are mixed by opening a septum before the fluid is connected to the machine.[1] In the present case, failure in opening the PD fluid bag septa resulted in a precipitous fall in serum sodium level at an approximate rate of 30 mEq/L over 5 h, leading to seizures. The mother had inadvertently missed opening the septa before starting PD. This PD fluid – which is 3,000 mL when mixed at the beginning of PD – initially contains 135 mEq/L sodium and 408 mOsm/L osmolality after septum opening (Table 1). In the present case, however, only the sodium-free glucose solution (800 mL each) was connected in two of the three bags due to failure of septum opening (total fluid amount, 2,600 mL). It was surmised that, as a result of this, the PD fluid contained only 52 mEq/L sodium; osmolality was calculated to be 264 mOsm/L by the following formula:

$$2[\mathrm{Na}+] + [\mathrm{Glucose}]/18 + [\mathrm{BUN}]/2.8 \quad (1)$$

where [Glucose] and [BUN] are measured in mg/dL (Table 1). In PD, solute movement (diffusion) and water movement (osmosis) generally occur from blood to fluid. The precipitous fall in the serum sodium level in the present case can be explained by a combination of the rapid diffusion of sodium into the fluid and simultaneous osmosis of water into the blood due to the low sodium concentration and osmolality of the PD fluid. The patient had actually gained 400 g in weight in one day. Although this two-chamber-type PD fluid is used worldwide, there are very few reports of adverse events caused by forgetting to open the septum in the literature. To prevent adverse events, some fluid bags are designed so that they cannot be used without opening the septum. Single-chamber PD fluid using osmotic substances other than glucose are also available.[2]

In potentially relevant situations, pediatricians and emergency physicians should ensure that they confirm whether CCPD was performed appropriately at home because patients on PD can develop rapid electrolyte abnormalities if the septum of a PD fluid component is left closed. Caregivers must be instructed on correct PD procedures. The development of safer devices for long-term PD is warranted.

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The authors declare no conflicts of interest.

Consent

Informed consent was obtained from the parent.

Author contributions

Y.A. managed the patient and reviewed the clinical chart, reviewed the literature, and drafted the initial manuscript. Y.I., S.N., N.Y., and K.Y. contributed to patient management and critically reviewed and revised the manuscript. Each author listed on the manuscript has seen and approved the submission of this version of the manuscript and takes full responsibility for the manuscript.

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Reactivation of SARS-CoV-2 after recovery

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Key words COVID-19, pediatrics, reactivation, SARS-CoV-2.

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Coronavirus disease 2019 (COVID-19) has now spread worldwide as a global pandemic.[1] We report on an 8-year-old boy who might be a patient with reactivation of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in a family cluster.

We retrospectively reviewed medical records including symptoms and signs, laboratory examination, sequential cycle threshold values of real-time reverse transcription-polymerase chain reaction (qRT-PCR) tests for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), radiological findings, and management. The transmission route to SARS-CoV-2 was described based on the report by the epidemiological investigation service officer and the history taken from the parents. qRT-PCR tests for SARS-CoV-2 were performed using samples collected serially from the upper airway (nasopharyngeal swab), lower airway (sputum), urine, stool, saliva, and serum. Viral RNA was detected by using Allplex™2019-nCoV Assay (Seegene Inc., Seoul, Korea) for amplification of the RNA-dependent RNA polymerase (RdRP), N genes specific for SARS-CoV-2, and E genes for all *Sarbecovirus,* including SARS-CoV-2. The cycle threshold (Ct) values from the qRT–PCR were measured; Ct values <35 were reported as positive, and Ct values between 35 and less than 40 were considered indeterminate.

On March 3, 2020, the 8-year-old boy presented a 3-day history of intermittent cough and was diagnosed with COVID-19 after having been in contact with his father, who was confirmed SARS-CoV-2 positive 3 days before. He was previously healthy and had no travel history within two weeks. Once the father had tested positive, the family members had gone into self-quarantine at home. They had all been tested for COVID-19 on February 29 and were negative and had continued to self-isolate. Other family members were also tested but were found to be negative. The child was then hospitalized in a nationally designated negative pressure room together with his mother.

Upon admission, the boy's initial blood tests were within reference ranges. Chest X-rays were performed during admission but the radiographs showed no active lesions. However, chest computed tomography (CT) revealed non-specific ground glass-opacity nodules in the subpleural area of the left lower lobe, suggesting a viral pneumonia. Supportive care was given to the boy without antiviral medication.

On day 3 of admission, his cough gradually improved and resolved on day 15, following which symptomatic medication was discontinued. The results of the qRT-PCR tests from both the upper and lower respiratory tracts were positive until day 8 of admission, becoming negative on day 14 and qRT-PCR was performed after 24 h (Table 1). The patient was discharged on day 17.

