is vaccination. Countering this, particularly in the United States, is vaccine hesitancy. Vaccine hesitancy refers to a person's choice to not get a vaccine, even when one is freely available (3). Luo et al (3) performed a survey of over 6000 Medicare beneficiaries (>65 years of age), assessing various factors that influenced their willingness to get the COVID-19 vaccine. Sixty-one percent were willing to receive vaccination when it became available. Forty percent were vaccine hesitant; the primary reason cited for this was mistrust of the government. During a pandemic, mistrust has consequences. Radiologists "see" this consequence quite directly in the lungs on CT scans.

After 2 years of the COVID-19 pandemic, most radiologists have interpreted chest radiographs or chest CT scans in patients with COVID-19. At our practice, rates of abnormal chest radiographs have paralleled the roller coaster oscillations of the multiple pandemic surges. Patients with the most severe lung damage go on to receive extracorporeal membrane oxygenation, which temporarily replaces the lungs with an external machine to oxygenate the blood. This allows oxygenation of the blood while the patient's lungs have time to recover from a severe case of ARDS caused by SARS-CoV-2.

When patients admitted for COVID-19 are discharged from the hospital, the lungs are still recovering (4). Pan et al (4) reviewed 209 patients who underwent follow-up CT after hospitalization for COVID-19. A notable 25% of patients had persistent chest CT abnormalities 1 year later. In addition to pulmonary fibrosis, bronchial dilatation was seen in 12% of patients at 1-year follow-up (4). Besides these anatomic abnormalities, the lungs do not have normal function. Grist et al (5) studied air exchange in the lungs using hyperpolarized xenon MRI in nine patients. Alveolar capillary diffusion was abnormal, despite normal or nearly normal chest CT findings 3 months after hospital discharge.

Despite the remarkable success of vaccines, little is known about radiologic abnormalities in vaccinated versus unvaccinated patients. In this issue of *Radiology*, Lee et al (6) studied the impact of COVID-19–related pneumonia in relationship to vaccination status. The overall vaccination rate in Korea is very high at 84%; 86% of the population is at least partially vaccinated (7). Even with full vaccination, breakthrough cases of COVID-19 occur. In their multicenter study of patients in Korea, the authors studied the presence of pneumonia according to vaccination status (fully vaccinated, partially vaccinated, or unvaccinated).

The first result given by the authors may elicit the response "I told you so" from chest radiologists. More than two-thirds of all patients with COVID-19 had a negative

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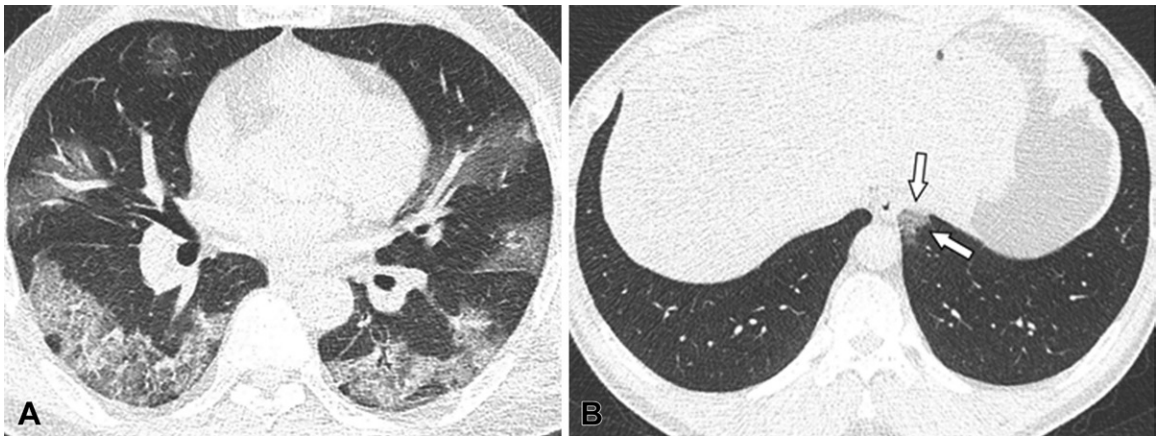
See also the article by Lee and Hwang et al in this issue.



