Pediatrics and Neonatology 62 (2021) 499—505

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.pediatr-neonatol.com

Original Article

Neonatal outcomes of pregnant women with COVID-19 in a developing country setup

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Received Dec 14, 2020; received in revised form Mar 8, 2021; accepted May 10, 2021
Available online 18 May 2021

Key Words
neonates;
odisha;
rooming in;
SARS-CoV-2;
vertical transmission

Background: Current evidence on vertical transmission of severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) and neonatal outcome among exposed newborns is emerging and posing a challenge for preventive interventions. Perinatal transmission to the neonates especially during breastfeeding and rooming in is also relatively unknown.
Methods: This prospective observational study was conducted in Kalinga Institute of Medical Science (KIMS), Odisha state from 1st May to 20th October 2020. A total of 165 neonates born to SARS-CoV-2 infected mothers were enrolled. Real time polymerase chain reaction (RT PCR) testing was done in first 32 neonates in initial 24 h of life.
Results: The clinical characteristics of 162 mothers & 165 neonates were analyzed. Mode of delivery was by caesarian section in most (n = 103, 60%) cases. Three (3/32, 9.4%) inborn and 6 outborn neonates were SARS-CoV-2 positive. Thirty-eight (23%) babies needed neonatal intensive care. Clinical characteristics of neonates were meconium-stained amniotic fluid (MSAF [23.63%]), prematurity (16.9%), respiratory distress (10.5%), moderate to severe hypoxic ischemic encephalopathy (3.6%), sepsis (7%) and hyperbilirubinemia (8.7%). Out of 138 stable babies kept on mother side and initiated breast feeding, none of them developed any signs and symptoms attributable to SARS-CoV-2. Five (3%) neonates died in COVID hospital of which one baby was SARS-CoV-2 positive.

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https://doi.org/10.1016/j.pedneo.2021.05.004

Conclusion: There was an increased rate of incidences of hypoxic ischemic encephalopathy, meconium stained liquor and cesarean section delivery in COVID hospital. We found a possible vertical transmission in 9.4% cases. None of the neonates developed sign and symptoms of SARS-CoV-2 infection during rooming in and breast feeding.

1. Introduction

In December 2019, there was a rapid rise in the acute respiratory failure related cases in Wuhan, China which led to the identification of the novel pathogen as Severe Acute Respiratory Syndrome Coronavirus 2 or SARS-CoV-2 which was the causative organism of the disease. WHO (World Health Organization) termed the disease as novel coronavirus disease (COVID-19) and later on 11th March 2020, WHO declared this disease a global pandemic.[1] As of 4th December 2020, the disease has affected over 60 million individuals, out of which over 45 million people recovered and 1.5 million were declared as deceased. According to various studies, it was found that the novel coronavirus infects all age groups including newborns and elderly, but there are a few groups which are more vulnerable to the infection. One such group is pregnant women.[2] The COVID-19 can severely affect the pregnant women. Current evidence on vertical transmission of SARS-CoV-2 and natural passive immunity among exposed newborns is emerging and posing a challenge for preventive interventions. Initial data by Vivanti et al., 2020 showed a transplacental transmission of SARS-CoV-2 in a neonate born to a mother infected in the last trimester,[3] but current data demonstrate very rare maternal—fetal transmission, i.e., less than 1%.[4] Some studies showed elevated IgM antibodies to SARS-CoV-2 in neonates born to mothers with SARS-CoV-2 while others excluded the same.[5] Perinatal transmission to the neonates especially during breastfeeding is also unknown.[6] Moreover, infected newborns are mostly asymptomatic or present with mild clinical symptoms like shortness of breath, fever, or gastrointestinal symptoms.[7] There is limited information about the manifestation and outcome of neonates born to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) positive mothers from developing countries.

The KIMS (Kalinga Institute of Medical Science) Hospital is one of the largest tertiary maternity units in Eastern India which was designated as a COVID Hospital by the state government in April 2020. It has a 10-bedded separate level III Neonatal Intensive Care Unit (NICU) for babies delivered to SARS-CoV-2 positive mothers and also a facility for management of high-risk pregnancy. The objective of the present study was to evaluate maternal, fetal, and neonatal clinical characteristics and outcomes among pregnant women admitted to hospital with laboratory-confirmed SARS-CoV-2 infection. Besides this, the safety of babies with breastfeeding and rooming in was evaluated.

