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Possible Vertical Transmission of SARS-CoV-2 From an Infected Mother to Her Newborn

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is highly infectious, with multiple possible routes of transmission.¹⁻³ Controversy exists regarding whether SARS-CoV-2 can be transmitted in utero from an infected mother to her infant before birth. A series of 9 pregnant women found no mother-child transmission.⁴ We report a newborn with el-

evated IgM antibodies to SARS-CoV-2 born to a mother with coronavirus disease 2019 (COVID-19).

Methods | A mother with COVID-19 and her infant delivered February 22, 2020, at Renmin Hospital, Wuhan, China, were evaluated. The institutional review board of Wuhan University approved the study, and written informed consent was obtained.

Clinical information was obtained from interview of the mother and clinical records. Both mother and infant underwent chest computed tomography (CT); real-time reverse transcriptase-polymerase chain reaction (RT-PCR) for SARS-CoV-2 nucleic acid of nasopharyngeal swabs; and IgM and IgG antibody, cytokine, and other biochemistry tests in blood. The mother also underwent RT-PCR testing of vaginal secretions at delivery. The sensitivity of IgM for SARS-CoV-2 reached 70.2% and specificity was 96.2%. The sensitivity of IgG for SARS-CoV-2 reached 96.1% and specificity was 92.4%.³

Results | On January 28, 2020, a 29-year-old primiparous woman (34 weeks 2 days of gestation) suspected of being exposed to SARS-CoV-2 developed a temperature of 37.9° C and nasal congestion, which progressed to respiratory difficulties. On January 31, a chest CT showed patchy ground-glass opacities in the periphery of both lungs. The RT-PCR on a nasopharyngeal swab was positive. On February 2, the patient was admitted to Renmin Hospital and received antiviral, antibiotic, corticosteroid, and oxygen therapies. Results from 4 repeat RT-PCR tests were positive (Table 1). On February 21, IgG and IgM antibody levels to SARS-CoV-2 were 107.89 AU/mL and 279.72 AU/mL, respectively (normal IgM and IgG <10 AU/mL). The results of an RT-PCR test of the patient's vaginal secretions were negative.

On February 22, an infant girl was delivered by cesarean in a negative-pressure isolation room. The mother wore an

Table 1. Laboratory Results for the Mother

Time	Laboratory test	Value	Reference range
Feb 2	White blood cell count, $\times 10^9/L$	8.03	3.5-9.5
	Neutrophil count, $\times 10^9/L$	6.57	1.8-6.3
	Neutrophil ratio, %	81.9	40-75
	Lymphocyte count, $\times 10^9/L$	1.08	1.1-3.2
	Lymphocyte ratio, %	13.4	20-50
	C-reactive protein, mg/L	57	0-10
	PCT, ng/mL	0.086	0.1
	ALT, U/L	40	7-40
	AST, U/L	38	13-35
Feb 10	PCR of nasopharyngeal swab	+	—
Feb 19	PCT of nasopharyngeal swab	+	—
	PCR of vaginal secretion	—	—
Feb 21	SARS-CoV-2 IgG, AU/mL	107.89	<10
	SARS-CoV-2 IgM, AU/mL	279.72	<10
Feb 26	PCR of nasopharyngeal swab	+	—
Feb 28	Breast milk	—	—
Feb 29	SARS-CoV-2 IgG, AU/mL	116.30	<10
	SARS-CoV-2 IgM, AU/mL	112.66	<10
Mar 1	PCR of nasopharyngeal swab	+	—

Abbreviations: ALT, alanine aminotransferase; AST, aspartate aminotransferase; PCR, polymerase chain reaction; PCT, procalcitonin; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; —, negative; +, positive.

Table 2. Laboratory Results for the Neonate

Time	Laboratory test	Value	Reference range
Feb 22	White blood cell count, $\times 10^9/L$	18.08	3.5-9.5
	Neutrophil count, $\times 10^9/L$	13.46	1.8-6.3
	Neutrophil ratio, %	74.5	40-75
	Lymphocyte count, $\times 10^9/L$	2.89	1.1-3.2
	Lymphocyte ratio, %	16.00	20-50
	C-reactive protein, mg/L	<5.0	0-10
	PCT, ng/mL	0.137	<0.1
	ALT, U/L	11	7-40
	AST, U/L	65	13-35
	Total bilirubin, $\mu\text{mol/L}$	44.2	0-23
	Direct bilirubin, $\mu\text{mol/L}$	7.5	0-8.0
	Creatine kinase, U/L	937	40-200
	Lactate dehydrogenase, U/L	629	120-250
	Glucose, mmol/L	2.91	3.9-6.1
	Potassium, mmol/L	4.88	3.5-5.3
	IL-6, pg/mL	28.26	≤ 20.0
	IL-10, pg/mL	153.60	≤ 5.9
	SARS-CoV-2 IgG, AU/mL	140.32	<10
	SARS-CoV-2 IgM, AU/mL	45.83	<10
Feb 24	PCR of nasopharyngeal swab	–	–
Feb 27	PCR of nasopharyngeal swab	–	–
Mar 1	PCR of nasopharyngeal swab	–	–
Mar 6	PCR of nasopharyngeal swab	–	–
Mar 7	SARS-CoV-2 IgG, AU/mL	69.94	<10
	SARS-CoV-2 IgM, AU/mL	11.75	<10
Mar 9	PCR of nasopharyngeal swab	–	–

Abbreviations: ALT, alanine aminotransferase; AST, aspartate aminotransferase; PCR, polymerase chain reaction; PCT, procalcitonin; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; –, negative.