Chest CT findings of COVID-19–related pneumonia severity depend on that individual's COVID-19 vaccination status. **(A)** Image in an unvaccinated patient with COVID-19 pneumonia. **(B)** Image in a partially vaccinated patient with a COVID-19 pneumonia breakthrough infection shows much less opacity than that of a typical unvaccinated patient. Arrows indicate unilateral ground-glass opacity with a nonrounded morphologic appearance in the left lower lobe. (Reprinted with permission from reference 6.)

chest radiograph when admitted to the hospital. There was no difference between patient groups when studied by vaccination status. Chest radiographs are simply limited in their ability to depict interstitial lung disease associated with COVID-19.

The situation was different for chest CT, which was performed as needed by clinicians. The proportions of patients who underwent clinically indicated CT (5% and 79% of vaccinated and unvaccinated patients, respectively) were almost identical to the proportions of patients in the vaccinated and unvaccinated groups (6% and 77%, respectively). This set the stage to determine the frequency of pneumonia at chest CT according to vaccination status. The answer: pneumonia was present in 78% of unvaccinated patients, but only 41% of fully vaccinated patients (P = .003 for the difference between groups). Put another way: pneumonia was roughly twice as frequent for unvaccinated compared with fully vaccinated patients.

Beyond the lower rates of pneumonia at CT, the clinical course of patients paralleled the chest CT findings: vaccinated patients were much less likely to require supplemental oxygen (odds ratio, 0.24; P = .005) and had a lower rate of intensive care unit admission (odds ratio, 0.08; P = .02) than unvaccinated patients. The results add up: patients who received a vaccine were much less likely to have CT evidence of SARS-CoV-2 infection in their lungs, leading to less need for supplemental oxygen and fewer intensive care unit admissions.

If a patient in the hospital survives COVID-19 infection or does not need intensive care unit admission, do we care if there was or was not pneumonia on chest CT scans? We think it matters. The presence of pneumonia requires specific treatment. Unfortunately, clinicians simply cannot be certain whether pneumonia is present or absent using a stethoscope (or chest radiography). Even the lay public is now aware that low blood oxygen saturation is another clue to lung disease. Many people have purchased a smart watch or pulse oximeter for this reason during the pandemic. But low blood oxygen levels can have multiple causes, including cardiac abnormalities and pulmonary embolus. Blood oxygen levels cannot help diagnose ground-glass opacities due to COVID-19.

Second, for many people (doctors included), seeing is believing. If chest CT does not show pneumonia, then the lungs are likely fine; the clinician can move on to evaluate other complications of COVID-19 disease. In addition, pneumonia can take considerable time to heal and contributes to so-called long COVID; of more than 3700 patients with COVID-19 disease, 90% had persistent pulmonary complaints 7 months after their initial illness (8).

Do we need more evidence that vaccines prevent lung disease related to COVID-19? Perhaps. In the study conducted by Lee et al, it would have been better if risk factors, age, and sex had been matched in the vaccinated, partially vaccinated, and unvaccinated groups. In that fashion, we could more carefully tease out the relationship of COVID-19 pneumonia to outcome. Perhaps we would like to know if certain vaccines are more effective than others in preventing COVID-19 pneumonia; matched groups would also help answer that question. Unfortunately, we are unlikely to get this information any time soon. The COVID-19 vaccines are remarkably effective; matching patient groups is not possible when overall sample sizes are small. Proliferation of milder variants such as Omicron also allows less clinical need for chest CT.

The adage "a picture is worth a thousand words" holds true. Lee et al (6) have shown that the burden of COVID-19 pneumonia is much less in those who have been vaccinated (Figure). The authors have furthered our understanding of vaccine effectiveness. If seeing is believing, the visual evidence provided by Lee et al might even help strengthen the hand of public health officials still working to overcome the problem of vaccine hesitancy. We can only hope.

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