2. Material and methods

2.1. Study design

This prospective observational study was conducted at the COVID hospital, KIMS, Bhubaneswar in Odisha state from 1st May to 20th October 2020. All the babies (n = 165) born to SARS-CoV2 infected mothers were enrolled. Written informed consent was obtained from the neonates' parents. The study was approved by the institutional ethics committee. A mother was considered positive either if she delivered within 10 days of being SARS-COV-2 positive as per Indian Council of Medical Research (ICMR) guidelines (Guidance for Management of Pregnant Women in COVID-19 Pandemic-ICMR, 2020) or if delivery occurs 10 days after she becomes positive, but still, she is not negative in repeat RT-PCR testing. The policy of doing tests was followed as per the Govt of India ICMR guidelines by using a single nasopharyngeal (NP) swab. The SARS-CoV-2 virus was diagnosed by real-time reverse-transcriptase PCR with detection of the N and ORF1ab gene using the U-Top COVID-19 Detection Kit (Seasun Biomaterials, Daejeon, Korea) or the E and the S gene using the RealStar PCR (Altona Diagnostics, Hamburg, Germany). Interpretation of the result was done as per the manufacturer's recommendation.

Mothers with fetal distress, meconium-stained amniotic fluid (MSAF), post-dated pregnancy, severe pregnancy-induced hypertension (PIH), obstructed labor, and oligohydramnious were planned for cesarean section delivery. Neonates born to those mothers were tested within 24 h of age by taking nasopharyngeal (NP) swab. If RT-PCR of the baby was positive, then the same schedule of testing was done for them as for the mother. For SARS-CoV-2 negative neonates who were kept at mother's side in the postnatal ward, repeat testing was not done and babies were discharged along with mothers after 10 days as per ICMR guidelines if they were asymptomatic. For neonates who were admitted to COVID NICU with RT-PCR negative, a repeat test was done on day 7 of life. If the test was negative, the baby was shifted to NICU in non-COVID hospital.

RT PCR testing was done in the first 32 neonates in the existing facility at KIMS COVID Hospital. Six RT-PCR positive babies were received after 3 days of delivery from the outside hospitals.

Asymptomatic neonates who were kept in the postnatal ward at the mother's side were allowed to room in with

their mothers unless the mother is unwilling to keep the baby or she was critically unwell and therefore unable to take care of the baby. Infants who were roomed in were allowed to breastfeed with adequate droplet and contact precautions.[8] Babies were kept in a separate baby cot placed at least 6 feet away from the mother's bed. Mothers were advised to wear a mask when in close proximity to their babies and to perform proper hand hygiene practice while handling the baby or during breastfeeding. No visitors except healthcare persons with appropriate personal protective equipment were allowed to enter the COVID neonatal care unit. Expressed breast milk was given to neonates admitted to NICU as soon as it was available.

Babies were discharged after they reached a weight of 1.8 kg and were hemodynamically stable taking full paladai feeds or shifted to other hospitals after they became SARS-CoV-2 negative if parents wished. Babies were followed up every week till 4 weeks by telephone about their wellbeing.

2.2. Data analysis

Data regarding demographic, epidemiologic, and clinical features were collected from case records. Laboratory investigations like Chest X-ray, Clinical Breast Examination (CBE), C-reactive Protein Test (CRP), Liver Function Test (LFT), blood culture sensitivity, electrolytes, urea, and creatinine were done. Data were analyzed using SPSS Version 20 (IBM Corp).