The patient stayed at home without contact with other people after discharge. However, his cough reoccurred and he developed a poor appetite 4 days after discharge. The qRT-PCR test for SARS-CoV-2 was therefore conducted again the following day and the results were negative. However, the cough continued and deteriorated, and a follow-up test was therefore performed 14 days after discharge. On April 4, the test for SARS-CoV-2 was positive and so the patient was admitted again (Table 1). Laboratory and imaging studies showed no remarkable abnormalities. Even though he had a mild fever of 37.7 °C, the patient's general condition was very good. Another multiplex PCR test was also performed to assess for various respiratory pathogens and was negative. On April 7, 2020, 4 days after re-admission, his fever subsided and did not increase further above 37.5 °C after 48 h. Until the 7th day, the qRT-PCR test at upper airway confirmed that

Table 1 The change of cycle threshold values using qRT-PCR in two respiratory and three non-respiratory specimens

	4-Mar	6-Mar	9-Mar	12-Mar	16-Mar	17-Mar	2-Apr	3-Apr	6-Apr	8-Apr	9-Apr	11-Apr	12-Apr
Upper airway													
RdRP gene	**24.85**	**26.33**	**32.66**	–[†]	–	–	**31.16**	–	**31.09**	–	–	–	–
E gene	**22.70**	**23.94**	**30.97**	–	–	–	**29.21**	–	**31.11**	–	–	–	–
N gene	**25.01**	**28.46**	**34.95**	–	–	–	**30.87**	–	**31.53**	39.85	–	–	–
Lower airway													
RdRP gene	**26.93**	**26.49**	**29.14**	–	–	–	•	–	–	–	–	–	–
E gene	**25.44**	**24.21**	**32.28**	–	–	–	•	–	–	–	–	–	–
N gene	**29.45**	**27.72**	**33.38**	37.17	–	37.88	•	–	–	–	–	–	–
Urine													
RdRP gene	–	–	–	–	–	•	–	–	–	–	–	–	–
E gene	–	–	–	–	–	•	–	–	–	–	–	–	–
Serum													
RdRP gene	–	–	–	•[‡]	•	•	–	•	•	•	•	•	•
E gene	–	–	–	•	•	•	–	•	•	•	•	•	•
Saliva													
RdRP gene	40.00	•	–	–	–	•	–	–	–	–	–	–	–
E gene	**23.88**	•	**34.34**	**34.03**	–	•	–	–	–	–	–	–	–
Stool													
RdRP gene	•	**28.55**	•	•	**31.19**	**33.42**	•	–	–	–	–	–	–
E gene	•	**23.88**	•	•	36.26	**30.26**	•	–	–	–	–	–	–

Abbreviations: E, E gene for all *Sarbecovirus* including SARS-CoV-2; N, N genes specific for SARS-CoV-2; qRT-PCR, real-time reverse transcription-polymerase chain reaction; RdRP, RNA-dependent RNA polymerase.

[†]Undetectable.

[‡]Not tested.

Bold values, SARS-CoV-2 qRT-PCR positive test results.

it was positive. However, it was confirmed as negative by two tests conducted at 24 h intervals from the 9th day to the 10th day (Table 1). The patient was then subsequently discharged on April 13, the 11th day of hospitalization. Fortunately, his mother had not been infected since he was first diagnosed.

In a recent report on adults with reactivation of COVID-19, 5 (9%) of all 55 patients who were discharged from hospital presented with SARS-CoV-2 reactivation.[2] As the prevalence of COVID-19 in children has been even lower than adults,[3,4] our study could be provided as a basis for future studies. Even though detection of viral RNA does not necessarily mean that infectious viruses are shedding, further research is needed to understand its significance for transmission-based precautions.

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Disclosure

The authors declare no conflict of interest.

Author contributions

S.Y.Y., Y.L., G.H.L., and D.H.K. were involved in the medical management of the patient, and collected and analyzed the clinical data. S.Y.Y. wrote the manuscript, and D.H.K. reviewed the manuscript. All authors read and approved the final manuscript.

Ethical approval

This study was approved by the Institution Review Board (IRB) of Inha University Hospital (IUH-IRB-2020-04-002). Written consent was obtained from the parents of the patient for publication.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Fig S1. The change of cycle threshold values using qRT-PCR in upper and lower respiratory specimens. Positive range, shown in pink color. Abbreviations: E, E gene for all of Sarbecovirus including SARS-CoV-2; N, N genes specific for SARS-CoV-2; qRT-PCR, real-time reverse transcription-polymerase chain reaction; RdRP, RNA-dependent RNA polymerase; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; (U), upper airway specimen; (L), lower airway specimen.

Fig S2. Chest computed tomography revealed non-specific ground glass-opacity nodule (white arrow) in the subpleural area of the left lower lobe in axial view.