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Can SARS-CoV-2-infected women breastfeed after viral clearance?*

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The recently emerged novel coronavirus pneumonia, named the coronavirus disease 2019 (COVID-19), shares several clinical characteristics with severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS), and spread rapidly throughout China in December of 2019 (Huang et al., 2020). The pathogen 2019 novel coronavirus (2019-nCoV) is now named SARS coronavirus 2 (SARS-CoV-2) and is highly infectious. As of Apr. 9, 2020, over 80000 confirmed cases had been reported, with an estimated mortality rate of 4.0% (Chinese Center for Disease Control and Prevention, 2020). Person-to-person transmission and familial clustering have been reported (Chan et al., 2020; Nishiura et al., 2020; Phan et al., 2020). However, there is no evidence of fetal intrauterine infection in pregnant women who have been infected with SARS-CoV-2 in their third trimester (Chen et al., 2020). It is unclear whether breastfeeding transmits the virus from previously infected and recovered mothers to their babies. Here we report the clinical course of a pregnant woman with COVID-19. In order to determine whether SARS-CoV-2 can be transmitted to newborns through breastfeeding, we measured viral RNA in the patient's

breastmilk samples at different time points after delivery.

The patient was a 30-year-old female (gravida 2, para 1) at 35 weeks and 2 d of gestation with no underlying medical conditions (Huang et al., 2020). Her husband had a fever on Feb. 1, 2020, and was subsequently diagnosed with COVID-19. On the same day, the patient went to a local hospital complaining of a dry cough, but had no fever, chest tightness, or shortness of breath. However, her sputum tested positive by real-time polymerase chain reaction (RT-PCR) for SARS-CoV-2. She was then transferred from the local hospital to our center, the First Affiliated Hospital of Zhejiang University, Hangzhou, China, on Feb. 6, 2020.

After admission, laboratory testing revealed a slightly elevated C-reactive protein level (11.76 mg/L) and a normal leukocyte count (8.7×10^9 cells/L), with 81.4% segmented neutrophils, 12.9% lymphocytes, and 0.5% monocytes. Tests for influenza virus type A/B, parainfluenza type I/II/III, respiratory syncytial virus, and adenovirus were all negative. The chest computed tomography images revealed diffuse bilateral lung infiltrates. The patient received the antiviral lopinavir-ritonavir. On the third day of hospitalization, she underwent an emergency delivery by cesarean section due to a decrease in the fetal heart rate to 110 beats/min. At this time, RT-PCR testing of her sputum for SARS-CoV-2 was still positive. She delivered a baby boy with Apgar scores of 9 and 10 at 1 and 5 min post-delivery, respectively. Caution was taken during delivery to avoid contact, droplet, and airborne transmissions of the virus. At delivery, RT-PCR tests of maternal serum, urine, stool, cord blood, amniotic fluid, and placenta were negative for SARS-CoV-2. An oropharyngeal swab from the newborn baby was obtained immediately after birth, and the result revealed that the infant was negative for SARS-CoV-2. The baby was then sent to a negative-pressure isolation room in the Children's Hospital of Zhejiang

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University (Hangzhou, China), and the subsequent tests of oropharyngeal swabs, blood, stool, and urine remained negative for SARS-CoV-2. Beginning on the fourth day of hospitalization, repeated RT-PCR analyses of the mother's sputum and breastmilk were consistently negative for SARS-CoV-2. On Feb. 19, 2020, based on the current expert consensus (Xu et al., 2020), the patient was discharged. A two-week quarantine was then required, and follow-up was needed.

Based on previous reports, life-threatening respiratory illnesses like SARS-CoV and MERS-CoV can be associated with critical maternal illness, spontaneous abortion, stillbirth, and maternal death (Payne et al., 2014; Assiri et al., 2016; Maxwell et al., 2017). According to current reports, none of the pregnant women with SARS-CoV-2 infections have developed severe adverse outcomes. Due to the highly similar sequence and identical angiotensin-converting enzyme 2 (ACE2) entry site of SARS-CoV (Zhou et al., 2020), we should be attentive to the disease course and prognosis of COVID-19 in pregnant patients.

