

[CASE REPORT]

Evidence of the Sequential Changes of Lung Sounds in COVID-19 Pneumonia Using a Novel Wireless Stethoscope with the Telemedicine System

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Abstract:

A 60-year-old woman was admitted to our hospital due to coronavirus disease 2019 (COVID-19) pneumonia with a chief complaint of persistent low-grade fever and dry cough for two weeks. Thoracic computed tomography demonstrated a crazy paving pattern in the bilateral lower lobes. In a COVID-19 ward, we used a novel wireless stethoscope with a telemedicine system and successfully recorded and shared the lung sounds in real-time between the red and green zones. The fine crackles at the posterior right lower lung fields changed from mid-to-late (day 1) to late inspiratory crackles (day 3), which disappeared at day 5 along with an improvement in both the clinical symptoms and thoracic CT findings.

Key words: COVID-19, lung auscultation, wireless stethoscope, telemedicine, telemedicine system

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Introduction

The year 2016 marks the 200th anniversary of the invention of the stethoscope by Dr. René Théophile Hyacinthe Laennec (1). In the view of diagnostic accuracy, the stethoscope may not be as strong a tool as hoped for, especially for trainees. However, we have recently developed a novel stethoscope with a telemedicine system in collaboration with JVC Kenwood (2-5), or Digital Global Systems, for disasters, after the tsunami following the 2011 Great East Japan earthquake in northeastern Japan. In this coronavirus pandemic, we found that the novel technological approach could be successfully applied to the coronavirus disease 2019 (COVID-19) ward.

Case Report

A 60-year-old woman was referred to our isolated emergency room for suspected COVID-19. She had a 2-week history of dry cough after having a transient high fever of

38°C. Right upper lobectomy for lung cancer had been carried out 26 years previously. Her vital signs were normal except for low grade fever of 37.2°C, tachycardia 106 beats per minute, and tachypnea of 24 breaths per minute. Thoracic computed tomography (CT) revealed a subpleural reticular shadow with ground glass opacities, indicating a crazy paving pattern in the bilateral lower lobes, predominantly seen at the base of the right lung (Fig. 1A, B).

After admission to the COVID-19 ward, we tried recording the sequential changes in lung sounds, in a seated position, from the posterior right lower lung fields with relaxed respiration. We used the novel wireless stethoscope, manufactured by Digital Global Systems company (Japan) to record the lung sounds directly by connecting systems between a wireless receiver and a cellular phone (Fig. 2, red zone). It can also transfer and share the sounds by telemedicine using 3 G/4 G or Wi-Fi to an outside area such as green zones and/or other distant areas through a cloud system (Fig. 2, green zone) (6).

Physicians with personal protective equipment (PPE) applied the wireless stethoscope (Fig. 3A) over the patient's

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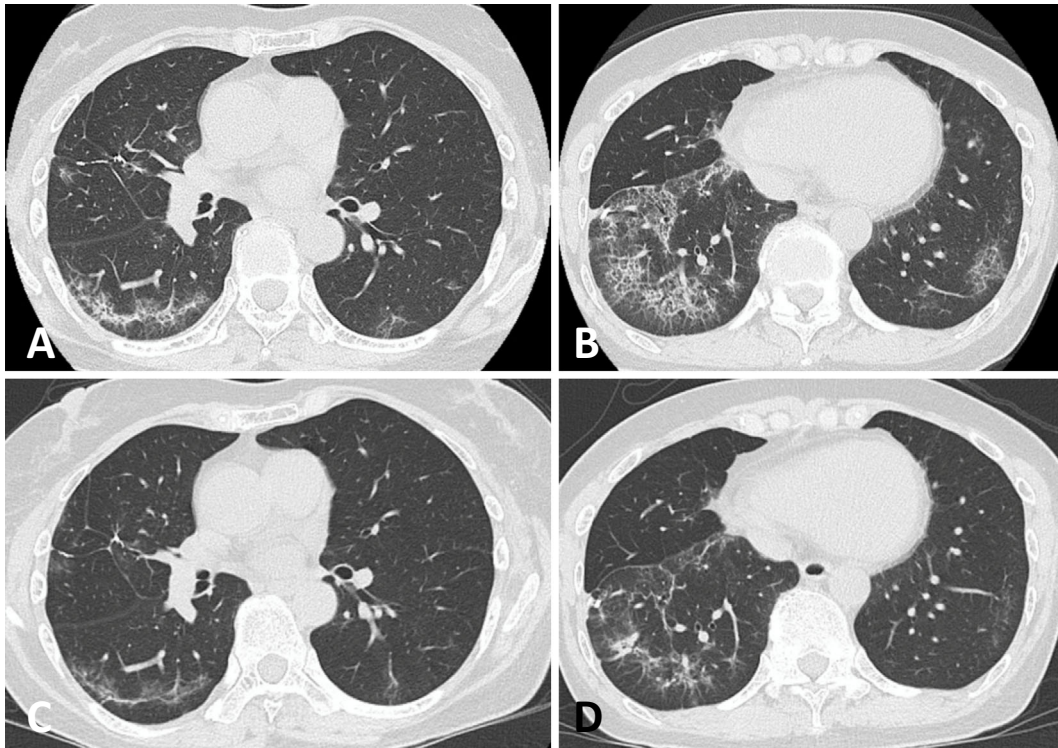