3. Definitions

Diagnosis of Hyaline Membrane Disease (HMD) was done on clinical and radiological findings and surfactants were given in severe HMD cases as per the European consensus guideline.[9] Hypotension was defined as mean arterial pressure <5th centile of mean and it was considered significant when it required inotropic support.[10] Grading of hypoxic ischemic encephalopathy (HIE) was based on Sarnat staging.[11] Diagnosis of clinical sepsis was based upon positive sepsis screen markers like total leucocyte count, absolute neutrophil count, and C reactive protein along with positive blood culture growth done by Bac T Alert method. Necrotizing enterocolitis (NEC) was defined based on clinical and radiological evidence as per Bell's staging.[10] Chronic lung disease (CLD) was defined as the requirement of either oxygen or assisted ventilation beyond 36 weeks corrected age.[10] Polycythemia was defined when packed cell volume (PCV) was more than 70 and partial exchange transfusion was done when PCV was more than 75 or with symptoms like hypoglycemia, seizure, and feeding intolerance with PCV more than 70 ref. Blood sugar below 40 was defined as hypoglycemia which was managed as per national neonatology forum (NNF) protocol.[12] Diagnosis of neonatal hyperbilirubinemia requiring phototherapy was done based on American academy of pediatrics (AAP) guidelines.[13] Prolonged rupture of membrane (PROM) was taken as rupture of membrane for more than 24 h.[9,10]

4. Results

4.1. Maternal and neonatal characteristics

Of the 162 COVID-19 positive mothers, there were 5 twin pregnancies and two babies were stillborn. The clinical characteristics of 162 mothers and 165 neonates were analyzed. The majority (n = 103, 63.6%) of deliveries were made by caesarean section. The gestational age of babies varies from 25 weeks to 41 weeks (average 37.5 weeks). One maternal death occurred on day 3 of the postoperative period. The maternal profiles are summarized in Table 1. Out of 37 symptomatic mothers of SARS-CoV-2, 21 cases had breathing difficulty requiring oxygen, and 16 cases had flu-like manifestations. All cases recovered well with symptomatic treatment without the use of antiviral drugs.

Testing and outcome of neonates are shown in the flow chart (Fig. 1). Out of 32 tested inborn neonates, 3 (9.4%) were positive for SARS-CoV-2. Six SARS-CoV-2 positive babies were referred cases from outside centers to COVID NICU. There were 4 deaths in 162 babies (negative/non screened), whereas one baby died from among 9 positive cases.

Low birth weight and preterm babies constitute 49 (29.7%) and 27 (16.4%) of cases, respectively. The HIE and MSAF cases were 6 (3.6%) and 39 (23.63%), respectively. Out of the 165 infants, 38 (23%) babies were admitted to neonatal intensive care unit. The majority of the babies (n = 125, 75.7%) were breast fed at the time of discharge. Rooming-in with the mother was done for 138 (83.6%) babies (Table 2).

4.2. Neonatal morbidities and etiology of mortality

Morbidities of babies admitted in NICU are described in Table 3. The majority (n = 22, 58%) of these neonates were admitted for respiratory distress both in term and preterm infants. Surfactant was used in 4 (10.5%) cases. Assisted ventilation was done for 13 (34.2%) babies, out of which invasive ventilation was used in 8 cases. Out of 12 clinical sepsis, four (10.5%) babies were culture positive.

Table 1 Clinical characteristics of mothers with COVID-19 (n = 162).

Parameters		Number	Percentage
Mean Age (years)		31 (19—41)	
Gravida	Multi	90	55.5
	Primi	72	44.4
PROM (Premature Rupture of Membrane)		25	15.4
Meconium-stained liquor		39	24.07
Mode of delivery	Vaginal	59	36.4
	Caesarean section	103	63.6
With COVID-19 symptoms at time of delivery		37	22.8
Oxygen received for COVID-19		21	12.9
PPH (Post Partum Haemorrhage)		2	1.2
Mortality		1	0.6