Despite the vertical transmission reported in H1N1 and respiratory syncytial virus (Wong et al., 2004; Takahashi et al., 2011), there are still no reports of maternal-fetal transmission of SARS-CoV-2 or other coronaviruses SARS-CoV and MERS-CoV.

Consistent with the virological testing in other cases of SARS-CoV, Robertson et al. (2004) reported a pregnant patient infected with SARS-CoV at 19 weeks' gestation. She recovered after 15 d in the hospital, and later delivered a healthy baby in the 38th week of pregnancy. No viral RNA was detected in her breastmilk by RT-PCR, although antibodies to SARS-CoV were positive. Stockman et al. (2004) also reported a case of a pregnant woman with SARS. This woman contracted SARS-CoV in her first trimester. After recovering from SARS, she underwent a cesarean section at 36 weeks' gestation, and her infant was also not infected. Three days after delivery, since SARS-CoV was not detected in the specimens collected at delivery, she breastfed her baby (Schneider et al., 2004). Chen et al. (2020) studied nine pregnant women diagnosed with COVID-19 in their third trimester. All patients underwent a cesarean section, and all nine newborns tested negative for the virus. Breastmilk samples were collected from six postpartum patients after their first lactation, and the samples tested negative for SARS-CoV-2.

Our case also found that the infant was healthy based on multiple repeated tests, and the breastmilk samples showed no evidence of SARS-CoV-2 infection. Moreover, the patient was reexamined one week after discharge, and no viral RNA was detected in her sputum or breastmilk.

Breastfeeding provides benefits to both babies and mothers and it is well supported by public policy. Human milk provides optimal nutrients and helps bolster babies' immune systems to fight and prevent infections. Additionally, mothers who breastfeed have a decreased risk of diabetes mellitus, hypertension, and breast cancer (Schwarz and Nothnagle, 2015). However, for many pregnant women who are infected with severe acute and highly pathogenic infectious diseases such as SARS, MERS, and COVID-19, the safety of breastfeeding is still a concern.

The existing data indicates that SARS-CoV-2 cannot be transmitted through breastmilk. In order to minimize neonatal transmission risk, the mother should be isolated from the neonate until she has recovered from COVID-19 and is considered no longer infectious, which requires a two-week quarantine after hospital discharge. However, too few cases have been studied to clearly define the risks and provide guidance for pregnant women infected with SARS-CoV-2. Additionally, the pregnant women reported were in their third trimester at the onset of COVID-19 infection (Da, 2020), so we were unable to ascertain the possibility of intrauterine vertical transmission during the first or second trimester. More data from randomized and controlled multicenter studies are needed to rigorously assess the risks of breastfeeding.

In conclusion, our results suggest that breastfeeding can be practiced after an isolation period is completed and repeat testing is normal. In the meantime, breast pumping is suggested so that breastfeeding may begin once the isolation period ends.

Contributors

Guan-jing LANG and Hong ZHAO participated in the study design. Guan-jing LANG collected the data and wrote the manuscript. Hong ZHAO edited the manuscript. Both authors have read and approved the final manuscript and, therefore, have full access to all the data in the study and take responsibility for the integrity and security of the data.

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Compliance with ethics guidelines

Guan-jing LANG and Hong ZHAO declare that they have no conflict of interest.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5). Informed consent was obtained from the patient for being included in the study.

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中文概要

题目：新型冠状病毒感染后治愈的女性可以进行母乳喂养吗？

概要：浙江大学医学院附属第一医院感染科收治一名新型冠状病毒（SARS-CoV-2）感染的妊娠晚期孕妇。在其住院期间，患者进行了剖腹产术，新生儿被证实无 SARS-CoV-2 感染。结合已有的相关文献报道，SARS-CoV-2 通过母婴垂直传播的依据不足，同时乳汁的病毒检测阴性，因此目前不能证明 SARS-CoV-2 病毒能通过乳汁传播。通过研究，我们建议感染 SARS-CoV-2 的孕妇，在治愈出院后，应经过两周隔离观察，并且病毒复查结果为阴性，才可以进行母乳喂养。

关键词：新型冠状病毒（SARS-CoV-2）；孕妇；哺乳；母婴传播