Figure 1. Sequential changes of thoracic CT. Thoracic CT taken on admission demonstrated GGO with superimposed interlobular and intralobular septal thickening, also called a “crazy-paving pattern” in both lower lung lobes predominantly on the right side (A, B), which had almost completely disappeared by the day of discharge (C, D).

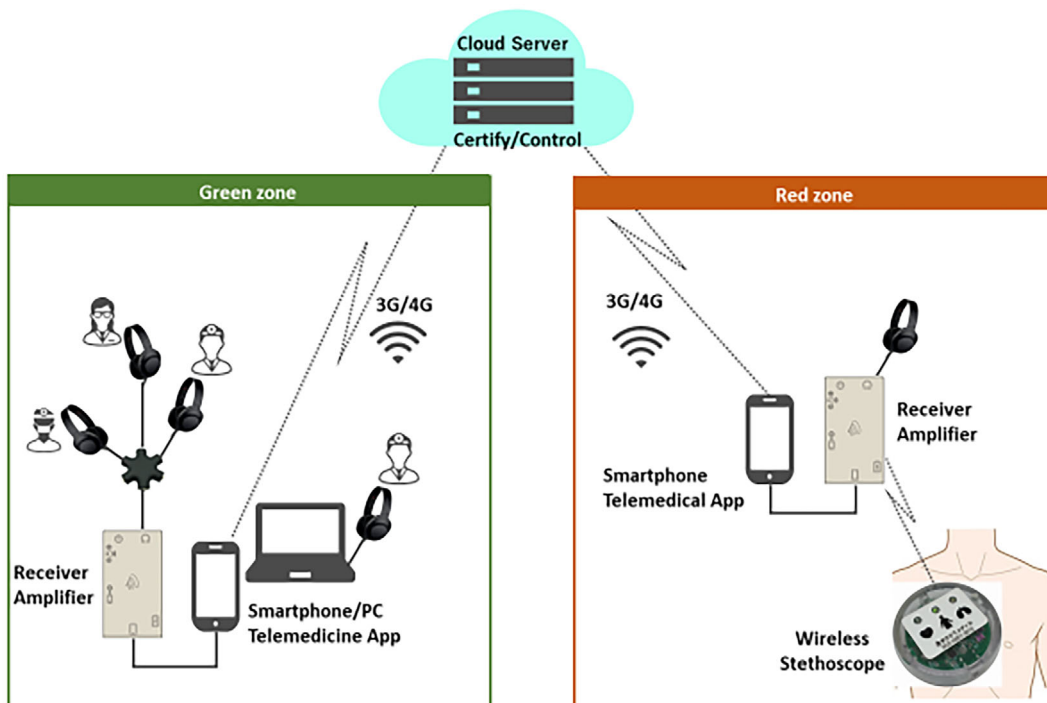


Figure 2. Telemedicine system for real time auscultation and record the lung sounds. Physicians can record and share the lung sounds at a time via the route; 1) wireless stethoscope→2) receiver/cellular phone→3) from the red zone to green zone via 3 G/4 G or Wi-Fi→4) cloud server→5) auscultate and record the lung sounds at a real time in green zone or distant area outside the hospital via a cloud system.