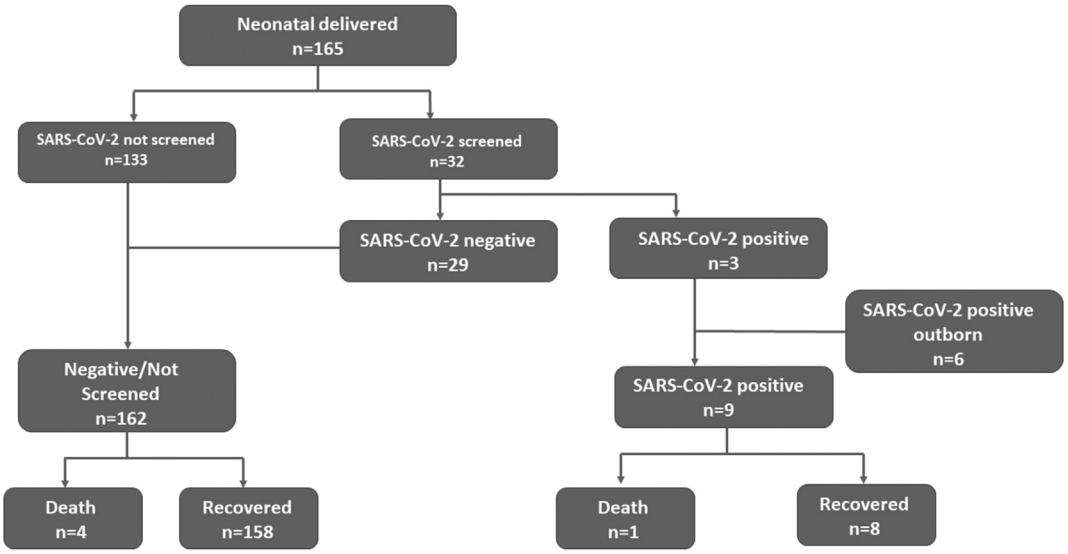

Figure 1 Testing, positivity, and outcome of neonates (n = 165).

Table 2 Clinical characteristics of neonates born to COVID-19 mothers (n = 165).

Parameters	Number of cases	Percentage
Average birth weight (kg)	2.69 Kg (0.7 −4 Kg)	
Low birth weight	49	29.7
1.5−2.5 kg	36	21.8
1−1.5 kg	10	6
<1 kg	3	1.8
Mean Gestation (weeks + days)	37.4 (25 −41 Weeks)	
Preterm (<37 weeks)	27	16.6
Late preterm (34−36 + 6)	17	10.3
Very preterm (28−33 + 6)	9	5.4
Extreme preterm (<28 weeks)	1	0.6
Apgar scores at 5 min		
0−3	6	3.6
4−7	8	4.8
>7	151	91.6
Male: Female	87:78	
SARS-CoV2 positive neonates	3/32	9.4
Roomed in with mother	138	83.6
On breastfeeding at the time of discharge	125	75.7

Table 4 shows clinical characteristics of 9 positive neonates, of which 3 were from KIMS COVID hospital and 6 babies were referred cases from outside centers. Two neonates were asymptomatic. Sepsis was found in 4 cases and 2 neonates had HIE with seizure. Neonatal hyperbilirubinemia and shock were found in 2 cases each. One preterm outborn baby succumbed to sepsis and NEC on day 7 of life with NEC stage 3 and its complications. All other babies recovered and discharged with hemodynamically stable conditions. Details of COVID positive neonates are described in Table 4. Five babies died during treatment, of which 3 babies had refractory seizures and 1 baby had hyaline membrane disease (HMD) and the other had culture positive sepsis (Table 5).

5. Discussion

The KIMS COVID hospital is the largest tertiary care center of Odisha state for SARS-CoV-2 positive pregnant mothers. There was an increased rate of cesarean section in COVID hospital. Also, the incidence of HIE and MSAF cases was more prevalent. We found a possible vertical transmission in 9.4% of cases, which is higher than other reported literature.[8] None of the neonates developed signs and symptoms of COVID-19 during rooming-in and breastfeeding.

In this study, 29.7% of all neonates were low birth weight and 55.1% of them were secondary to prematurity. The national neonatal-perinatal database shows 30% of Indian neonates are of LBW (Low Birth Weight) and 40% are premature.[14] There is a rise in prematurity in SARS-CoV-2 positive pregnancy which might be due to an increased level of stress to the mothers. In this study, 60% of babies were delivered by a cesarean section, which is higher than the normal situation. In one study, the average cesarean section birth rate in India was around 17.2% with wide variation across states (range 5.8%−40.1%). However, the WHO threshold is 15%.[15] However, in a systematic review of 108 SARS-CoV-2 positive pregnancies, all outside India showed 92% were delivered by cesarean section and indication was fetal distress.[8] Meconium - stained liquor was found in 22% of deliveries in our study compared to 10% in pre-COVID era.[16] The fetal distress leading to MSAF during intrapartum period could not be explained solely by maternal COVID-19 infection, hence the need for further studies. The HIE incidence in our COVID hospital is 3.6%, compared to 1.5% in National Neonatal-Perinatal Database. This might be due to delay in getting RT PCR reports of mothers from ICMR as there was overload of testing samples and delayed referral to designated COVID hospital.