N95 mask and did not hold the infant. Her birth weight was 3120 g and Apgar scores were 9 at 1 minute and 10 at 5 minutes. The neonate had no symptoms and was immediately quarantined in the neonatal intensive care unit. At 2 hours of age, the SARS-CoV-2 IgG level was 140.32 AU/mL and the IgM level was 45.83 AU/mL. Cytokines were elevated (IL-6, 28.26 pg/mL; IL-10, 153.60 pg/mL), as well as a white blood cell count of $18.08 \times 10^9/L$. Chest CT was normal. The neonate was transferred to a children's hospital as per protocol. Results from 5 RT-PCR tests on nasopharyngeal swabs taken from 2 hours to 16 days of age were negative. Her IgM (11.75 AU/mL) and IgG (69.94 AU/mL) levels were still elevated on March 7 (Table 2), and she was discharged on March 18.

On February 28, the mother's breast milk had a negative RT-PCR test result. On February 29, her IgG level was 116.30 AU/mL and her IgM level was 112.66 AU/mL. A CT examination showed moderate resolution of the ground-glass opacities.

Discussion | A neonate born to a mother with COVID-19 had elevated antibody levels and abnormal cytokine test results 2 hours after birth. The elevated IgM antibody level suggests that the neonate was infected in utero. IgM antibodies are not transferred to the fetus via the placenta.² The infant potentially could have been exposed for 23 days from the time of the mother's diagnosis of COVID-19 to delivery. The laboratory results displaying inflammation and liver injury indirectly support the possibility of vertical transmission. Although infection at delivery cannot be ruled out, IgM antibodies usually do not ap-

pear until 3 to 7 days after infection, and the elevated IgM in the neonate was evident in a blood sample drawn 2 hours after birth. Also, the mother's vaginal secretions were negative for SARS-CoV-2. The infant's repeatedly negative RT-PCR test results on nasopharyngeal swabs are difficult to explain, although these tests are not always positive with infection. IgG antibodies can be transmitted to the fetus through the placenta and appear later than IgM. Therefore, the elevated IgG level may reflect maternal or infant infection.

Limitations of this report include the single case and that no PCR testing of amniotic fluid or placenta was performed. Additional examination of maternal and newborn samples should be done to confirm this preliminary observation.

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Antibodies in Infants Born to Mothers With COVID-19 Pneumonia

Tests for IgG and IgM antibodies for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) became available in February 2020. On March 4,



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the *New Coronavirus Pneumonia Prevention and Control Protocol* for the novel coronavirus disease 2019 (COVID-19) was released by the National Health Commission of the People's Republic of China and

added serological diagnostic criteria.¹ A previous study of 9 pregnant women and their infants found no maternal-infant transmission of SARS-CoV-2 based on reverse transcriptase-polymerase chain reaction (RT-PCR).² We applied these new criteria to 6 pregnant women with confirmed COVID-19 and their infants because serologic criteria would allow more detailed investigation of infection in newborns.

Methods | Clinical records and laboratory results were retrospectively reviewed for 6 pregnant women with COVID-19 admitted to Zhongnan Hospital of Wuhan University from February 16 to March 6, 2020, confirmed based on symptoms, chest computed tomography, and positive RT-PCR results.

Blood samples were collected from the mothers at delivery and neonatal blood and throat swab samples were collected at birth. Quantitative RT-PCR for SARS-CoV-2 nucleic acid (RT-PCR Kit, BioGerm) was conducted on neonatal serum and throat swabs. Inflammatory cytokines (CBA Human Th1/Th2 Cytokine Kit II, BD Biosciences) were tested on neonatal serum. Maternal and neonatal sera samples were used to test for IgG and IgM antibodies. All tests were performed by 2 researchers (Y.T. and Q.D.), with SARS-CoV-2 IgG and IgM samples from infants double checked (CLIA assays Kit, YHLO). Sample collection, processing, and laboratory testing followed guidance from the World Health Organization.³ The sensitivity and specificity reported by the manufacturer for IgM are 88.2% and 99.0% respectively, and for IgG are 97.8% and 97.9%.⁴

This study was approved by the Zhongnan Hospital of Wuhan University institutional review board, which waived informed consent for this retrospective study.

Results | All 6 mothers had mild clinical manifestations. All had cesarean deliveries in their third trimester in negative pressure isolation rooms. All mothers wore masks, and all medical staff wore protective suits and double masks. The infants were isolated from their mothers immediately after delivery.

All 6 infants had 1-minute Apgar scores of 8 to 9 and 5-minute Apgar scores of 9 to 10. Neonatal throat swabs and blood samples all had negative RT-PCR test results. All 6 infants had antibodies detected in their serum. Two infants had IgG and IgM concentrations higher than the normal level (<10 AU/mL). One infant had an IgG level of 125.5 and IgM level of 39.6 AU/mL; the second infant, had an IgG level of 113.91 AU/mL and IgM level of 16.25 AU/mL (**Table 1**). Their mothers also had elevated levels of IgG and IgM (**Table 2**). Three infants had elevated IgG levels (75.49, 73.19, 51.38 AU/mL) but normal IgM levels; all 3 mothers had elevated IgG

Table 1. Antibody and IL-6 Levels in Infant Sera Samples

Clinical value	Reference range	Infant ^a					
		1	2	3	4	5	6
IgM, AU/mL	<10	39.6	16.25	3.79	1.9	0.96	0.16
IgG, AU/mL	<10	125.5	113.91	75.49	73.19	51.38	7.25
IL-6, pg/mL	0.1-2.9	15.07	33.65	19.16	18.15	32.75	19.62

^a Infants and mothers correspond by number between tables.