Figure 3. Auscultation method with a novel device. Physicians with PPE apply the wireless stethoscope over the patient's lungs (A), with lung sounds being automatically transferred to the receiver and recorded in an app in the cellular phone (B). Both the receiver and the cellular phone are usually wrapped in plastic. The lung sounds are simultaneously transferred to a cloud server as well and can be shared in real time with the medical staff in the green zone using a cellular phone or tablet-type device.

lungs. The lung sounds were automatically transferred via a wireless receiver to a cellular phone on the table (Fig. 3B) by the bed side and recorded in an application on the cellular phone. Importantly, the recorded lung sounds were also transferred, via a telemedicine system (Fig. 2), from the red zone (i.e., depressurized rooms) to the green zones, where nurses or other physicians could hear them in real time using a cellular phone or tablet-type device (Fig. 3C).

To minimize the risk of contact transmission, we wrapped the wireless receiver and cellular phone (Fig. 3B) with plastic.

On admission (day 1), physical examination indicated mid-to-late inspiratory crackles (fine crackles) mainly consisting of high-pitched sounds (higher than 500 Hz) at the posterior right lower lung fields (supplementary material 1-3: day 1 original sound and frequency based data of lower or higher than 500 Hz. <https://www.dgs-j.com/download/>). The severe acute respiratory syndrome-coronavirus 2 (SARS-CoV-2) polymerase chain reaction (PCR) examination done from a nasopharyngeal specimen was positive.

She was thus diagnosed with COVID-19 pneumonia at the day of admission and was thereafter treated with supportive care. On day 3, subtle fine crackles with high pitched sounds (mainly higher than 500 Hz) were noted only at the late inspiratory phase and the duration of the individual crackles became shorter (supplementary material 4-6: day 3 original sound and frequency based data of lower or larger than 500 Hz, <https://www.dgs-j.com/download/>), which disappeared by day 5 (supplementary material 7: day 5 original sound: <https://www.dgs-j.com/download/>) along with the improvement of the lung lesions and other clinical symptoms (Fig. 1C, D).

She was discharged uneventfully at day 12 after confirming two consecutive negative results for the nasopharyngeal SARS-CoV-2 PCR test.

Discussion

We successfully recorded and evaluated the lung sounds of COVID-19 by a novel wireless stethoscope with its cloud system during the clinical course, which demonstrated the healing process of COVID-19 pneumonia along with the improvement of the clinical symptoms and heart-resolution computed tomography (HRCT) findings. This was characterized by the change of the timing of inspiratory crackles from “mid to late” to “late” inspiratory crackles with relatively high-pitched sounds higher than 500 Hz through the phase (both day 1 and day 3). Indeed, Piirila et al. (7) reported that the beginning of crackles in community acquired pneumonia had shifted in comparison to the initial phase (average 6 days after the onset of pneumonia) and the later phase (2 or 4 days later). Although the lung sounds of COVID-19 pneumonia have not been previously described elsewhere, severe cases under mechanical ventilation occasionally have coarse crackles at their acute exaggerated respiratory phase, while most cases with mild to moderate COVID-19 pneumonia usually seem to have subtle fine crackles or no adventitious sounds through the phase. In this regard, this is the first report of mild COVID-19 pneumonia, describing the representative sequential lung auscultation under PPE conditions.

Regarding the HRCT findings, Pan et al. (8) reported that the pathognomonic radiological findings were classified into four patterns based on the time from initial onset, such as ground glass opacities (GGO) at stage 1 (0-4 days), a crazy-paving appearance at stage 2 (5-8 days), consolidation at stage 3 (9-13 days), and gradual resolution of consolidation at stage 4 (14 days after). Although the initial onset of the COVID-19 pneumonia in this case was precisely unknown, the presence of a crazing paving pattern at the initial visit seemed to correspond to stage 2.

COVID-19 pneumonia lacks data regarding lung sounds; however, this case demonstrated that careful auscultation specifically focused on the involved area on thoracic CT reflected the disease status. In this perspective, even with PPE, the accumulation of sequential lung sounds of COVID-19

pneumonia using a wireless stethoscope is considered to be useful for characterizing the disease in future studies.

The authors state that they have no Conflict of Interest (COI).

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