Table 3 Morbidity pattern of neonates admitted to COVID hospital NICU (n = 38).

Morbidity	No	Percentage
Prematurity (<37 weeks)	27	71
Respiratory distress syndrome	8	21
Surfactant	4	10.5
Transient tachypnea of newborn	7	18.4
Assisted ventilation	13	34.2
Hypotension requiring inotropes	8	21
Seizures	8	21
Hypoxic Ischemic Encephalopathy (Grade II or III)	6	15.8
Hypoglycemia	4	10.5
Clinical Sepsis	12	31.6
Culture positive sepsis	4 (*Acenatobacter boumanii*,*Candida krusei*,*Staph. hemolyticus*,*Candida krusei*)	10.5
Polycythemia requiring partial exchange transfusion	1	2.6
Hyperbillirubinemia requiring phototherapy	15	39.5
Acute kidney injury	6	15.8
Coagulopathy	7	18.4
Necrotizing enterocolitis	1	2.6
Mortality (<28 days)	5	13.2
Stillborn	2	5.2

Due to many logistical issues, nasopharyngeal swab RT PCR could not be done in all inborn neonates; hence neonatal outcome was represented in two headings, i.e., neonates of COVID positive mothers and SARS-CoV-2 positive neonates. A total of 138 babies were kept at the mother's side and breastfeeding was initiated. The neonatal SARS-CoV-2 infection through breast milk is not confirmed though there is limited evidence for the presence of SARS-CoV-2 excretion in breast milk.[17] None of the breast feed neonates of our postnatal wards of COVID hospital developed any signs and symptoms except hyperbilirubinemia. We presume the vertical transmission rate was 9.4% in this cohort, whereas it varies from 0 to 2.7% in various studies. Less presence of ACE - 2 receptors over placenta is hypothesized to account for minimal vertical transmission by some authors.[4]

Among 3 inborn SARS-CoV-2 positive neonates, Case 1, a preterm (31 weeks) baby delivered from a mother with HELLP (haemolysis, elevated liver enzymes, low platelet count) syndrome developed all complications related to prematurity. The other 2 neonates were term gestation with no significant SARS-CoV-2 related symptoms. In a study done by Zahigam et al., 2020 one of 75 newborns delivered from COVID-19 positive mothers was infected with SARS-CoV-2 and did well clinically except for transient lymphocytopenia and deranged liver function tests.

Among 6 outborn SARS-CoV-2 positive neonates, 2 babies were asymptomatic. Cases 3 and 4 were term neonates with hypoxic ischemic encephalopathy with early-onset sepsis. Cases 5 and 6 were sick preterm (30 weeks) twins referred to our hospital after maternal death due to COVID-19 related complications. They were diagnosed as late-onset neonatal sepsis at the time of admission. We had not used any specific medication for the treatment of positive neonates. In a systematic review of 44 neonates infected with SARS-CoV-2 (most of them from Italy and China), one fourth of neonates were asymptomatic, and the rest developed symptoms limited to respiratory and gastrointestinal systems.[18] Out of 36 SARS-CoV-2 symptomatic babies, 4 (11%) and 2 (6%) required mechanical ventilation and non-invasive respiratory support, respectively, but the authors could not exclude the need for respiratory support secondary to other neonatal morbidities. In this study, a total of 13/165 (7.6%) neonates required assisted ventilation, whereas 3/9 (33%) SARS-CoV-2 positive neonates required ventilator support. In the present study, the major morbidities of neonates of SARS-CoV-2 positive mothers were prematurity (16.9%), respiratory distress (10.5%),

Table 4 Clinical characteristics of SARS-CoV-2 positive neonates (n = 9).

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Term/Preterm	Preterm	Term	Term	Term	Term	Preterm	Term	Term	Preterm
Inborn/Outborn	Inborn	Inborn	Inborn	Outborn	Outborn	Outborn	Outborn	Outborn	Outborn
Asymptomatic				Yes	Yes				
Hyperbillirubinemia		Yes	Yes						
Respiratory Distress Syndrome	Yes								
Shock	Yes								Yes
Pulmonary hemorrhage									Yes
Hypoxic-Ichemic Encephalopathy							Yes	Yes	
Seizure							Yes	Yes	
Sepsis						Yes	Yes	Yes	Yes
Necrotizing enterocolitis									Yes
Death									Yes

Table 5 Etiology of mortality of neonates (n = 5).

	Case 1	Case 2	Case 3	Case 4	Case 5
Inborn/Outborn	Inborn	Inborn	Inborn	Inborn	Outborn
Term/Preterm	Term	Term	Term	Preterm (25 weeks)	Preterm (30 weeks)
Birth Weight	2.9	3.8	3.2	700 gm	960 gm
Respiratory Distress Syndrome				Yes	
Hypoxic-Ichemic Encephalopathy	Yes	Yes	Yes		
Refractory Seizure	Yes	Yes	Yes		
Meconium Aspiration Syndrome/Persistent Pulmonary Hypertension in Neonates (MAS/PPHN)	Yes				
Sepsis	Clinical sepsis				Culture positive sepsis
Shock	Yes	Yes	Yes	Yes	Yes
Coagulopathy	Yes	Yes	Yes	Yes	Yes
Acute kidney Injury		Yes	Yes		
Necrotizing enterocolitis					NEC Stage 3
Pulmonary hemorrhage	Yes			Yes	Yes
SARS CoV-2 Positive					Yes

moderate to severe hypoxic ischemic encephalopathy (3.5%), sepsis (7%), and hyperbilirubinemia (8.7%). The neonatal morbidity pattern in COVID-19 hospital is similar to the Indian neonatal tertiary care burden as described in various studies.[19–21]

Five out of 38 (13.2%) neonates admitted to NICU died in the KIMS COVID hospital. Among the death cases 3 (60%) were due to severe hypoxic ischemic encephalopathy with multi-organ dysfunction, and 2 (40%) were due to extreme low birth weight and prematurity-related complications, of which one baby (SARS-CoV-2 positive) was due to late onset of sepsis (*Acinetobacter boumanni* positive) with NEC stage 3 and multi-organ dysfunction. The neonatal mortality in the present study was higher compared to studies from overseas.[9,18] High frequency oscillatory (HFO) ventilation, nitric oxide, cooling devices, bedside echocardiography, and invasive blood pressure monitoring were not available in COVID hospital NICU, which may be the cause of the high mortality in our study. Most of the neonates died as a result of pulmonary hemorrhage due to a lack of rescue strategies like HFO in COVID hospital.

Though we had 165 neonates in the study group, we tested RT-PCR in 32 cases only due to hospital policy. However, these neonates are consecutive neonates out of symptomatic and asymptomatic SARS-COV-2 positive mothers reflecting the true presentation. We had not tested antibodies in these positive cases for confirmation of vertical transmission, which was a limitation. The neonates of SARS-CoV-2 positive mothers were not compared with non-COVID hospital neonates. However, we have compared the clinical presentation of these cases with existing NNPD and other literature.

There is an increased incidence of meconium-stained liquor and cesarean section deliveries in SARS-COV-2 positive mothers. We found possible vertical transmission in 9.4% of cases. Hypoxic ischaemic encephalopathy is the leading cause of mortality in our COVID-19 NICU. Breast-feeding and rooming in of healthy neonates with SARS-COV-2 positive mothers with special precautions should be encouraged.

Declaration of competing interest

The authors declare that there is no conflict of interest related to this article.

Funding

No funding was received to perform this study.

Acknowledgment

The authors acknowledge the Kalinga Institute of Medical Sciences, Bhubaneswar; School of Biotechnology, Kalinga Institute of Industrial Technology, Bhubaneswar; and KIIT Technology Business Incubator, Bhubaneswar for providing facilities and support. We appreciate all our lab colleagues for insightful discussions and advice.

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